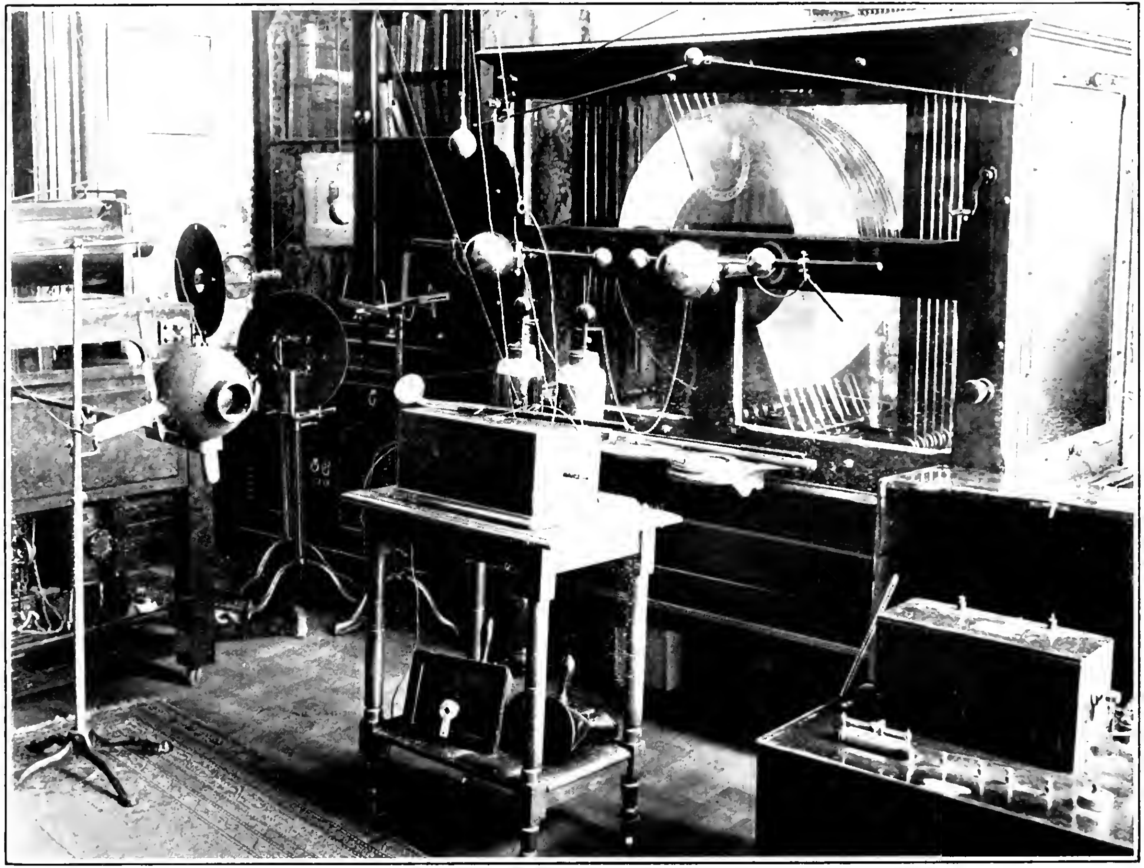
Dixitque Deus: Fiat lux.

PLATE I.



The Author's Roentgen Ray and High-frequency Office Equipment.

RADIOTHERAPY AND PHOTOTHERAPY,

INCLUDING

RADIUM AND HIGH-FREQUENCY CURRENTS,

THEIR MEDICAL AND SURGICAL APPLICATIONS IN DIAGNOSIS AND TREATMENT.

FOR STUDENTS AND PRACTITIONERS.

BY

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PREFACE.

The new therapy, based upon recent discoveries in the domain of radiant energy, has already achieved such positive results in some hitherto intractable maladies as to warrant us in considering it a powerful addition to our armamentarium. Naturally this has stimulated an immense amount of investigation and experiment, so that the reduction of this mass of knowledge to a usable form and the elimination of faulty observation have required the review of a vast quantity of literature coming from all quarters of the civilized globe. Much that is incorrect has gained publicity and even credence. In order to secure adequate data on which to base a judgment of the actual merits and relative values of the various methods of treatment by light and rays, the author and those aiding him have endeavored to ascertain the truth, so far as possible, by actual work before committing any statement to print.

As several excellent books are already available upon the practical and technical side of radiography, this subject has been briefly treated in the present volume, and the space thus gained has been devoted to the newer, larger, and more important field of therapy. For similar reasons shadow pictures and elementary electrophysics have been excluded as foreign to the purpose of the work. High-frequency currents have been considered at length because of the newness of the subject, its comparative absence from American medical literature, and its close relations to other new methods here discussed.

The object of the book is distinctly practical, to enable the reader to secure for his patient the most prompt and permanent benefit. Accordingly, the author has especially endeavored, in the chapters on Cancer and on Skin Diseases, to indicate therapeutic measures of value aside from those directly related to radio- and phototherapeutics.

It should never be forgotten that forces so powerful for good may equally work harm if improperly applied. Cautionary directions are therefore freely given.

Decided advances have been recently made in the matter of exact dosage, a point quite as important as in the case of drugs. We can to-day apportion the dose necessary to be absorbed by the skin for the cure of many distinct diseases. Utility and exactitude have been the constant aim. Where the preferable technique differs from the usual it has been given prominence under each separate chapter.

The author desires to thank his many friends who have extended courtesies, but especially his former and present office associates. To Dr. Franklin belongs the credit for most of the original drawings. Indeed, had it not been for his known ability in electrophysics the work would not have been undertaken. Without the willing and able efforts of Dr. Stern the book could not have been completed and brought so fully up to the date of issue within the allotted time.

Acknowledgment is also made to the publishers for their uniformly courteous and kind consideration and willingness to carry out the writer's views.

C. W. A.

NEW YORK, JULY, 1904.

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PART III.

RADIOTHERAPY.

RADIOTHERAPY AND PHOTOTHERAPY.

INTRODUCTION.

The beginning of an epoch in medical science will always be associated with the name of Professor Roentgen. Intimately linked with his name will go down to future generations those of Finsen and Becquerel. Important as were the discoveries of methods of exploration of the great cavities of the body by auscultation and percussion, they appear to us to-day to recede into secondary positions, when compared with those newer methods which permit the eye to do or to aid materially the ear in doing what was formerly left to the latter alone. Great as have been the benefits to humanity from the newer methods of exploration in surgery made possible by his discovery of this new force, their extension to non-surgical conditions and the development of a wholly new method of ray treatment bid fair to confer a still greater boon.

Few great discoveries in the realms of science have come so suddenly and seemingly so unheralded into a field of practical utility. Still if we pause for a moment to consider these startling and sensational phenomena, bursting, as it were, from the confines of a Crookes tube, and if we bear in mind the years of painstaking experimental work preceding and leading up to what seemed almost an accidental discovery on the part of Roentgen, the subject takes on a wholly different aspect, and we ask ourselves the question, "Why was not this new form of energy discovered earlier in the world's history?

In a review of the scientific labors which preceded those of the discoverer we perceive that for years Geissler, Crookes, Hertz, Lenard, and Hittorf were preparing the way. It was left to Roentgen to take that one necessary step in advance along the path of light which had its beginning in v. Guericke's electric spark, and whose whole extent was refulgent with the brilliancy of discovery of such men as Keppler, the father of the modern science of light; Wallaston, whose substitution of the slit for the round hole made possible the science of spectroscopy; Sprengel, Boyle, and Hawksbee. The beautiful experiments made by Crookes in demonstration of his theory of radiant matter, though combated by Lenard, went far toward that culmination of work upon these lines which fell to the lot of Roentgen. Indeed, had not Crookes persisted in his work under the stimulation of attack and proven his theory, the brilliant discovery to which it led might have been delayed many years or even indefinitely.

At about the same time that Roentgen surprised and edified the world with his announcements, Finsen, of Copenhagen, entered upon a line of treatment by light whose benefits, though almost restricted to that form of skin-tuberculosis known as lupus, is nevertheless remarkable in the fact that pathological conditions hitherto practically incurable and most disfiguring withal are now cured.

Becquerel, inspired by the achievements of Roentgen, entered with renewed vigor and confidence into his investigations of the luminous properties of phosphorescent bodies, and finally in 1896 announced his discovery, which may be said to have inaugurated the science of radio-activity.

The new ray now known by his name has been found to possess most remarkable qualities, and to be capable of producing decided therapeutic effects. Thus there have arisen three methods of treatment by light which are so intimately associated in their natures, origins and results that they can well be studied together.

If we consider these new forces in association with recent discoveries in the application of electricity and especially the currents of high frequency to various pathological processes, we have, as it were, a new practice of medicine.

The therapeutic application of high-frequency currents or d'Arsonvalization has attained such importance, and can be employed oftentimes with such advantage along with the more strictly speaking light methods, that its consideration in association with them here seems not inappropriate. Though exaggerated optimism should be warned against, still it seems to me the time has arrived when we must lay aside doubts, fears, and prejudices and realize that we are entering upon an entirely new era in the science of medicine, whose horizon grows brighter the more we strive to penetrate it. Our present efforts will be largely expended in a study of these newer agencies as applied to the detection and cure of disease. Nothing need be said of the numerous workers in these new spheres of discovery. Their achievements are of themselves far too luminous to require any laudatory remark, and no brilliancy of verbiage could add to their lustre.

NOMENCLATURE.

The many names applied in connection with light and ray matters, and the careless manner in which terms are sometimes used, makes it necessary to define clearly the meaning of the various neologisms employed in this volume.

When the term *x-ray* is used it always means the ray of unknown quantity so designated by its discoverer, Professor Roentgen, and not any of the other rays connected with radio-active substances which have been likewise called "*x*."

The *cathode ray* means, unless otherwise explained, that formed within a Crookes tube, and taking an essential part in the production of the *x*-ray.

Radiodiagnosis, *radiopraxis*, *radiotherapy*, *radiography*, etc., refer to the methods in which Roentgen's ray are utilized. While it is proper to employ the same terms for effects produced by radio-active substances, too little has, till now, been done in this direction, and the faulty use of these terms might confuse.

Phototherapy refers to treatment by light in general, and to that by the Finsen light and its modifications in particular—but not to *x*-ray treatment.

Heliotherapy, on the contrary, means treatment by light of the sun in its various applications other than those devised by Finsen.

Finsen's method, treatment, etc., are terms restricted to his original or actual recommendations and technique, and do not apply to phototherapy in general. They refer especially to his plan of focusing sun and arc lights specially produced, before they reach the surface to be affected.

Actinotherapy relates to the various methods in which the actinic or chemical rays are known to be or thought to be the effective agent, in treatment by violet or ultra-violet rays, including the methods of Finsen and his followers.

Skiagraphy can be employed synonymously with radiography just as we speak of photography, telegraphy, etc.

Chromotherapy. This term has been employed for treatment by variously colored lights such as red, blue, etc. It is not strictly proper to employ it in connection with Finsen's treatment of the suppurative stage of variola, for here it is not so much a treatment by color effects, but an exclusion of the irritating actinic or chemical rays.

Light treatment has been much employed as a term for the use of therapeutically active rays—blue, visible violet, ultra-violet or actinic—but it is too indefinite.

High-frequency currents in therapy are those currents without evident polarity, but of enormous frequency and possessing oscillations whose rate is too great to be appreciated by human senses.

D'Arsonvalization is a method devised by d'Arsonval of applying these high-frequency currents in a closed circuit without producing any sensation.

Becquerel rays are those named after their discoverer, the French scientist, Henri Becquerel, in 1896, and refer to the radiations emanating from uranium, radium, polonium, thorium, etc.

Radio-activity is the acting force of these radiations, and the term is used to denote the comparative strength of the emanations, with uranium as a standard.

Histofluorescence. The production of fluorescence in the tissues of the body by the administration of various substances before exposure to *x* or other rays.

PART I.

GENERAL CONSIDERATIONS UPON RADIOLOGY. THE HISTORY AND NATURE OF THE X-RAY AND THE METHOD OF ITS PRODUCTION.

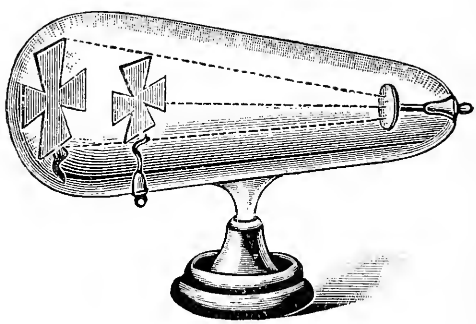
CHAPTER I.

HISTORY AND CHARACTER OF THE X-RAY.

HISTORY.

ROENTGEN or *x*-rays are generated in a vacuum tube of the general type of that invented by Geissler, and afterward extensively employed and modified by De la Rue, Spottiswoode, and many others, but particularly Crookes, Lenard, and Roentgen. The discovery of the *x*-ray, while it burst upon the world without the least warning, and completely astounded the most astute and learned physicists of the time, was only the natural consequence of a series of discoveries that were rewarding a few earnest workers who were persistently following the clew that Geissler had laid bare when he discovered that in the partial vacua of different gases, the electric discharge is very different from that in air, which was disruptive and called a spark. Thus it was first noted that the colors emitted by the "tube" changed with every variation of the vacuum within, and with every different gas that the tube contained. Then it was discovered that the discharge, or presumably the matter remaining within the tube, divided itself into disks or striæ, of different shapes and sizes depending upon the state of the vacuum and the potential of the discharge, and that the spaces occupied by these differently colored bodies exhibited various conditions of resistance. Following this came the discoveries of Crookes, the most important of which was, that a stream of some kind emanated from the negatively attached pole or cathode of the tube and flowed across the tube to the positive pole, or the anode. He later discovered that this stream was propagated in straight lines, by the following experiment: In a tube of the shape shown in Fig. 1 was placed a cross made of mica, in such a position that the stream from the cathode would encounter it on its way to the glass side of the tube opposite. When the tube was excited by a suitable discharge of electricity it was seen that the mica cross, which

Fig. 1.

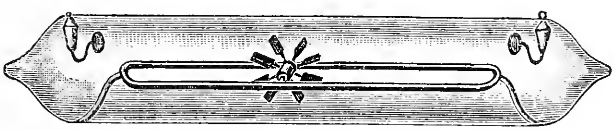


Crookes' experiment.

evidently occluded the stream, cast a sharp and clear shadow upon the glass side of the tube. It was noted at the same time that the glass fluoresced brilliantly wherever the stream impinged. Later the same observer discovered that the cathode stream was capable of being transformed into kinetic energy, and he demonstrated this by means of an ingenious glass railway that he had constructed. The form of this is shown in Fig. 2. The small wind-wheel is supported on an axis passed through the centre and protrudes on both sides, where it may run on the glass rails. Now if the cathode stream is so directed that it strikes the top of one of the mica vanes of the wheel above the axis, it will cause the wheel to revolve toward the anode, indicating that the vane of the wheel is repelled by the stream.

The motive power of the cathode stream was further shown by the following simple experiment: In the centre of a vacuum tube was suspended a small screw propeller. The cathode stream was directly in a line with the axis of the propeller, and when the current was allowed to flow the wheel turned as would a turbine. To show that the action of the cathode stream was propulsive, Crookes constructed a tiny weather-vane in a vacuum tube, and when the vanes were connected with the cathode, the streams flowing from the surface in one direction caused the wheel to rotate in the opposite. The speculations of Crookes as to the nature of the phenomena which he had discovered in these tubes led him to the conclusion that there existed

FIG. 2.



Crookes' experiment.

a new state of matter which he called radiant matter. This name seems to have been selected unfortunately in that it was fiercely attacked by a great many of the scientific men of the time, who endeavored to prove that the theory amounted to nothing.

It is well, however, that this difference in opinion existed, because it is almost directly due to this fact and the disputes engendered that the Roentgen rays were eventually discovered. Crookes' greatest opponent was Lenard, in France, who performed many experiments with the object of disproving the theory that Crookes had advanced as to the nature and causation of his phenomena. The most important discovery of Lenard was that the cathode stream could be detected outside of the tube as well as within, and that the stream was capable of being deflected or attracted by a magnet. There were many others who were engaged in research along the same lines, and almost every day some new fact was discovered bearing upon the peculiar effects of the electric discharge in more or less complete vacua. When on November 8, 1895, William C. Roentgen, a professor of physics in the University of Würzburg, in Bavaria, discovered that a great many photographic plates which were within the range of the rays from a Crookes tube with which he was making some experiments were spoiled or fogged, although they were amply protected from light by regular plate-holders, it was at once suspected that the cause of the chemical action on the plates was due to the peculiar radiations from the tube. He was strengthened in his suspicion by finding shadows of the forms of various objects which had lain upon the holders, over the developed plates. He had noted a short time before that the rays that emanated from the tube were capable of causing fluorescence in certain salts, and this fact combined with the evident effect on photographic plates, encouraged him to go farther into the matter and directly experiment with these newly observed rays. These observations led to the discovery that the rays could pass through black paper that was totally unable to transmit the ultra-violet or other chemical rays of the sun or arc light, and then cause platino-barium cyanide to fluoresce brilliantly; that the radiation was capable of passing through the thick, black cardboard covers of the plate-holders and affect the plates within; that the radiation was capable of acting through many substances and causing fluorescence on their emergence, these substances being totally opaque to ordinary light and the ultra-violet rays; and that the transmissibility of the substance to the rays had a relation to the specific density of that substance. The reason for this was at the time not quite clear. When Roentgen read his first paper, announcing his discovery, in December of the same year, he had already experimented with many substances to ascertain their perviousness to the new form of radiation, and was able at this early date to give considerable information on this subject.

In the tube with which the work of Roentgen was performed the cathode consisted of a plate of metal from which the rays travelled in a straight line and struck the glass side of the tube opposite, at which point the new rays were generated. The effects that Roentgen observed were clearly not due to the cathode stream, as he found that they differed from the latter in that they were not capable of being reflected, refracted, or polarized, and were not affected by a magnet, or capable of discharging negatively charged bodies. The rays were further distinguished from ultra-violet rays among other ways by the fact that the ultra-violet rays are capable of discharging either negatively or positively charged bodies; of being regularly refracted, reflected, and polarized; also in the fact that there were bodies which the rays would not traverse, some being substances that readily transmitted the ultra-violet rays, such as rock salt.

The theories that were advanced to show the position of the *x*-ray in the physical firmament were at first numerous, but are fewer now. The most important among those first advanced was that of Roentgen himself, that the rays were a short form of longitudinal vibration in the ether. Later this was totally abandoned in favor of the two views which now hold the field. The first of these is the theory that the rays consist of minute particles or ions, projected into space at an enormous velocity; and the other, that the rays are short transverse vibrations of the ether, similar to those of light, but infinitely shorter than the latter, and that they occupy a space in the spectrum of ether vibrations, beyond the Becquerel rays. The latter theory, while it is far from being satisfactorily confirmed, and while the emission theory has many strong points, seems destined to hold the field to the exclusion of all others.

While a discussion of the many theories cannot here be entered into, an attempt will be made in another chapter to give an insight into what has been accomplished along these lines.

CATHODE RAY.

This ray, which was discovered and named by Crookes, plays a very important part in the production of the *x*-ray.

It is the ray which, given off from the cathode, strikes the target of the anode and is there converted into and sent forth from the tube as an x-ray.

Cathode rays are thrown off as particles from all highly heated and highly electrified bodies.

According to Villard, they consist of a stream of hydrogen corpuscles negatively charged, moving at about 70,000 miles per second.

This molecular bombardment within a Crookes tube can cause phosphorescence of various substances. Some German physicists believe that these rays are due to longitudinal vibrations, but J. J. Thomson's theory, that they consist of a shower or stream of corpuscular particles striking the anode, is the explanation generally regarded as correct.

The cathode has an exaggerated saucer-shape to converge the rays to a point on the target and to counteract the tendency of the particles making up the stream to repell one another. They are clearly visible in a very low vacuum tube, generally coming to a focus before they reach the anode, when they do not cross one another, but converge to form a pencil-like stream and continue in a straight line until they meet an obstruction.

At times, beyond the focus point, the stream may seem to widen, making a second funnel whose base includes and often passes beyond the anode, so that the latter does not intercept all its rays. As the vacuum increases the focus moves toward the anode.

That Roentgen rays can be converted back again, so to speak, into cathode rays has apparently been demonstrated by Hammer.

By bombarding the outside of an Edison tube with x-rays, he found that cathode rays are stimulated in its interior, causing tungstate of calcium to become brightly phosphorescent.

Rudis-Jicinsky says that to get the anodyne effects in treatment we must have an abundance of cathode rays which are changed into the unknown rays. The x-rays alone or the cathode rays alone are not sufficient. The cathode rays may be deflected by a magnet or they may pass through substances opaque to light, and they may cast shadows of objects less opaque. They possess the property of acting upon photographic plates. They will pass in straight lines, independent of the position of the anode. In very low vacua they exhibit a beautiful violet color. They produce fluorescence of the tube or of certain objects contained within the tube, and their main difference from the *x*-ray consists in the fact that they may be focused.

The cathode rays are similar to the ultra-violet rays in that they will not affect the deeper tissues, nerves, or nerve centres, unless the parts are first deprived of their usual blood contents.

It is generally conceded that all possible therapeutic effect of the cathode ray is lost because of its non-emergence as such from the tube.

THE NATURE OF THE X-RAY.

The so-called *x*-ray is a form of energy manifested in its action upon certain unstable chemical compounds in which it produces chemical changes, and on certain salts in which it produces brilliant phosphorescence.

The mode of transmission of this energy and its nature are matters of some importance and great obscurity, though there exist several plausible theories. All these, however, lack confirmative basis, owing to the limited amount and indefinite nature of our present knowledge. The *x*-ray, although itself invisible, is at times spoken of as light on account of its ability to produce light in certain fluorescent substances, and because of its chemical action being in a measure similar to that of light; at least in so far as results obtain.

The *x*-ray is produced by passing electric discharges of tremendous potential through gases at different degrees of attenuation.

The latest point of interest in the controversy, as regards the nature of the rays, is the statement of Lord Rayleigh, Professor of Natural Philosophy in the British Royal Institution, who has announced that M. Blondelot, a skilful French experimenter, very recently adduced evidence going far to prove that the Roentgen rays are susceptible of polarization, if they have not been already polarized, and can therefore be traced in the solar spectrum. If this is true, and the rays are transversal, as M. Blondelot thinks, it follows that they are a form of ordinary light, but of extremely short wave-length, perhaps a hundred times shorter than visible light waves.

Lord Rayleigh said that he saw no reason to question the discovery, which is of great importance in aiding to determine the nature of the x-rays, which has been a matter of doubt ever since their discovery.

As to the nature of the light itself, if it is in reality proper to speak of its application as a form of light treatment, very little more is known to-day than when the rays were first discovered. Of the two surviving theories, that of extremely rapid wave vibration seems to have the greatest number of supporters. The fact of the vibratory nature of Herzian and electric phenomena, and the more recent placing of the Becquerel rays in the wave-gamut, make a sequence beginning with the Herzian waves on the one hand, and sliding by fine gradations, successively through the electric, heat, light, actinic, Becquerel, and, lastly, the x-rays, and offer a tempting scientific classification which seems rather convincing. When taken in connection with the various other phenomena which point in the same direction, it appears almost inevitable that the x-ray should find its proper place in the vacant space which has apparently existed in the scale of ethereal vibrations. It is interesting to note in this connection that Goldschmidt has amply demonstrated that a thin layer of ultra-violet light is generated at the point of impact of the x-ray within the tube, but he denies that the chemical action of the ray is due to this agent, having experimented amply with ultra-violet rays otherwise generated.

In the evolution of the cathode ray it would seem that its component atoms are broken up into one larger portion immobile and positively electrified, and a smaller portion negatively electrified, which by its rapid flight produces the phenomenon known as the x-ray. It is not some form of electricity, but is a higher rate of vibration even than light—it is the transformed energy of the electric current.

Pratt claims that it is a form of electric energy.

Many physicists, including Thomson and Stokes, believe that the ray is an irregular electromagnetic wave as compared with light, which is of a regular recurrence. A great many German scientists claim that the phenomenon is due to longitudinal vibrations.

Heidingsfeld[1] believes that the *x*-ray consists of minute particles of platinum, in a very high state of "radiant" excitation, emanating from the enclosed disk and moving radially with sufficient velocity to readily penetrate the circumscribed glass enclosure and all exposed soft and fairly hard substances. He thinks that this theory is to a degree confirmed by the close analogy that exists between the *x*-rays and the rays emanating from uranium, radium, polonium, and other allied substances. An objection to this view lies in the fact that rays may be generated in tubes without metallic anode.

The reason these waves cannot be reflected is probably that they are so small that no polish which we can secure upon a surface can turn them back.

The cathode rays in striking the anode are deflected and not reflected.

The *x*-rays are capable of discharging electrified bodies; they accomplish this by making the air through which they pass a good conductor.

We find that they not only act at the site of entrance, but also at the site of exit. As regards the way the rays act upon living tissues, it is undoubtedly a reducing or chemical action, very similar to their effect on photographic plates.

x-rays, radium rays, or Becquerel rays have one property in common, and that is they all show their effect in the distance without affecting the media through which they pass.

Eder and Valenta have proven that only plates prepared with gelatin show results in *x*-ray photographic work; those prepared with collodion show little or no result.

[1] Journal of Cutaneous Diseases, January, 1904.

The lighter the specific gravity of a substance, the easier it is penetrated by the x-rays, but it also depends a great deal upon the thickness of the substance. V. Novak, Sule, Voller, and Walter have proven that the penetrability of substances to x-rays depends more on their atomic weight than on their density.

Lead, platinum, and gold are almost impenetrable to the rays. Zinc, nickel, iron, and chiefly mercury are very difficult of penetration. Glass weakens the rays much more than the same thickness of aluminium.

CHAPTER II.

APPARATUS—METHODS OF PRODUCING THE RAY—MEASURE OF CURRENTS—PHYSICS OF THE RAY—TUBES AND ACCESSORIES.

STATIC MACHINES.

WE will first consider the static electric machines. These are of three general varieties, as used at present, the Holtz, Toepler-Holtz, and the Wimhurst. The first two are used principally in this country, while the last is used chiefly in England. In other Continental countries of Europe the use of the static machine is almost unknown.

The Holtz machine was invented in 1854, by Holtz, of Berlin, who introduced it as a vast improvement upon the friction type of machine which had grown out of that invented by Hawksbee. The Holtz machine was indeed a wonderful invention, and was so far superior to the friction-plate apparatus as to completely supersede it. It possessed two inherent weaknesses, however, which, notwithstanding its many advantages, such as tremendous power and ease of operating, etc., rendered its use limited, and these were that it was not self-charged—*i. e.*, before starting, it had to be separately excited by another body which had been electrified. It was in every respect an influence machine, or, more plainly, an inductive machine, and for this reason the second weakness, that of susceptibility to moisture, became evident. The machine did not operate, except in the driest of weather.

The Toepler-Holtz added to this machine certain improvements, in the shape of metal disks set in the revolving plate, with metallic brushes, causing to communicate disks at opposite points upon the periphery of the plate. The friction of these brushes caused the machine to become self-exciting. The influence of the atmosphere was, however, quite as much felt in this type as in the older machine, with the added disadvantage that the machine current, being made up of a series of pulsating charges, would frequently, on account of slight interruptions, alter its polarity, even while running, and thus cause very serious inconveniences when used for delicate work or experiments.

The Wimhurst machine is of a different type from either, and in its present form, while not quite so powerful as the Holtz or Toepler-Holtz machine, is truly self-exciting and more reliable than either, under varying conditions of weather. All of these machines as at present made contain many more plates than was formerly the case, most of them for *x*-ray work having from six to twenty revolving plates, these being generally from twenty-six to thirty-two inches in diameter. Other machines have been made which have had twenty-six revolving plates, and there is one machine in existence having plates sixty inches in diameter. The principle which governs the construction of these machines is that the insulation should be as nearly perfect as it is possible to construct it, and the whole protected from moisture by means of waterproof and nearly air-proof glass cases.

The static electric machine has enjoyed a long popularity, in America especially, and is reputed to possess several advantages of importance, but it is scarcely probable that a coil of the most modern type will not be found far superior to any static machine now made. Besides this, it is undoubtedly true that the better informed operators have expressed a preference for the coil, as a more scientific apparatus and capable of unlimited extension theoretically, even at a time when they were employing the modern static machine.

Advantages of the Machine.

The advantages claimed for the static machine are that the rays excited by it are more steady, and therefore better suited for direct screen examinations; that when applied to therapeutic uses the rays have a lesser tendency to produce burn, and that the machine being a primary generator, is independent of all other sources of electricity and need only be driven, even by hand-power, to produce results.

Its suitability for use for a wider range of tubes.

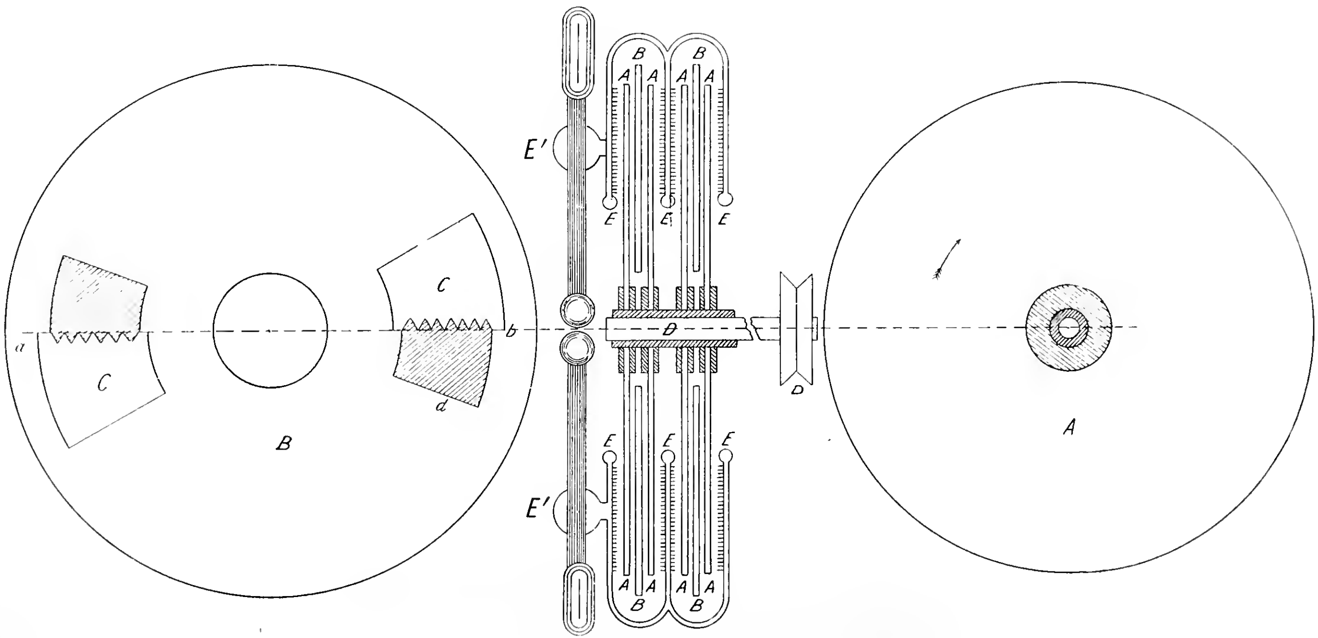
Two or more machines can be run simultaneously as one, giving increased voltage and current.

It may be used to better advantage than the coil for a greater number of therapeutic purposes outside of the production of *x*-rays.

Varney and others prefer the use of the static machine, since on account of its low amperage it will not heat the platinum disk as rapidly as the coil, and enables one to give much longer exposures.

Let us consider the advantages here claimed and determine how much truth there is in them. As to the steadiness of the light, it is more than probable that the observation was made in comparison with the older coils provided with electromagnetic vibrators, none of which, as is well known, is capable of giving a steady secondary current. With the more modern electrolytic break and the mercury jet breaks that have been latterly perfected, it is doubtful whether the static machine is capable of surpassing the induction coil in this respect. In the experience of the author a Wehnelt interrupter when properly adjusted, furnished with just enough condenser, will cause the coil to perform in a manner that very nearly approximates the ideal. The supposition that the static-excited rays are less prone to burn, a view which was at one time pretty generally accepted, does not at present receive the same support as at first. The difference if it does exist is probably due to the fact that the static machine furnishes a so much weaker current that it takes longer to produce the same result, or to other possible reasons that are mentioned in the chapter on *x*-ray dermatitis and "burns." The third advantage, that of its being independent of other sources of electricity, would be a factor if it were generally possible to utilize hand-power. The percentage of instances in which hand-power may be used is so small that the matter need not be seriously considered. Where it is necessary to have a source of power, it will be cheaper and better, all things considered, to use the power to drive a small dynamo with which to excite the coil. With the regulating and self-regulating tubes at our command at the present day, we find that a 12-inch coil may be used for a sufficiently wide range of tubes to

Fig. 3.



Details of Holtz influence machine.

give satisfactory results for practically any use to which we may put the x-rays. As regards the advantage of connecting two machines to get an increased current, this can be entirely left aside, as we find that the current one can get from an ordinary coil is sufficient for all practical purposes.

Disadvantages of the Machine.

The disadvantages of the static machine are great and glaring. It must of necessity be so large and heavy, and at the same time so essentially stationary, that it cannot be considered in any light but as a permanent immovable installation; it may be said to depend upon a motor for its operation; it is extremely unreliable, not working evenly in damp weather, and suddenly becoming "freaky" and working badly in a way which cannot always be explained; the capacity is very limited, both as to spark length—*i. e.*, potential difference—and current volume, it being necessary to enlarge the whole machine enormously to attain a relatively small increase in efficiency. It is more expensive than a coil of the same power. In photographic work it requires longer exposures. It is practically impossible to control the strength of current with any degree of certainty.

It has a low amperage. It is often almost necessary to add a two-series spark gap between the machine and the tube. Here the use of the spark gap for increasing excitation in the tube acts better, however, than when applied to the coil.

The Holtz Machine, as made by the several manufacturers, is essentially as follows: It consists of alternate movable (A) and fixed (B) plates (Fig. 3), the latter being circular or of any convenient shape, and the former being circular. The movable plate revolves upon an axis (D) passing through the centre of the immovable plate, and is placed at a distance of about one-half an inch from the latter. At a distance from the centre of the stationary plate, equal to a little less than one-half the radius of the revolving plate, are cut two holes (C), situated on either side of the diameter *a b*. At the margins of these two windows, and opposite to each other, on the side of the plate opposite to that opposed to the revolving plate, or on both sides, in multiple machines, are pasted pieces of paper (*d*) having a free edge of about three-quarters of an inch extending into the opening. These pieces of paper, called armatures, are sometimes covered with gold leaf, and have their free edges serrated. The movable disks revolve in a direction opposite to that in which the teeth of the armature point, or against the teeth. At a distance from the revolving disk equal to that of the armatures, and on the opposite side, are arranged the collecting combs *E*. These are a set of metal pins set in a metal rod in a straight line and so placed that they point directly at the free edges of the armatures. These collectors are connected directly with the prime conductors or terminals of the machine, *E'*. Where there are a number of plates, as in multiple machines, the collectors are all connected together on each side, thus adding the current from all of the plates.

The machine must be charged before it can be operated —*i. e.*, an electric charge must be given to one of the armatures from some outside source. For this purpose the machines of large size are generally provided with a smaller auxiliary machine, called an exciter, of some type, such as the Wimhurst, which is capable of self-excitation.

The working of the machine is somewhat complicated. If, for instance, there is imparted to one of the armatures (*d*) a positive charge, then there will be on the side of the movable plate opposite it an induced negative charge, and on the other side of the plate, at the same position, an induced positive charge, on the points of the comb *e*, a negative charge, and if the poles *E' E'* are in contact, as is necessary for the successful starting of the machine, a positive charge will exist on the points of the opposite comb; this will induce a negative charge upon the surface of the plate opposite to it, which in turn will induce a positive charge on the opposite side of the plate, and will result in an induced negative charge in the other armature. The negative charge on the first comb escapes to the face of the plate and is carried around toward the second comb. The positive charge on the second comb escapes to the surface of the plate and is carried around toward the other.

In the Holtz machine the length of spark is independent of the speed at which the machine is run, but the amount or volume of the current produced increases almost in exact ratio as the speed. This is true only if the hygrometric state remains constant. The electromotive force or difference in potential decreases with the addition of moisture to the atmosphere. The addition of plates to the machine does not increase the length of the spark, but only the volume thereof. The length of spark is limited by the diameters of the plates and the least distance of opposite portions of the machine, the spark never exceeding in length this minimum distance.

A description of the theoretical working of the Wimhurst machine is omitted as these types are seldom seen in this country, except in small sizes for charging the Holtz machine. For a given size, the Holtz machine is more powerful than any other type, but the extreme delicacy and the uncertainty of its performance, and the necessity of charging them every time they are used, the liability of their suddenly changing their pole, either while starting or while running, render them perhaps less useful than the Wimhurst, which possesses none of these drawbacks.

One firm has made a machine in which the plates are composed of a material which will resist great centrifugal strain, and in that way great speed is possible, and consequently great current strength, with safety to the machine. In this way the advantage of somewhat lessened space is gained, but the slight advantage is more than lost by the mechanical objections to high-speed machinery, besides the noise and additional expenditure of energy that is consumed in driving the machine.

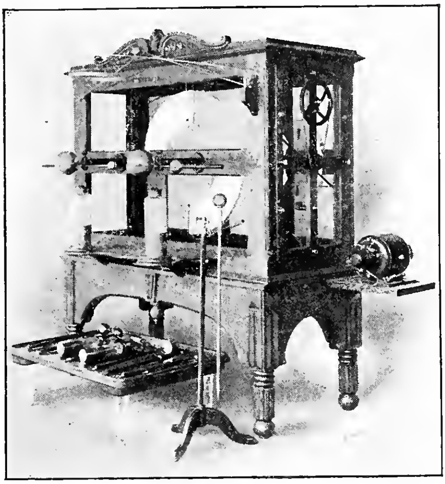
All plate machines suffer from moisture condensing upon the plates. This is overcome by employing some non-hygroscopic material for the plates' construction, but as this method is fraught with great difficulties in the finding of a suitable material, and in the better dialectric properties of glass, it is customary to varnish the glass plates with some non-hygroscopic varnish, and this must be renewed from time to time.

The loss of current is of great importance in the case of a plate machine where the total amount is small at the outset, and so every precaution must be employed in the construction of such a machine to avoid all loss. This is in a measure accomplished by avoiding all sharp corners and points. All of the conducting parts are made as smooth and round as possible and all joints are made very secure. Sharp points and all roughnesses tend to cause the escape of electricity into the air, while polished round conductors are more tenacious of their charge, and do not readily leak. For this reason it is customary to furnish all conductors with small globes of hard rubber at the terminals, and to avoid anything in the nature of a sharp point or corner anywhere in the circuit.

The Wimhurst Machine. This consists of a number of pairs of glass plates mounted upon a shaft, in such a manner that each plate of each pair may be revolved in an opposite direction. The diameter of these plates may be of any size, but thirty inches is found to be the most convenient. To each plate is attached a small pulley, which is driven by a belt from a common countershaft; the belts of the alternate plates are crossed, thus producing motion in different directions. On the outside of the plate, thin radial strips of tin-foil or brass are applied very close together. The action of these strips is barely material to the operation of the machine, as the surface of the glass holds the charge. In small machines, however, the presence of these strips renders self-excitation more readily accomplished, and it is for this purpose that they are applied.

The action of the Wimhurst machine does not seem to be fully understood at this time, though there are several inadequate theories at present in existence. Running across the face of each disk but separate from it is a rod of metal, which holds at each end a metal brush which communicates lightly with the surface of the plate, or with the metallic sector, where these exist. The two bars on each set of plates are at right angles to each other, so that at any moment two portions of the plate's surface diametrically opposite to each other are in electric communication. The inclination of one brush bar to the other may be varied from thirty to forty-five degrees, and each plate is furnished with a collecting comb, situated between the two brushes on the same side. The combs on each side are collected together. It is presumed that one of the strips or one portion of the plate possesses a small initial charge. When this is revolved, so that it comes opposite to the brush on the opposite plate, it induces an opposite charge at that portion of the plate, which is rapidly transmitted by the brush bar to the opposite diameter of the plate, where it induces an opposite charge at the point opposite on the first plate. This is carried along until it comes opposite a brush on the second plate, where

FIG. 4.



Type of Holtz machine.

it induces a further charge of the same kind as that which already there existed. Fig. 4 shows a static machine of the above type as generally used at the present time, and in Plate I. will be seen my own ten-plate machine, which now for a number of years has given entire satisfaction.

An excellent Wimhurst machine has recently been put upon the French market. Each pair of plates is supported upon an independent iron pillar, so that bending of the shaft is prevented.

The whole can be readily dismounted. The plates are of vulcanite, and a high rate of speed can be kept up for a long time. A great disadvantage is that it is not self-exciting. For fluoroscopic screen examinations this produces a minimum of flickering. By controlling the speed of the plates shadows of different densities can be readily appreciated.

Mica Plate Static Machine. There has recently been introduced a static machine, having plates made of mica instead of glass. They are prepared by cementing scales of mica together, with melted schellac, under hydraulic pressure. There are two movable plates in the machine, between which is placed a stationary plate of glass. Many advantages are claimed for this machine, such as high efficiencies, small compass, freedom from the effect of moisture, etc. The machine is constructed with the general view to withstand the strain of very high speed at which it is intended to be run—2000 revolutions. The mica plates, it is claimed, will not fly apart, while the shaft is mounted on ball bearings.

We have had no experience with this type of apparatus, but, judging by the claims made by the manufacturers, we would say that the apparatus is theoretically, at least, impracticable. It is claimed that the plates will hold together for indefinite periods, but experience with compound plates has shown that they are never durable.

The freedom from disturbance from hygroscopic conditions claimed is hardly tenable, in view of the fact that the immovable plate is of glass. The lessening of the number of plates lessens the size of the machine only in one dimension, while the great speed at which it is proposed to operate the machine, to compensate for the volume of current which a larger machine would produce, is hardly an adequate exchange for the greatly increased power demanded.

High-speed machinery, as is well known, is scarcely to be considered as durable in comparison with slow-speed machinery. The power required to drive a machine at that velocity is much greater than to drive a larger machine at a lesser velocity. Besides this, the machines are extremely noisy in operation. To such an extent in fact is this true, that instances are known in which machines have been removed from offices for this reason alone.

Glass plates may be run at a velocity equal to from five to six hundred revolutions per minute for a thirty-inch plate with perfect safety, and there are limits, as proven by experience, beyond which there is no benefit derived from increasing the speed. Ball bearings mounted upon wooden supports are mechanically poor construction, as weather changes in the wood distort the arrangement of the bearings. We may be mistaken in our valuation of the machine, but it is open at least to these theoretical objections.

Methods of Connecting Tube with Static Machine.[1] 1. By connecting the anode of the tube to the positive and the cathode of the tube to the negative end of the prime conductor.

2. By connecting as before with a spark gap, either single or multiple, in series.

3. By connecting up as in 2, with the Leyden jars in parallel.

4. In connecting the cords to the outside of the Leyden jars, producing an induced current through the tube in the opposite direction from the direct current, the tube must be connected up accordingly.

MEASURE OF CURRENTS.

Efforts have been made, from the earliest times at which static discharges have been observed, to determine the potential and the volume of these currents. It was quite early recognized that the spark followed the same general law as currents in other media, but attempts to exactly measure the spark have been in the main unsatisfactory. Small sparks up to and including one inch in length have been measured by means of Thompson's high-potential electroscope, and it appears from the data that, for small currents at least, the length of the spark varies with the

[1] Eden V. Delphey, New York State Journal of Medicine, July, 1903.

square of the current. It is estimated that the potential necessary to cause a spark of one inch in air is 70,000 volts, and on this basis a table may be constructed that may give a clew to the potential of longer discharges. We say "may" because there are so many known, and perhaps so many unknown, factors that might alter the ratios that exist between the spark lengths, that it is probable the table is far from accurate. For example, it need only be observed how different the results are in a Geissler tube from which a large quantity of air has been withdrawn, and one in which normal pressure exists when a static discharge takes place therein. Now, the rapid change that occurs in the appearance of the discharge from a static source, after it has been going for an instant, leads to the conclusion that a great change in the state of the atmosphere takes place and renders the nature of the discharge commensurable with that in a partially exhausted Geissler tube. The resistance of different degrees of vacua in Geissler tubes have been measured comparatively, but not with standards, and we do not possess any data upon which to base the actual resistance of air.

To measure the capacity of a machine by the length of the spark that it is capable of producing is erroneous, as it gives an indication of the difference in potential only, and none of the volume of the current. It appears that the intensity of the rays is directly proportionate to the volume of current, and that the penetration of the rays is proportionate to the difference in potential. From this it will be plain that an estimate of the value of a current will depend upon each factor equally. The "fatness" or thickness of the spark is the only ocular evidence of its volume that we possess, as the color depends upon other factors than volume or intensity.

In the case of coils we have one method more or less satisfactory for the determination of the strength of the secondary discharge, and that is by accurately measuring the amount of current consumed in the primary. The secondary current will bear a constant ratio to that in the primary, and theoretically they are equal. If a coil could be constructed perfect in every respect, the energy generated in the secondary would just equal that consumed in the primary; but there are elements of loss that enter into the construction of all coils that render the secondary current less than that in the primary. In large machines where there is not a great transformation effected, the loss is comparatively small; but in smaller machines, where there is a tremendous difference in the primary and secondary electromotive forces, there is a great loss, and this loss seems to increase with the size of the machine within certain limits. These losses depend upon a great many factors, among which may be mentioned distance of the secondary from the primary number of layers in the secondary, thickness of the primary, size of the core, and conditions of self-induction, and consequently condensers in the primary. The slower the rate of interruption in the primary, the higher will be the coefficient of value in the secondary; but at the same time the total output of the machine will be lessened. It is necessary to have the quickest interruptions that are at our disposal in order to get as even and nearly continuous a discharge at the secondary poles as possible. When the rate of discharge becomes rapid beyond certain limits, the core of the coil does not have sufficient time in which to become completely saturated magnetically, and then completely demagnetized at each interruption. The result is that the full inductive effect upon the secondary coil is not exercised, but the relatively high number of impulses generated in the secondary circuit renders the value of this form of discharge greater than when the slower interruptions are used.

With all of these losses and factors that render the exact estimation of the value of the current in the secondary impossible, it bears an exact relation to that in the primary, which is the same for each coil at each degree of primary consumption. We do not know whether or not the value in the secondary increases in the same proportion as that in the primary, but we do know that the value of the secondary output will be the same for the same coil, with the same primary consumption, and the same resistance in the secondary circuit. Thus, if we have a rheostat in the primary circuit capable of regulating the amount of current allowed to pass, and at the same time an ampèremeter, we can keep a record of the exact relations existing between two exposures to the ray, on the same person or on different persons.

It may be well to mention here that the amount of energy consumed in any form of electric machine, whether it be a lamp, a motor, a coil, or any other apparatus, is measured by the product of the electromotive force in volts into the amount of current in ampères, and the result expressed in watts commercially or in volt-ampères scientifically. It is evident that there is no difference in the amount of current consumption in a coil that runs on a ten-volt battery and uses ten ampères and one that is run on a hundred-volt circuit and uses one ampère. All statements concerning different results obtained in using a low or high voltage, or a high or low amperage, are false and misleading. The only way in which the amounts can be compared is, as was mentioned, in watts, and any other method may be stamped as wrong and not giving any clew to the results.

In the case of the static machine, it is true that there exists, theoretically, a constant ratio between the amount of mechanical power applied at the driving pulley and the amount of electric energy delivered at the machine terminals. In other words, the amount of power delivered by, say, an electric motor will depend on the amount of electricity consumed, and the amount of electricity generated in the machine will depend on the amount of mechanical energy consumed; now, if the machines were all perfect we could estimate the amount of electric energy delivered by the static machine as just equal to that consumed in the motor; but there are losses in converting the electric power in the motor to mechanical power, and there are other losses in converting the mechanical power in the static machine to electric power. We may arrive at a very satisfactory estimate of the amount of loss that there is in the motor, or at the amount of mechanical force consumed in the machine, but the vagaries and factors of loss and variation in the performance of the static machine are so numerous, complex, complicated, and diverse in their action, that any attempt to base the output thereof upon the value of the energy consumed can lead only to false results and confusion.

It is within reason to expect that there will be perfected coils in the future in which we may know to a certainty the exact voltage and the amount of current in ampères, or fractions of them, as compared with the same factors in the primary coil; that we will be able to know the exact power of the rays with regard to the voltage and the current in the secondary, and the vacuum in the tube; that we shall know definitely the relations existing between the currents in the secondary and the capacity of the primary. There is little or no reason to expect that there is likely to be a perfected static machine, as it will greatly increase the size, one of the great drawbacks; to increase either the volume or the length of the spark and to overcome some of the other faults will necessitate the discovery of an entirely new principle in the construction.

Care of a Static Machine. One must be extremely careful to keep the machine very evenly balanced, as at times a slight jar is apt to throw the plates out of balance, producing an undue amount of friction.

If the machine is used to any extent, it is advisable to clean the plates with ammonia-water at occasional intervals.

To keep the atmospheric state of the machine as favorable as possible as regards the amount of moisture present, we must keep several bowls of perfectly dried calcic chloride in the case, which must be changed at intervals, especially in summer, when it should be changed as often as it becomes moist.

An excellent method of drying out the machine and rendering less calcium necessary, since the latter tends to corrode the metallic fittings, is to enclose in several glass fruit-preserving jars a mixture of one part rock salt and four parts cracked ice. The lids are then securely fastened on, and the jars are placed for several hours in a pan in the bottom of the machine. As the hoar-frost forms upon the outside of the jars it can be wiped off, the jars being promptly replaced. To insulate the machine, thick plates of glass or saucers should be kept under the legs. All brass or metallic parts must be kept thoroughly dry and carefully polished.

THE INDUCTION COIL.

The induction coil consists of an electromagnet with an arrangement in series with the winding for breaking and making the circuit very rapidly, and a so-called secondary coil, that is, a coil of very fine wire closely wound around the electromagnet and carefully insulated from it.

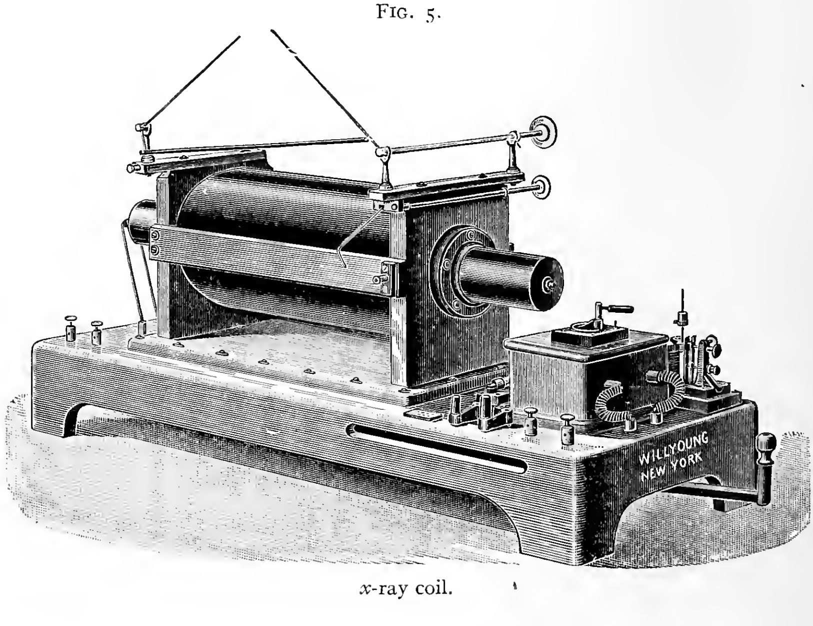
In 1832 it was discovered by Faraday that one galvanic current, when travelling in a wire under suitable circumstances, was capable of affecting another current in another wire entirely separate from the first; that it might cause a second current in a second wire entirely separated from it; and that a permanent magnet could cause a current to flow in a wire suitably arranged under certain circumstances. It was at that time known that if a wire covered with some insulating medium were wound spirally upon a piece or rod of iron, the passage of a current in the wire would render the iron magnetic, and, on the supposition that it is a poor rule that will not work both ways, Faraday assumed that if the iron in the coil of wire were magnetized by some outside source, a current would flow in the wire. This was proven to be true by an experiment which consisted in winding a length of wire upon a piece of soft iron, and then suddenly magnetizing the iron by bringing another piece of iron, strongly magnetized in proximity with the first piece. The ends of the wire were brought close together and so arranged that when the coil with its iron core was rapidly vibrated the two ends of the wire could be made to touch each other for an instant and then separate. The coil was then grasped in the hand and as rapidly as possible vibrated toward and from the permanent magnet, so that each time it approached the ends of the winding came in contact, and each time it was withdrawn the ends of the wire separated. Faraday observed that there occurred two sparks at each time that the coil was approached and withdrawn, a faint one when the wire ends separated. A further experiment consisted in constructing a coil having a hollow space in the centre into which could be slipped a magnet. The ends of the coil were connected with a galvanometer, and it was observed that when a magnet was suddenly slipped into the space in the centre of the coil a deflection took place in the galvanometer, and when the magnet was withdrawn a deflection took place in the opposite direction. This clearly indicated that there were two currents induced in the coil—one on the introduction of the magnet and another in the opposite direction—when it was withdrawn; and it was further found that the current formed on the withdrawal of the magnet was the much more powerful.

The Ruhmkorff Coil. The induction coil was invented by Ruhmkorff at a time when there was a great demand for an apparatus that would deliver currents of a high potential for exciting Geissler tubes. The coil is similar to the experimental apparatus described above, with the exception that instead of introducing and then withdrawing the magnet it is made of an electromagnet which can be made or rendered devoid of any magnetic properties in an instant by causing a current to flow in its winding and then interrupting it, and so on alternately. This arrangement, it will be seen, is much more efficient than that of rapidly approaching and withdrawing a permanent magnet, because the interruptions in the current may be made with much greater rapidity, and electromagnets may be much stronger than permanent ones.

The core of the induction coil consists of a bundle of thin iron wire bound together to form a solid rod. Wire is used because it is capable of a higher degree of magnetic saturation than a solid rod, and because the heating that generally accompany all rapid alternate magnetizing and demagnetizing is much less in a bundle of wire than would be the case in a solid bar.

The core is covered with a thin layer of some insulating material such as paraffin paper or a thin mica tube, and on this covering is closely wound the primary coil consisting of a thick and well-insulated wire. The primary generally consists of one or two layers, preference being given to the former. The whole winding is saturated with hard paraffin or shellac to ensure good insulation, and then covered with a further protection in the shape of a rubber cloth, or a tube made of red fibre, vulcanite, mica, or any other suitable material. The secondary coil consists of a great length of very fine wire, and is wound upon the primary coil which has been described. The object is to get the secondary coil as near to the primary as possible without weakening the insulation, which is one of the most important considerations in the coil. The secondary coil is not wound from one end of the core to the other as in the primary

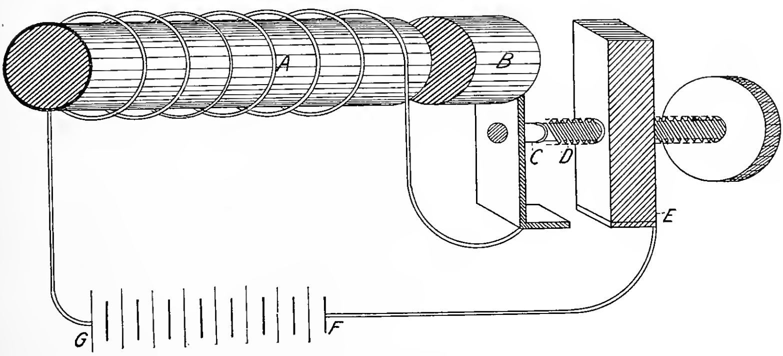
FIG. 5.



x-ray coil.

coil, but is wound in small sections, about five-eighths of an inch wide and as high as the finished thickness of the coil. The reasons for this are that the potential increases as the length of the wire, and the difference in potential between one layer at the initial end and the distal end of the next layer, which would lie just on top of it if the wire were wound from end to end of the coil, would be so great as to endanger the coil from sparking between layers, and thus rendering it useless or necessitating so much insulation as to render it very ungainly and inefficient. Another reason is that this method of winding makes it possible to take out and renew any sections that may be injured. A further advantage of the method of winding in sections is that the sections may be connected up in series and thus get an enormous potential, or in parallel of as many sections desired and then get a lesser potential, but a much increased volume. This is accomplished by having separate connections for the ends of each section, and then making the connections between these as may be desired.

Fig. 6.



Showing detail construction of primary coil, with vibratory interrupter.

How the Interrupter Works. The contact breaker or interrupter, first used by Ruhmkorff, was very simple, and while there have been many modifications of it, the most satisfactory magnetic breaks of the present day differ from the original only in minor details. Fig. 6 gives the essential features of the magnetic break. Here *A* represents the iron core of the primary coil of the induction coil and *B* a small mass of soft iron attached to the end of the spring *C*, which is fastened at its lower end to the base of the coil. *D* is a screw passing through the brass post *E*, and having a platinum tip which can be made to touch *C* when the latter is in the normal position. *G* is the positive pole of the battery, to which one end of the primary coil is attached. The current passes along the coil and around the magnet core to *C*, and thence through the screw *D* to the post *E*, and along the wire to *F*. This completes the circuit, and the core of the coil becomes at once a magnet and attracts the mass of iron *B*, which approaches *A* and drags the spring *C* away from the point of the screw *D*. This causes an opening in the circuit, and the core at once ceases to be a magnet and attract the mass *B*, which is released and permits the spring *C* to fly back and again come into contact with *D*, again completing the circuit and going through the same performance again.

At each make and break of the primary circuit there are currents in the secondary, and the circuit made on the completing of the primary circuit is in the opposite direction to the primary current and of high potential as compared with the current that flows in the primary coil, when the primary circuit is broken. When the circuit in the primary is completed the current does not at once attain its full intensity, owing to the resistance that the current in each turn of the coil meets from the current in the adjacent turn flowing in the same direction, and the result is that when the circuit is broken the current that has already flown into the coil, against the resistance, is piled up on itself at one portion of the coil, and continues to even its intensity over the whole circuit after the potential of the battery has been discontinued. The result is that the current does not cease after the circuit is broken, but continues, and on account of the high potential accumulated at the initial end of the coil is able to flow over the gap formed between *C* and *D* in the shape of a spark. This current continues to render the core magnetic and the current gradually weakens; the induced current is not formed by an instantaneous demagnetization of the core, and is therefore comparatively weak.

Self-induction. At the same time that the current in the primary coil is attaining its maximum intensity slowly, the induction that takes place between the different turns causes the formation of an "extra" current flowing in the opposite direction, and this phenomenon is known as self-induction. Self-induction has a certain value for every circuit and depends on many factors, among which is the induced current in the secondary coil (Lenz's law). As has been seen, the strength of the secondary current on the break of the primary is dependent to a great extent on the rapidity of the demagnetization of the core, and that takes place slowly on account of the resistance and subsequent delay of the current.

Condensers. Fitzeau invented a small apparatus which so effectually increased the efficiency of the coil that at the present time there are no coils in use without one of these condensers, as they are called, excepting in special cases, as shall be mentioned later. The condenser consisted in the first instance in a Leyden battery which was shunted or connected in "parallel" with the primary coil.

The condenser as now universally used is in a much more compact form than a Leyden battery of the same capacity. It consists of two sets of tin-foil plates each carefully insulated from the other, forming the two plates of the condenser. The arrangement is as follows: A thick sheet of mica is first laid on the table, and then a sheet of tin-foil, smaller in each dimension than the mica and having a lug at one side, say the left, to project over the edge of the mica. Then comes a thinner sheet of mica of the same dimensions as the last, and on this is laid another sheet of tin-foil having the lug on the right side, and so on, a sheet of foil and a sheet of mica, until the required amount is obtained. The lugs on the alternate sheets of foil are placed on the alternate sides, so that the first, third, fifth, etc., are on one side, and the second, fourth, sixth, etc., are on the other. The lugs on each side are connected together, forming the two poles. The sudden demagnetizing of the core and the buck that the current from the condenser gives to the primary current ensure a sudden break and consequently a powerful current in the secondary. The capacity of the condenser depends on the size and number of the plates, and must be accurately adjusted for each coil. There are many factors which enter into the question of the size of the condenser or rather into the self-induction of the primary, as on that directly depends the size or capacity of the condenser. The amount of current in the primary, the number of turns, the length of the wire, the rapidity of the break, and in the secondary the length of the coil, the relation of the length of wire to that in the primary, the number of turns, the carrying capacity of the wire, the space between the two coils and numerous other small details have a bearing on the result. In practice the capacity of the condenser is not arrived at by calculation, as that would be a Herculean task, but practically by trying with varying capacities, until the proper amount is reached. The coils are built as nearly alike as possible by each maker, with the result that there is a very constant quality of performance.

On the large modern coils it is customary to place an adjustable condenser, so that it may be varied with each change in the conditions.

A very interesting recommendation is made by Borden.[1] He advises the condenser of the coil to be made in sections and connected to a series of four plugs on the top of the base, by which it is possible to use any portion or the whole of the condenser at will. It will be found that some focus tubes will work best when using only a few sheets of the condenser, other focus tubes require considerably more condenser, and in some cases it is necessary to plug it all in.

Insulation. One of the first difficulties that Roentgen and his followers found with the coils then existing was that the insulation was insufficient, and that under strain the current in the secondary would spark from one turn of the coil to the others.

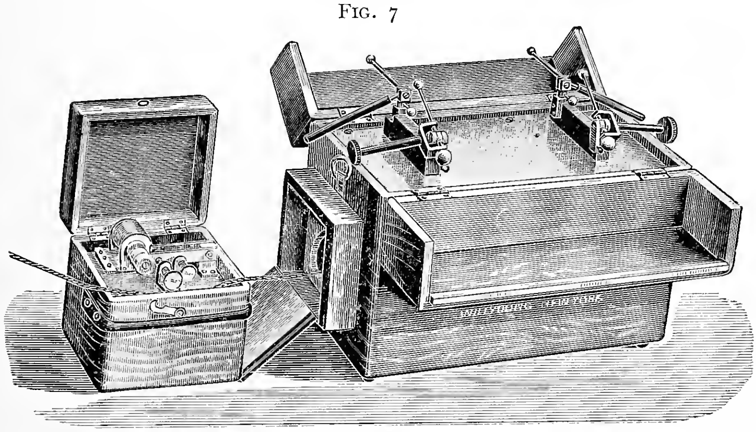
This and the other imperfections that constantly arose soon led to improvements in construction, and to-day they are so far ahead of the tubes in this respect that a comparatively small coil will be amply sufficient to run the largest and most powerful tube that can be constructed.

The primary coils are now insulated from the secondaries by the thinnest and most perfectly insulating media that can be found. Thus vulcanite, red fibre, and mica are used, the idea being to get the secondary as near to the primary as possible, and at the same time to get the best insulation. The secondary is wound in small separate coils from one-half to two inches long and of as many layers as the whole coil. These are wound separately upon spools and then finished

[1] The Use of the Roentgen Ray by the Medical Department of the United States Army in the War with Spain.

and cemented with shellac, and when taken from the spool they look like disks of wire, having a hole in the centre large enough to permit of their being slipped upon the primary coil. In the more improved forms of coils these have each their separate terminals, so that several lengths and several thicknesses of the secondary may be utilized by suitably selecting the connections. These coil disks are slipped upon the core formed by the primary with its insulating ring, and separated from each other by a glass or mica plate, and are thus very little liable to short circuit. The whole is then covered with a dust-proof case of hard rubber, and mounted upon a heavy base to ensure rigidity.

Fig. 7



Portable coil to be attached to street current.

In computing the exact amount of current consumed in the primary circuit of the induction coil Ohm's law is not altogether reliable, because when any circuit is at first completed it requires an appreciable space of time for the wire to attain the charge of maximum saturation; and when the interruption is very high the circuit never quite attains its full charge before the current is interrupted. Also, the new current induced in the secondary coil will offer additional resistance to the primary current, which resistance cannot be accounted for in terms of the resistance of the primary circuit (Lenz's law). Thus it will be evident that the only satisfactory way of determining the current consumption in the primary is by direct measurement with an ampèremeter. The interruptions being very fast and even, the instrument does not have time in which to drop back to the zero point after the current has been broken and before it is again made, and the result is that in the small space of time between impulses the meter remains steady and gives a mean value of the current employed.

High-frequency coils excited by a series of currents of rapid oscillation are represented by the Kinraide type. While they fulfil therapeutic indications, the rapid alternations of the discharge in these coils do not give sufficient definition, as a rule, for good radiographic work.

Some of these coils are attached to portable apparatus supplied with storage cells, which has the advantage of being used in the patient's own house. These should contain at least from four to eight cells in order to supply sufficient voltage. Charging at a battery charging station is necessary from time to time, although a charge can be supplied from a primary battery or from the street main. Such a storage-cell portable apparatus is seen upon the right in Plate I.

TUBES.

How the Ray is Produced. The apparatus required in the production of the *x*-ray consists essentially of a vacuum tube of one form or another, and an electric apparatus for exciting the same by means of a high-tension electric current. The tubes are usually some modification of the type perfected by Sir William Crookes in his endeavor to demonstrate and validate his theory of radiant matter, at the time so bitterly combated by Lenard and other Continental physicists. In the original form the tube with which the rays were first produced and demonstrated consisted of a globe having fused into its substance two or more metal bodies communicating with its interior. When the air or other gas within was exhausted to a high degree of vacuum, phenomena of varying natures were observable within the tube upon the passage of an electric discharge between the metal plates. In these tubes the cathode stream emanating in straight lines from the negative pole struck the glass of the tube at various points, at each producing x-radiation. Improvements have been suggested and added from time to time until in the present form all tubes consist essentially of a globe with a platinum plate forming the anode, and at the same time acting as a target for the focal point of the cathode stream. It is so inclined that the x-rays emanating in all directions from the point of impact are directed to one side of the tube.

Fig. 8.

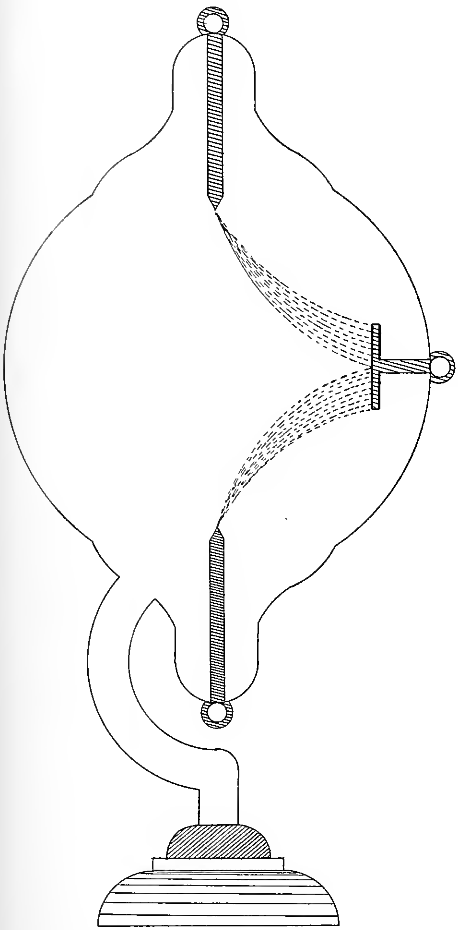
Early forms of Geissler tubes.

Opposite to the anode is placed the cathode, which consists of a concave aluminium mirror so placed that the stream will be accurately focused upon the centre of the target. It is necessary to place the target at twice the distance of the centre of curvature from the cathode. The cathode stream does not focus at the centre of curvature of the condensing mirror, but owing to mutual repellance the similarly charged molecules focus at a point found to be at about twice the distance from the cathode as the centre of curvature.

Earlier Forms of Tubes. The Geissler tube, which is the forerunner of all the tubes that are now used, consisted originally of a simple glass tube having fused into each end a tip of platinum wire. The tube was generally hermetically sealed, or was in connection with an air pump, so that the degree of the vacuum of the medium within the tube could be varied at will (Fig. 8). The object of the tube was to observe the phenomena of electric discharges of high potential in different pressures of air and other gases confined within the tube. The source of electricity was connected with the platinum ends of the tube, and the discharges took place between the tips within the tube. The tubes of Crookes were many in number and various in design, but the ones that concern the history of the discovery of the Roentgen ray are the later ones that he made and which are represented diagrammatically in the cuts (Figs. 9 and 10). The numerous plates inside of the tube could be connected up in any manner that it was desired. If one pole was connected with the negative pole of the electric generator and all of the others were connected with the positive pole when the vacuum was moderately high, the cathode stream, visible as a purplish-violet beam, would divide itself and approach each of the positive plates, no matter what its direction from the negative plate. It was observed that if the vacuum became still higher, the cathode stream would proceed in a straight line to the boundary of the glass and not follow the former path. At the position on the glass globe where the cathode ray impinged, it was noted that a most brilliant fluorescence occurred; but it was not until the subject was taken up by Roentgen that the discovery was made that a new kind of ray was generated at the point of impact of the cathode ray, and that this new ray possessed some remarkable properties.

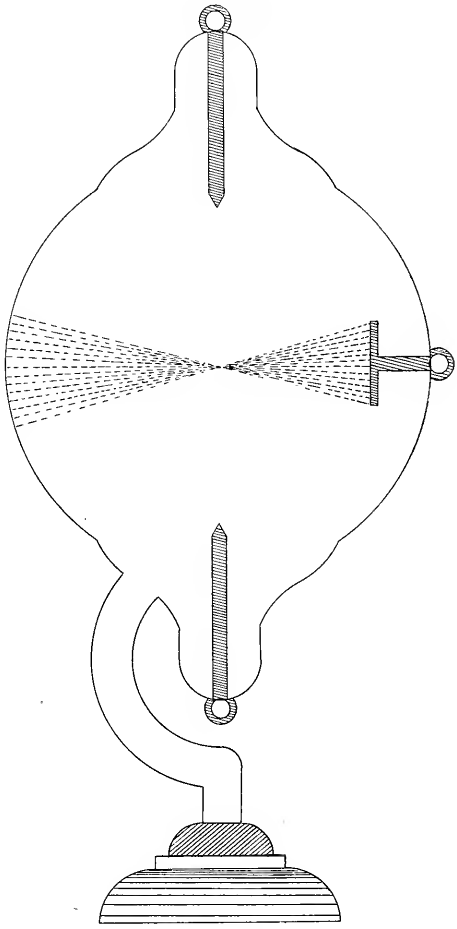
The nature of the cathode ray, as the emanations from the negatively connected pole were called, had been pretty thoroughly investigated by Crookes and more fully by Lenard, who amply disproved the erroneous theory of "radiant matter" which had been advanced by Crookes. The controversy that this started among the scientific men of the time is responsible for a great deal of the investigations that were carried on in that line, and eventually for the discovery of the Roentgen ray. The theory of Crookes is essentially that a new state of matter exists at the high degree of attenuation which he had attained in his tubes,

FIG. 9.



Crookes' tube at low exhaustion

FIG. 10.



Crookes' tube of a higher vacuum.

and the experiments that he performed to demonstrate the truth of his conception were as ingenious as they were numerous, and were the means of disclosing many facts in connection with the cathode stream that were not at the time being sought for.

The tube that was designed and utilized by Roentgen has been previously described. This was at first the form of tube that was used by almost all of the men who took up the investigations at the beginning and worked along the lines that Roentgen had laid out. As soon as the ray was in a condition to be demonstrated, and was found to be of general importance, Crookes' tube became the most widely used, as it was desirable to have a clear path from the cathode to the side of the tube where the rays are produced, and that the surface over which the rays are generated should be as large as possible. It was soon found that the large amount of energy that the cathode rays projected against the glass caused heating that resulted in melting of the glass in many cases, and that the large area that was the source of the rays caused a confusion of the image that rendered the number of applications of subjects to which the ray could be applied extremely limited.

Modern Forms of Tubes. The most important step in advance that was made in the construction of tubes for the generation of the ray was that of Mr. Herbert Jackson, who invented a form of tube in which the cathode was a convex mirror of aluminium that would accurately focus the rays in a point, and thus vastly improving the definition of the fluoroscopic and photographic images made by the rays. The fault was found with this tube that the heat generated by the intense concentration of the cathode rays was so great as to destroy the tube in a few minutes, and a metal plate was introduced within the tube at a point opposite to the cathode, so that the cathode ray would impinge upon it and there generate the x-rays. After many experiments and modifications a tube having a concave aluminium cathode and an anode of a flat plate of platinum, or platinum and iridium, was developed, and is the type of all tubes used at the present time.

It has been claimed by some operators that if the "target," as this plate has been termed, is connected with the anode of the tube the results will be much better. It is not at all certain that this is strictly the case, but at all events it is frequently very satisfactory to make the tube after this pattern for mechanical reasons, and the majority of tubes at the present time have an anode that is also the target. As a result a confusion of the terms, target and anode, has resulted, and they are often used synonymously.

It had been found by Crookes that different metals at the cathode were acted upon in a most peculiar manner by the discharges within the tube, and that many were disintegrated and small particles were torn off and driven with great rapidity in the direction of the cathode stream. Aluminium was found to suffer the least in this way, and has therefore, come into general use for the formation of cathodes.

That aluminium undergoes the same change is almost certain. In the possession of the author is a tube which has undergone much blackening. In a position upon the glass corresponding with the area of impact of the cathode ray, if it is regularly reflected, is an area of much more intense coloration than the surrounding parts, indicating that metal from the cathode follows the stream in all its course.

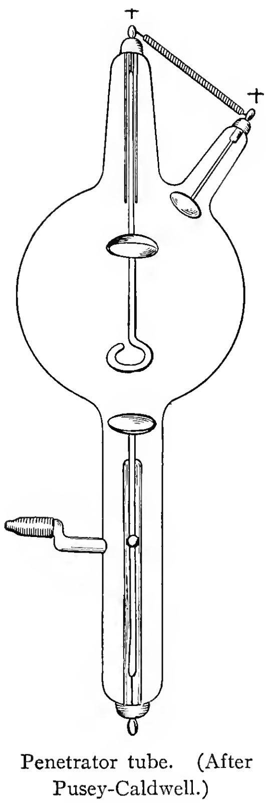
The cathode rays are capable of regular reflection, and are therefore focused by a concave mirror in the same way as light rays. This fact is taken advantage of in the designing of the Jackson or, as it is now known, the "focus tube." The cathode ray is focused upon a spot on the target, and at the point of impact the *x*-rays are generated. The target is inclined at an angle to the side of the tube so that the rays emanating from the anode are sent in straight lines.

The factors that are necessary to the perfect working of a tube are that the vacuum be properly regulated to the utmost degree; that the anode and cathode bear the proper relative positions and are of the proper metals and correct size; and that the resistance be the best for the work that is to be done with the particular tube.

The vacuum in a tube is usually produced by attaching to a regular air pump and exhausting it until a certain low vacuum is attained, when it is connected by fusing to a mercury pump of the Sprengel or Geissler pattern. When the degree of exhaustion is sufficient, the tube is sealed and is ready for use.

The position of the anode must be opposite the cathode, in the optical axis of the curvature. It is generally placed at an angle of 135 degrees to the current of the cathode stream. The size of the anode will in a small measure determine the resistance of the tube, but is not important on that account. There should be enough metal in the anode, if it forms the target, to prevent its fusing at the ordinary heat to which it is subjected. The position of the anode is a matter of some importance, as the distance from the anode to the cathode determines the resistance in the tube after a certain distance has been reached. There are certain positions in the tube, near the cathode, at which the resistance is so high that no discharge can be made to pass in it under ordinary conditions. If the anode be situated in this region it will obviously increase the resistance of the tube without regard to the vacuum within certain limits. This principle has been utilized in the "penetrator tube." In this tube the cathode is arranged as usual, and the anode is placed very near, so as to occupy the zone of greatest resistance near the cathode. The target is placed in the usual position, at the focal point of the cathode, and may or may not be in connection with the anode. To give the anode the proper area, it is usually made in the form of a ring, so situated as to allow the cathode stream to pass through it. It is especially valuable for fluoroscopic work where high penetration is desirable. The general appearance of this tube is shown in Fig. 11.

Fig 11.



Penetrator tube. (After Pusey-Caldwell.)

That the size of the cathode has an effect on the working of the tube has been shown by Mr. A. A. Campbell Swinton, who after thoroughly investigating the subject came to the conclusion that there was nothing gained in making the cathode of larger diameter than 1.125 inches for use on coils of about 10-inch spark, and that they should not be smaller than 0.375 inch in diameter for fear of the heating effects of the current. Smaller sizes may be used with smaller coils.

It is impossible to say that the thickness and diameter and radius of curvature of the cathode should be this or that. The conditions in each case govern the circumstances of dimensions. It is customary, however, to make the cathode about one and one-eighth inch in diameter and less than one-eighth inch thick. The diameter of the curvature is generally one-fourth that of the bulb in which it is designed to work.

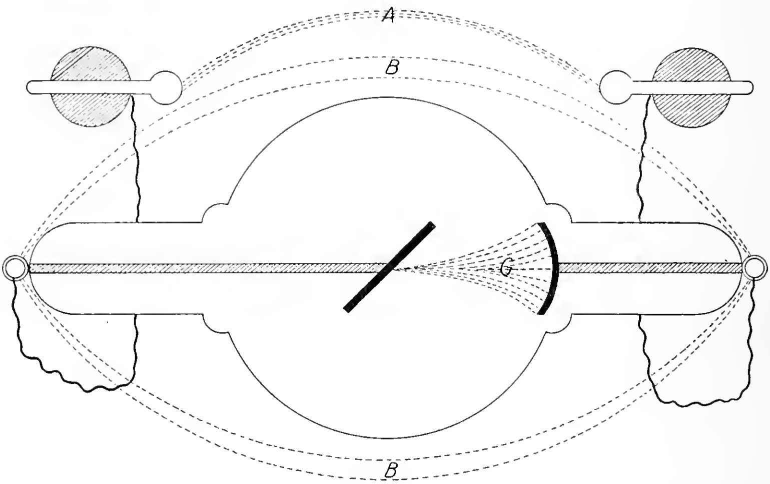
The condition of the tube for use in radiotherapy is of the utmost importance, as upon this, to the greatest extent, depends the results obtained, assuming that the patient is always treated with the same source of power.

DEGREES OF VACUUM.

Tubes are described as high or low, according to the degree of vacuum within them. A low tube is one in which the vacuum is low, 2 mm. being about the lowest vacuum or conversely highest pressure at which *x*-rays can be generated. A high tube is one in which the vacuum is extremely high, and may be so high that no current under any attainable pressure can be made to pass. Thus, it will be seen that the terms high and low are distinctly relative. For general usage, however, certain rough standards have been accepted.

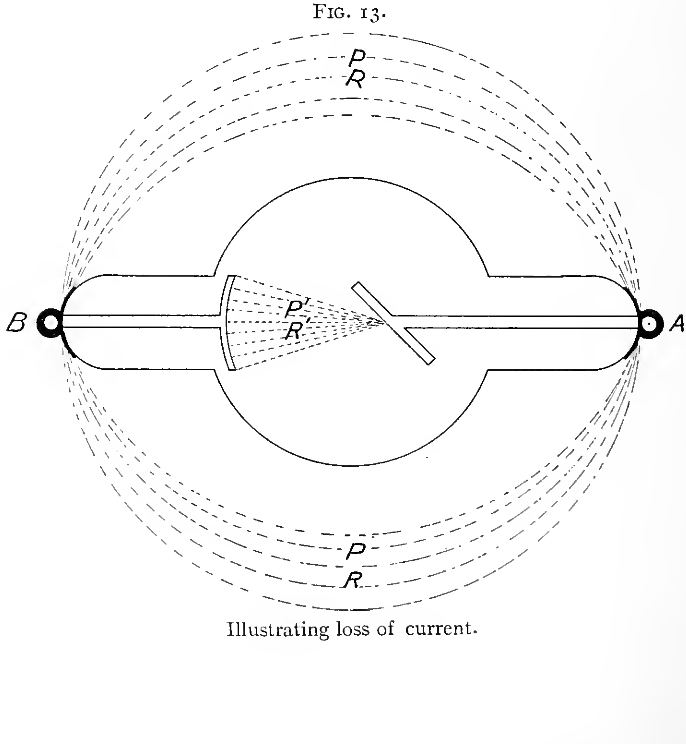
Roentgen divides tubes into two classes: hard or high, and soft or low. This does very well *per se*, but as the point when a tube ceases to be high and becomes low is not stated, it is of no use where fine differences are essential, as in radiography. On the general principle that the electric current will always follow the path of least resistance, it will be readily seen that in any tube only part of the current will go through, part will travel across the air space between the outside terminals of the tube, and part will

FIG. 12.



To illustrate current passing through air and poles of tube.

FIG. 13.



Illustrating loss of current.

escape across the air space separating the two terminals of the source of energy. The amount passing in each of these circuits will vary inversely as its resistance to that of the other circuits (Fig. 12). The circuit between the terminals of the machine should be as long as possible, and therefore the amount of current passing therein (A) may be ignored. Let us assume, then, that all of the current passes from one outside terminal of the tube to the other, then part of the current will pass around the tube in the air (B) and part within the tube from anode to cathode (G). Now, in the same tube, if the vacuum be progressively raised, the ratio of current passing within the tube to that passing in the outside circuit will vary in inverse proportion as the resistance in the two circuits vary, it being understood that the resistance in the air path is constant.

Thus, in Fig. 13, if the resistance from A to B outside of the tube is equal to R, and the resistance from A to B within the tube is equal to R', and the difference in potential between A and B is equal to P, then the current passing outside the tube from A to B will be expressed by $\frac{P}{R}$ and the current flowing within the tube will be expressed by $\frac{P}{R'}$ and the total current C flowing from A to B will be expressed by

$$\frac{P}{R} + \frac{P}{R'} = C,$$

and the ratio of the current passing through the tube to that passing without the tube is expressed by

$$\frac{\frac{P}{R'}}{\frac{P}{R}} = \frac{R}{R'}.$$

Now, if the vacuum, and consequently the resistance, within the tube be increased until it equal $R' + n$, then

$$\frac{P}{R} + \frac{P}{R' + n} = C' =$$

amount of current passing from A to B when resistance within the tube is increased to $R' + n$.

$$C' < C,$$

$$\frac{\dfrac{P}{R}}{\dfrac{P}{R'+n}} = \frac{R'+n}{R}.$$

Thus the quantity of current passing within the tube will bear a definite ratio to the quantity of current passing between the terminals without the tube, which will vary inversely as the resistance within the tube to that between *A* and *B* without the tube. The resistance without the tube will be constant for any tube under similar conditions of atmosphere; but as conditions of atmosphere may alter the value of *R*, it will be seen that with an exciting current of constant value any tube may act very differently at different times irrespective of any change in the value of R′.

A tube whose vacuum is so high that a considerable portion of the current passes around it and a smaller amount passes through would be called a high tube, and thus when a much greater portion of the current passes within the tube and a comparatively small amount passes around, it is a low tube. It should be borne in mind that a portion of the current is always conducted around the tube.

Williams has devised an ingenious method of keeping this inevitable outside circuit of as high resistance as possible, and thus keeping the outside current as low as the conditions will permit. This consists of making a tube in which the ends are so long that the distance from one terminal to the other in air is as great as the principles of construction will permit. These tubes are a little difficult to handle, and on account of the long ends are apt to break easily.

An advantage of employing high-frequency currents to excite the tube would be that the patient would have the added benefit of these outside currents.

Classification of Tubes. The general classification of tubes is essentially as follows:

Low. Tubes that give an image of the hand, that when viewed with the fluoroscope shows little or no difference in the densities of the soft tissues and the bones. The whole hand resembles a silhouette against the illuminated part of the screen.

Medium. Tubes that give an image of the hand in which the soft parts appear to have a density of about one-half that of the bones, and the latter do not appear quite opaque.

High. Tubes that give an image in which the bones and soft parts seem to vary very little in density, both appearing to be very diaphanous to the rays.

Besides these tubes, which are within the limits of usefulness, there are tubes so low that the passage of the current does not result in the generation of *x*-rays, and still others that are so high that no strength of current within the limits of attainment can be made to traverse the tube.

Generally speaking, the strength or rather the activity of the rays generated in any tube is directly proportionate to the strength of the exciting current, and that differences in the tubes of different patterns have comparatively little effect upon the resultant rays. This may be demonstrated by taking two tubes of very different size and design, but of the same degree of penetration, and making two equal exposures, one with each tube running in turn on the same source of power and under the same conditions. If the tube in each instance is the same distance from the plate, the plate is the same in each case, and the object photographed is the same each time, the two pictures will be so nearly alike in strength and density that they may be called identical. This must not be construed to mean that a large tube will not give any more rays than a smaller one, because the larger tube may be excited to a greater degree, and thus will produce quicker results. The small tube will reach its limit of capacity before the large one, but if they are both excited with the same amount of current, the results will be the same.

It is generally supposed that the penetration of the rays depends upon the potential difference in the exciting current, and that the intensity or quality of the rays are more directly dependent on the volume of the current. While this is in a measure indirectly true, a consideration of the steps that have led up to the conclusion will show that it is an unsatisfactory means of expressing the conditions.

The strength or energy of the tube will equal the product of the penetrating quality and the intensity or quality of the rays produced. The degree of the vacuum of the tube will determine the resistance of the tube, it being higher as the resistance of the tube is increased. This is true only after a certain limit is attained. As the resistance of the tube is increased the amount of voltage required to transmit a current in the tube is proportionately increased, and the quantity of current that will pass at any voltage is lessened in the same proportion (Ohm's law). If we have a source of current, such as the static machine, whose potential difference will increase until it is just sufficient to overcome the resistance that is placed in the circuit, then on placing tubes of different resistances in the circuit, with no air gap or other resistance, there will be one potential and only one at which discharges will take place in that tube, and if the machine is run faster the only difference that takes place in the nature of the phenomena within the tube will be due to a lessening of the internal resistance of the machine, and not to any change in the voltage of the current. On the other hand, in a coil, where under any given conditions the voltage of the secondary will be constant, the amount of current passing in any tube will depend on its resistance, and the voltage for any tube will be the same instead of changing with every change of resistance as in the static machine; therefore, it will be seen that the tube that is naturally fitted for high penetrating qualities will require a higher voltage to operate, and the lower or less penetrating tube will naturally on account of its lower resistance permit a greater quantity of current to pass under similar pressures. If a long spark be used on a low tube, the penetration of the tube will not be materially changed, as the energy in the tube will be constant, viz., the penetration or voltage of the current into the volume. Where a static machine is used and the terminals are set for a spark having a resistance of five inches in air, or of say ten inches, if a tube be connected after the machine is running, then if the length of spark is again measured by means of the spark gap it will be found that the actual spark in the tube is five inches, and the result would have been the same if the machine had been started at any other length of spark. Where a coil is used, the result of using a long spark on a low tube is merely to increase the intensity of the rays and not to render them any more penetrating.

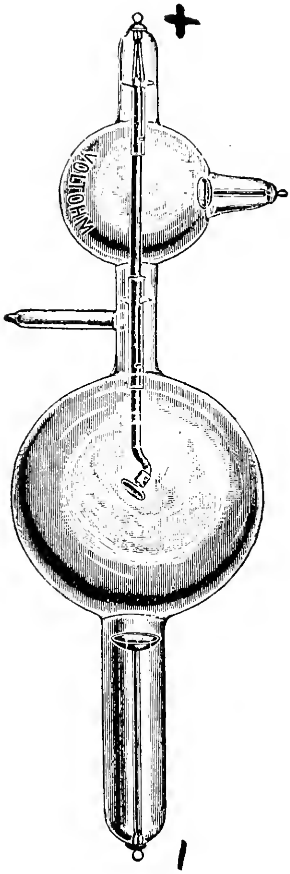
The ideal tube, according to what is at present understood of tube construction, is one that will (1) preserve a constant vacuum; (2) that will run for an indefinite length of time without overheating; (3) in which the rays will emanate from a single geometric point; (4) in which the angle of greatest intensity of radiation of the rays will be such as will render these rays available in the direction of greatest convenience without interference from other parts of the tube; (5) in which the material of the tube will not be fluorescent to the rays, and thus ensure freedom from one element of false light; (6) one that is composed of a material that does not absorb any of the rays; (7) one that is imperishable during any length of service.

The first requirement is not possessed by any tube *per se*, for it is the nature of the vacuum to change with every change of temperature, and the glass and metal parts within the tube are capable of absorbing gases under certain conditions and liberating them under others. Also, the nature of the metal of which the cathode is composed exerts an effect on the ultimate result. Crookes found that certain metals, as gold, platinum, etc., suffered a gradual dissolution if placed in communication with the cathode in the tube, and small particles of these metals followed the stream from the cathode and were later deposited on the glass of the tube, where they absorbed some of the air still remaining in the tube, as is well known platinum will. It was supposed that aluminium did not suffer the same change, and this accounts for the almost universal use of this metal for the cathodes of modern tubes. The tubes thus equipped are subject to a similar deposit on the glass in all positions where the rays impinge, and in a slight degree in all parts of the tube. It has not as yet been demonstrated what the exact nature of this deposit is, whether particles of the cathode or of the anode at the point of impact. It is said that Mr.

Snooks, formerly connected with one of the large manufacturers of *x*-ray apparatus, analyzed this deposit and found it consisted of metallic oxides.

Many steps have been taken in the direction of securing constancy of the vacuum, and at the present time, while the object is not completely attained, there are tubes on the market whose vacuum can be very accurately regulated.

Fig. 14.



Double-bulb tube.

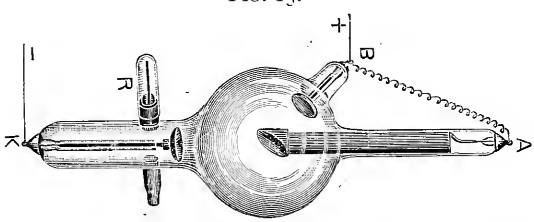
Enlarging the size of the tube with the supposition that the larger volume will render the ratio of air absorbed to the total amount insignificant has less effect than might be supposed, and as the area of the glass is increased in proportion to the volume, it is clear that the amount absorbed is increased in very nearly the same ratio. At all events, tubes of large size are practically little or no better than the smaller ones in the matter of maintaining an equal pressure within.

Bianodal Tubes. The introduction of a second anode to the tube has been very widely adopted by the largest manufacturers, for the alleged reason that tubes thus constructed are less variable and are more readily regulated because of the property of the metal to absorb and give off gas. This seems of more importance than the concentration or intensification of the rays by the double disk.

Double-bulb Tubes. A double-bulb tube at present on the market is shown in the accompanying illustration (Fig. 14). This tube is said to have a very steady vacuum, owing to the fact that the second bulb contains an amount of air condensed in the glass sides that is given up to the first bulb very slowly as the latter becomes more and more exhausted. The additional advantage is claimed that it will operate no matter in which direction the current flows through it, and can be used with high frequency or other apparatus of alternating discharge.

Regulable Tubes. It was recognized almost from the earliest use of tubes that the vacuum increased very rapidly as the tube was used, and efforts were made to discover a means of remedying this fault. Aside from uniformly heating the tube and thus liberating some of the gases held in the walls, the first method used was to fuse into the main tube a small tube containing a quantity of caustic potash and sealed at the outer end, while the inner end communicated with the interior of the larger bulb.

FIG. 15.



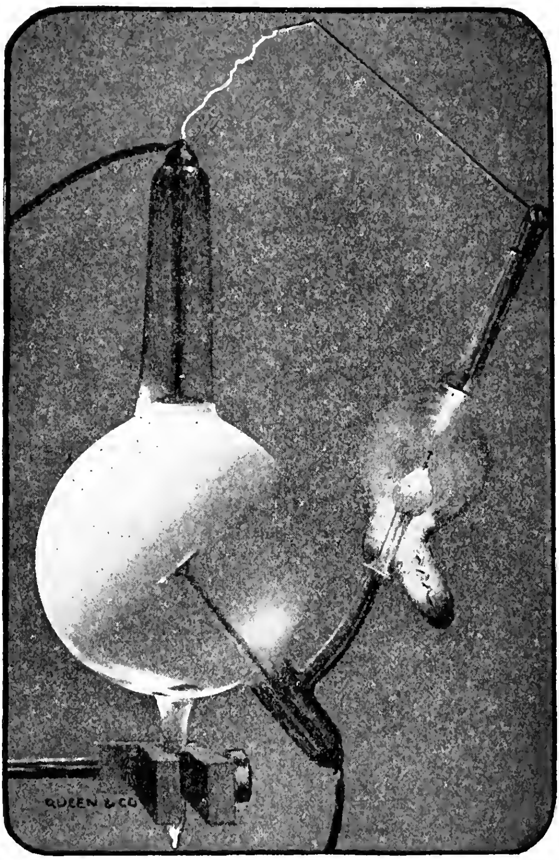
Gundelach tube with heavy anode for radiographic work.

The caustic potash in the small tube was maintained at a red heat by means of a small lamp, while the bulb was being exhausted, so as to cause it to give up the small amount of vapor it contained. When the exhaustion in the bulb had progressed to a certain point, the smaller tube was allowed to cool, and in so doing it absorbs the last trace of moist vapor in the tube. When the tube becomes too high, the annex containing the potash is heated by applying a lamp or by causing the current to enter the tube through a platinum wire embedded in the potash and fused into the glass, and thereby causing it to give up some of its contained moist gas, again lowering the vacuum.

The most commonly used type of this tube is that devised by Müller. It is very much like the preceding, but contains a piece of palladium wire as seen at *R* in Fig. 15, fused through the small tube instead of containing caustic potash.

The tube is filled with hydrogen before it is exhausted, to the complete exclusion of all of the atmospheric air. The palladium is kept cold while the tube is being exhausted and sealed. The tube depends for its action upon the fact

FIG. 16.

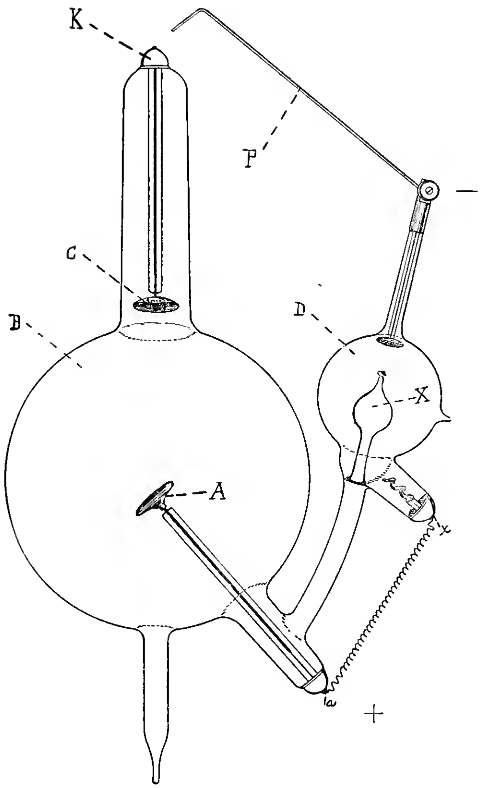


Queen self-regulating tube in action.

that palladium possesses the peculiar quality of absorbing 960 times its own bulk of hydrogen at ordinary temperatures and liberating it when heated.

Self-regulating Tubes. The preceding type of tube has been developed into an exceedingly ingenious self-regulating tube, which has the faculty of liberating some of the gas in the potash automatically whenever the vacuum in the main tube becomes higher than a certain previously set mark, and discontinuing the liberation of the gases as the vacuum assumes the normal. Of these tubes, the Queen self-regulating is a very good example, and as the principle in all

Fig. 17.



Details of a Queen self-regulating tube.

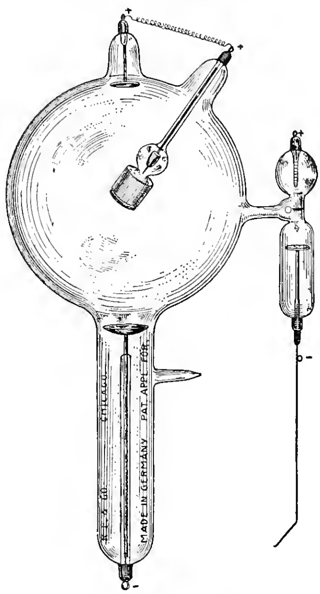
of them is the same, a description of one will answer for all (Figs. 16 and 17).

The tube may have one or more anodes. It consists of a tube of ordinary appearance, with which there communicates another smaller tube of somewhat peculiar construction. This small tube is in turn surrounded by, but does not communicate with, a small focus tube (*D*), and occupies the position of the target. The cathode of the tube *D* is accurately focused on the tube *X*, and when it is excited the cathode stream will impinge on *X* and cause heating of the contents, which may be caustic potash, as explained above. The metal arm *P* is movable, so that its end may be made to touch *K*, the negative attachment of the tube *B*, or separated therefrom to any distance. A wire connects the anode terminal of the tube *B* with the anode terminal of the tube *D*. The positive terminal of the source of current is connected with the wire, and is thus in electric communication with both anodes. The negative terminal of the current source is connected with the arm *P*, so that it is in connection with the cathode of the smaller tube only.

Now, when the machine is started the current has two courses that it can travel: one from the anode *A* to the cathode *C* within the tube and from the terminal *K* through the air gap to the arm *P* to the negative pole of the machine, and the other from the anode to the cathode in the smaller tube *D* and thence to the negative pole. It is well known that the current will take the course of least resistance, and if the resistance within the tube *B* from *A* to *C* plus the air gap from *K* to *P* is less than that in the tube *D*, the current will take that course. If the tube becomes higher in the course of operation (that is, if the resistance increases to the point that the course within the tube plus the air gap becomes greater than that in the tube *D*) then the current will immediately follow the course in the tube *D*, and the result will be that the tube *X* will become heated from the impact of the cathode stream, and the contents will give up some of the gas into the tube *B;* this will continue until the vacuum in the tube *B* is again so lowered that the resistance becomes less than that in the tube *D*, and the current will resume the former course. By varying the length of the air gap the resistance can be made of any desired value, and the resistance within the tube *B* will adjust itself so that the current will always pass that way. The tube, as a whole, will be highest when the air gap is eliminated and lowest when the air gap is increased to the utmost limit, and between these the range of degrees of penetration will be all that may be required.

Complex as the description of the working of these tubes may seem, the adjustment is very simple and satisfactory in actual application. It may seem that the tube would stop working as soon as the vacuum changed and continue only when the adjustment was complete; but stopping rarely takes place, and the tube runs steadily with no apparent fluctuation. At the beginning, sometimes, when the tube is cold, it takes a few minutes to attain a good working condition.

Fig. 18.



Regulating tube.

Another variety of regulating tube is that supplied with an extra cathode placed in a separate annex containing a metallic disk of dioxide of carbon, which gives off gas when the current is passed through it, lowering the vacuum very rapidly.

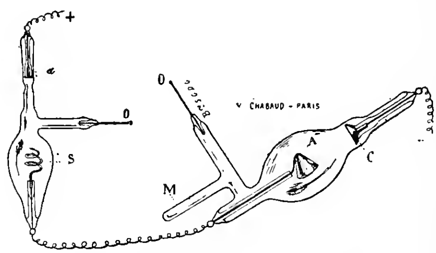
In a similar outside glass chamber is a spiral of platinum, which by giving off minute particles of platinum when the positive pole is attached raises the vacuum, but in a much slower way than it is lowered. The anode is made of varying thickness, according as the tube is designed for one or the other form of exciting apparatus.

Chabaud-Villard Osmo-regulateur Tube. This type is growing daily in popularity in Continental Europe. On a recent visit to France I found scarcely any other tube in use. By heating a platinum wire fixed into the bulb, hydrogen gas is driven into the bulb, lowering the vacuum. In order to raise the vacuum a metallic tube is placed over the projecting platinum wire, and the outside of this tube is heated in the flame of a Bunsen burner. The gas is now forced in the opposite direction. This description applies equally to the Gundelach tube of German manufacture. The regulation is based upon the law of osmosis.

Blue Tube. Friedländer has constructed a tube of cobalt-blue glass from which the radiations are claimed to be more powerful than from the ordinary tube. Since willemite fluoresced more brilliantly than in the rays of the ordinary tube, it was at first thought that ultra-violet rays were given off. This radiation was proven, however, to be due to the x-ray alone, or at least not to the ultra-violet, since it could not be reflected with either a plain glass or concave mirror. The rays would also not penetrate rock-salt.

Tubes for Treatment in Cavities. Caldwell, of New York, introduced a tube in which the object is to get the point of generation of the rays as near to the point of utilization as possible, and thus secure great concentration, at the same time rendering it possible to apply the rays to cavities of

Fig. 19.



Osmo-regulator tube. (Villard.)

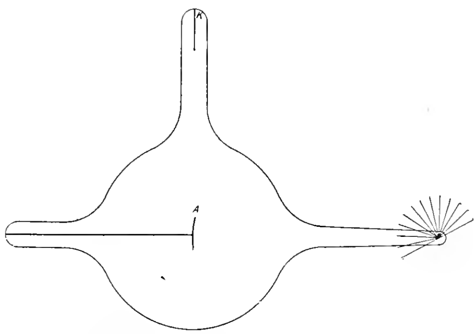
the body without penetrating the superimposed healthy parts. The greatest use of this tube is in the treatment of cancer of the larynx, as the direction of the ray is at right angles to the extended arm. A further use is for cancer of the cervix, when it can be reached by the end of the tube.

The disadvantages of the tube are that they must be run very much below their normal capacity, as all of the heat that is developed will be absorbed by the closely adjacent tissues Another disadvantage is that there is no method of confining the action to any particular locality, as the rays will cover a large area, and no means are at hand to afford protection where the whole field is hidden in some recess of the body.

In a general way it may be said that this variety of tube has not given great satisfaction.

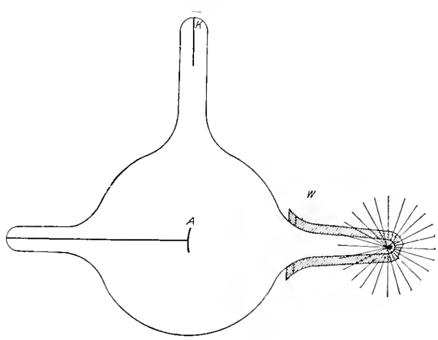
In the tube shown in Fig. 20 there is no anti-cathode, the glass at the end of the tube acting in that capacity. The rays emanate in the directions shown by the lines in the cut, and it will be seen that they are not absorbed in

FIG. 20.



Caldwell tube for treatment in cavities.

FIG. 21.

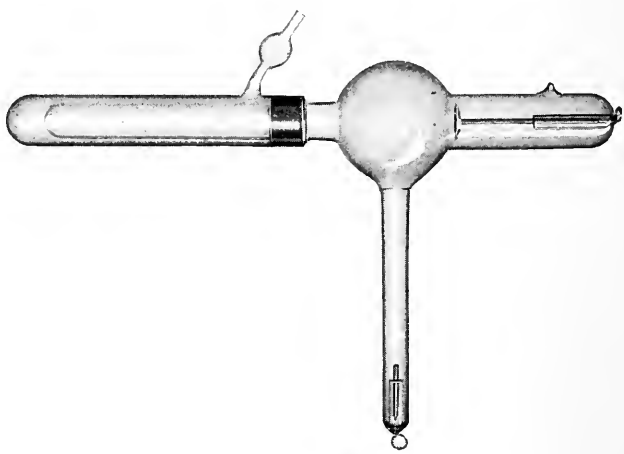


Same as Fig. 20, with water-jacket.

any direction by any part of the apparatus. This tube was designed for treatment of cancer of the uterus and other cavities. A water-jacket, shown in the illustration (Fig. 21), is applied to the tube to absorb the heat generated at the point of impact and prevent the end of the tube from melting.

The tube has the advantage of great concentration of the rays at the point of utility, but the disadvantages greatly outweigh any benefit that might be derived therefrom. The water in the jacket gets so hot in a short time that treatment must be discontinued; this is not helped appreciably by having the water circulate. The rays emanate on every side, so that no part of the tissues escape from their action. Besides this, the water in the jacket will absorb a certain amount of the rays, which can be ill afforded, and the heating is excessive even when the tube is operated very conservatively.

FIG. 22.



Improved Caldwell tube.

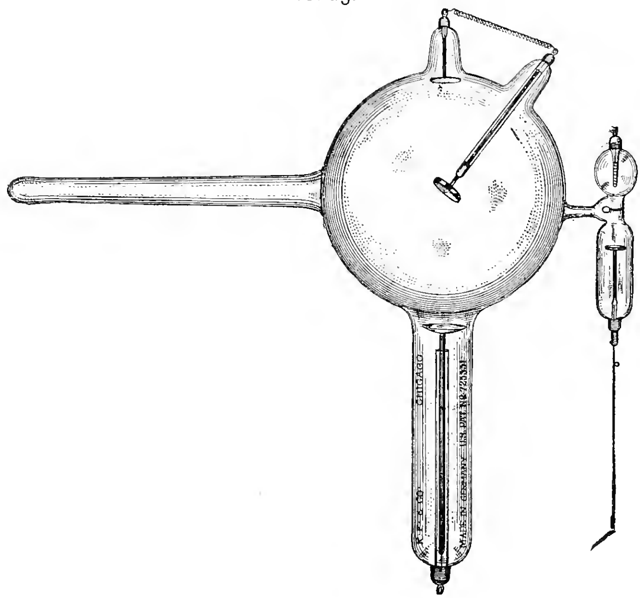
An improved Caldwell tube is seen in Fig. 22; it has the advantage of doing away with the tube-holder.

Another variety of this tube manufactured with a regulating attachment is seen in Fig. 23. This has the advantage that the vacuum can be regulated with ease.

Another form of tube for the treatment of cavities is seen in Fig. 24. This tube is made of lead glass, which does not permit the x-rays to pass through, with the exception of the tip of the projection, which is made of ordinary glass. The extension at the other extremity of the tube is for the purpose of enabling the operator to hold the tube while it is in operation.

Heating of the Tube. The second essential of a perfect tube, that of remaining cool within safe limits, was of the

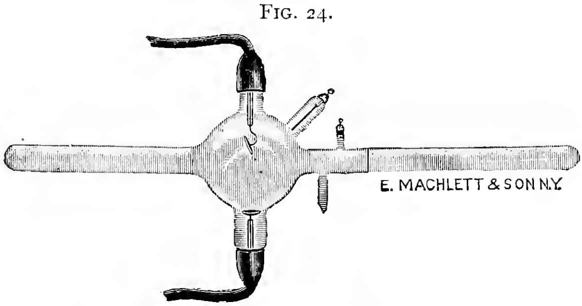
FIG. 23.



Friedländer's tube for internal treatment.

greatest importance in the days when the glass side of the tube formed the anode, and it took very little heating to

FIG. 24.



Tube made of lead glass for the treatment of cavities.

melt a hole in the tube and ruin it. At the present time, however, the method of constructing the anode of an almost infusible metal and the material reduction in the duration of all forms of exposures have rendered the question of overheating one of rather theoretical than actual importance. At the same time it must be admitted that there are occasions when, in order to secure the desired amount of rays, the current must be pushed to a dangerous point.

The first step in the direction of securing a safe tube was taken only after the invention of the focus tube, when it was found that, while a comparative immunity from overheating existed in the old Crookes tube, where the cathode ray struck the glass over an extended area, in the concentrated condition the cathode ray generated so much heat that the glass was not safe. Almost immediately after the introduction of the concave focusing cathode, the infusible target was introduced into the interior of the tube, and different metals were tried until platinum was hit upon as the most generally suitable.

Metals for Anode. Platinum was not altogether satisfactory, as it is found that if the cathode stream is focused too finely or if the tube is operated too long or too strongly, there is a great risk that the target will have a hole fused in the spot where the rays impinge. Different means have been tried to overcome this wasteful and dangerous tendency in the targets, and many metals and other substances have been employed. Osmium, which has never been fused at any temperature, was introduced by Mr. Mackenzie Davidson, and proved of the utmost satisfaction in his hands and in others who tried the metal; but for some reason the tube thus equipped has fallen into disuse, and is now rarely to be seen.

A second method was the employment of a support for the platinum anode that would conduct the heat from it and at the same time dissipate it into the surrounding space. This was accomplished by having a large mass of copper in contact with the anode, and depending upon the conductivity of the copper and the large area exposed to cause the desired radiation. Most tubes are now made with a copper stem to support the target, with this object in view.

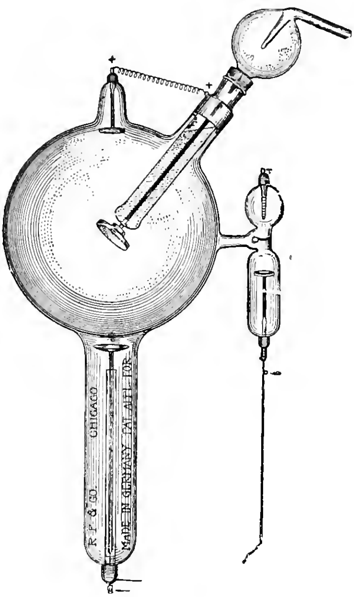
Besides platinum the anode can be made of iron and steel especially hardened. The surface should be as highly polished as it is possible to make it. It has also been made of selenium iron, and there are various other secret methods of preparation causing gas to be given off which tends to keep the vacuum stable.

At the focus point of the cathode stream the anode target may perforate through, due to too strong a current. It has been sought to obviate this by making the target so that a slight jar of the tube will cause it to change its position so as to present a new point where the cathode ray is focused.

Water-cooled Tubes. Tubes have been introduced in Germany in which the anode is supported upon a hollow stem of a diameter as large as that of the anode itself. This stem is somewhat in the nature of a test-tube with a flat bottom projecting into the centre of the tube, and to the outside of the bottom of which is attached the anode; the upper end of the tube is open and communicates with the air. If the tube is started, and the stem of the anode filled with water, the heat that is generated in the anode will be absorbed in the water and dissipated by the evaporation that takes place at the open end of the stem. This form of tube is very complicated, and although the cooling is very perfectly done the additional expense of manufacture and the liability to breakage do not warrant the general adaptation of these tubes (Fig. 25).

The Centre of Radiation. The *x*-rays will be generated at the point of impact of the cathode stream, and if that point is small the centre of radiation will gradually approach the dimensions of a point. This is the generally accepted explanation of the facts. Lately, however, Gocht, of Berlin, has shown that in tubes in which the anode had been perforated the *x*-rays were generated in almost undiminished quantity, although almost all of the cathode stream passed through the hole thus formed. His conclusion is that the rays are generated in a ring around the area impinged upon by the cathode stream. If the rays are given off over a rather large area, the image formed by such a tube will lack sharpness and the finer details will be rendered inaccurately or not at all. The smaller the area from which the rays are given off, the finer will be the definition and the detail in the resulting picture. If the point at which the cathode stream comes to a focus be accurately determined and the target be placed at this point, then the conditions of definition will be the best that can be had for that tube. There are certain reasons for not placing the target as near to the focal point of the cathode as is possible, the first of which being that at this point the heat developed will melt any ordinary platinum target at present in use. Further, it is not absolutely necessary that the target be placed at the exact mathematical centre of the focal point of the cathode stream, as the definition falls off in a very much smaller ratio than the heat, and at a small distance from the centre the definition is very little affected, while the heat falls off in a marked degree.

Fig. 25.

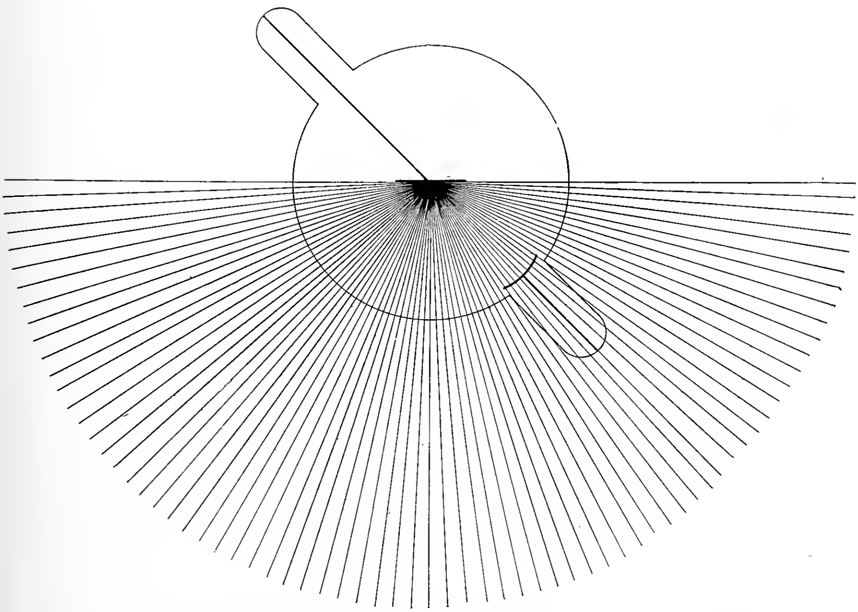


Water-cooled regulating tube.

It is only essential that the point of radiation be kept small in the tubes that are for use in diagnosis and radiography; the tubes that are for therapeutic use need not be so accurate in this detail. If the point be not so small, the number of parallel rays over a given area will be greater and the tube consequently more efficient. The size of the area over which the cathode rays act upon the anode may be determined by observing the gradually heating up. The small area referred to will heat up first; or it may be observed on the screen by interposing a sheet of thick lead-foil having a minute pinhole punched in the centre.

The Angle of Greatest Intensity. It is generally supposed that the rays at the target radiate into space in every direction equally, and that the rays are given off in the manner indicated in Fig. 26. It is known that the rays at the margin of the hemisphere of the total rays that are emitted by the target are weaker or less in number than at the line normal to the centre of the target. Now, it has been shown that the rays from a surface are stronger at the centre, and fall off or decrease as the angle of the ray to that of the central ray increases. It has been further shown that the strength of the light decreased as the cosine of the angle and the relative strength of the light at any point is roughly shown

Fig. 26.



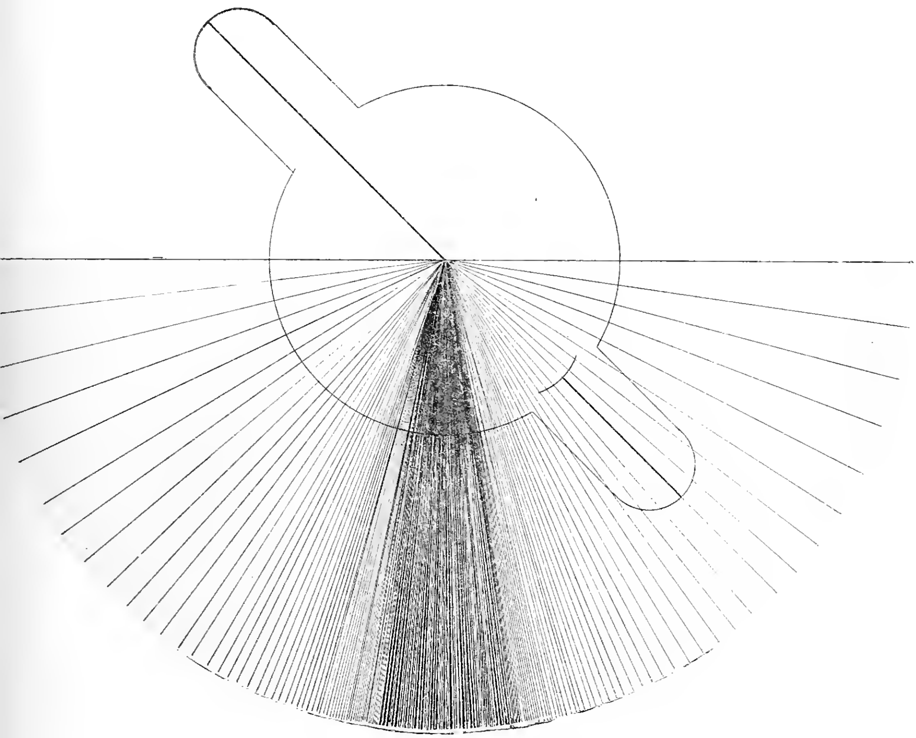
Illustrating the generally accepted but erroneous conception of distribution of the rays.

in the cut (Fig. 27). There have been no exact measurements of the relative intensities of the rays at the different angles from the central perpendicular ray in the case of the x-ray, but it is evident to the most casual observer that the intensity of the rays decreases as the angle to the central ray is increased. The exact ratio in which this decreases is not yet determined, but we are justified in assuming that the ratio is roughly similar as that of light, especially as the ray is now being regarded as a form of vibration in ether similar to the vibrations of light. At all events, whatever the rate of decrease in the strength of the radiation from the central point outward, it is certain that the rays that emanate from the centre of the cathode, in a direction perpendicular to its surface, are the most powerful, and it seems advisable to utilize rays as little removed from these central rays as the case will permit of. The best use of these rays is prohibited in the tubes of the ordinary pattern, as their utilization brings the cathode end of the tube nearer to the patient than is safe or convenient. It also entails some inconvenience to the operator in the proper adjustment of the tube for any particular use. The most useful rays, coming as they do in a diagonal direction from the tube, often render considerable thought necessary in the proper arrangement of the tube in making an examination or a picture. Also in certain forms of shields it is impossible to so arrange the tube that these rays can be readily used.

A new form of focus tube devised by Dr. Milton Franklin, has for its essential feature the difference in position of the target and the cathode.

The rays from the target in the focus tube now in use do not emanate in all directions with equal intensity, but follow the same rule as light waves from a flat illuminated surface, and are the strongest in a line at right angles to the surface, and steadily decrease at every increase of the angle of obliquity. In the case of illuminating rays, as is well known, the decrease is as the cosine of the angle, and in a direction corresponding with that of the plane of the illuminated surface, the light becomes *nil*. In the case of the x-rays it can be assumed that the rule would be the same if the rays came from a geometric point, but on account of the size of the area from which the rays emanate, there are some rays at the plane of the anode. The greatest intensity of the rays is, as in the case of light rays, in a direction perpendicular to the plane of the anode, and in a line passing through the point on the anode at which the cathode stream impinges. It is therefore very inconvenient, in the tube of ordinary construction, to utilize these rays, on account of their direction being away from the centre of the tube and in a direction toward the cathode annex (Fig. 27). The rays of greatest intensity pass from the tube in a direction corresponding with the centre of the free side of the bulb, and the strength of the rays at any angle to the right or left of this centre will be the same. In aiming the rays at any part, an exact indication of the

FIG. 27.

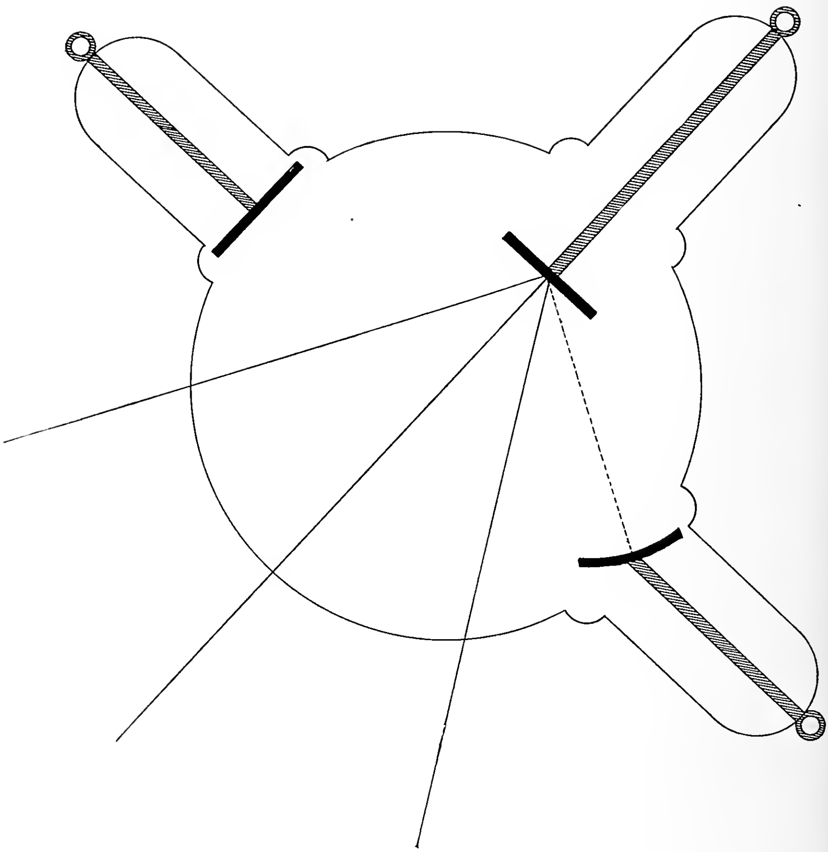


Illustrating the field of greatest intensity of the rays.

direction of the most powerful rays can be obtained from the annex through which the target support is directed.

The annex through which the target enters is placed midway between the other two provided for the second anode and the cathode, and the plate of the target placed at right angles to its stem, presents a plane at right angles to a line passing through the free boundary of the tube midway between the anode and cathode annexes. The cathode is inclined to its stem in an angle of about sixty degrees, so that the cathode stream impinges upon the target at an angle of about thirty degrees.

Fig. 28.



Dr. Milton Franklin's device for focus tube.

We are indebted to the *Journal of Cutaneous Diseases* for the accompanying cuts as well as for that of the Stelwagon shield in the succeeding chapter.

Radiations at the Surface of the Tube. The fluorescence of glass to the x-rays causes brilliant light to be visible at the point where the rays strike the glass of the tube on their way through. This light is often of a decided disadvantage in making screen examinations, as it quite illuminates the room and interferes with the perfect viewing of the screen. Besides this, it is within the range of possibility that these rays may in some measure interfere with the results obtained in making radiographs, as they may possess some penetrating qualities not yet determined which influence the plate, causing the blurring often found, and the lack of definition. The difficulty may be obviated by making the tube of such a glass that the fluorescence is of a different and less brilliant color. Red has been tried in this way, since it is not active photographically, and does not interfere with the observations made directly. Another way to cut off all light which does not interfere with the x-rays is to coat the tube with some paint that is not of too dense a composition. This may easily be done. Lampblack mixed with boiled linseed oil to the color desired will answer admirably. A window may be left in the back of the covering to render possible the examination of the parts within the tube. This is the advantage claimed for the blue tube previously mentioned.

Absorption of the Rays by the Tube Wall. In the earlier tubes the desire to attain sufficient strength in the tube often led the manufacturers to use dense and thick glasses, which had a marked absorptive effect on the rays. This has now been remedied to a very great extent. Tubes are now made of such light transradiant glass and of such thinness that they scarcely interfere with the ray's passage.

The Life of the Tube. The length of service yielded by a given tube depends upon various factors entering into its application and its manufacture.

A tube that is used steadily will not last as many hours as one that is used intermittently. A tube that is used for long exposures at each time will not last as long as one that is used for shorter exposures. To secure long life a tube should be given occasional rests. A high tube will not last as long as a low tube, taking the terms relatively.

Tubes degenerate and spoil in a variety of ways. They become leaky so that they will not retain their state of vacuum for any practical length of time. These tubes would best be discarded, as they require too frequent pumping to be useful.

Tubes burn out—*i. e.*, they become perforated at the point on the anode where the cathode stream impinges. No method of remedying this, excepting the careful use of the tube, has proved practical. The use of thick targets is a safeguard to a certain extent. It costs more to mend such a tube than to buy a new one.

Tubes perforate from being too high. They also perforate from having a conducting surface brought too near to the tube surface while a current is passing through, thus causing the spark to perforate the glass.

Tubes become opaque from long usage. The minute particles that are torn from the anode are deposited on the glass and render it at first of a purplish color and then black. When a tube has acquired so much of this opacity as to interfere with the ray's passage it is useless, but it usually perforates before this. Perforated tubes may be usually repaired and repumped.

The cheapest tube may give excellent ray, while the most expensive may prove unsatisfactory. Personally we have had more satisfaction from having on hand a large supply of inexpensive and uncomplicated tubes than from attempts to do all kinds of work with adjustable tubes.

Breakage of tubes has relatively decreased of late, due perhaps to a better appreciation of their frailties and knowledge of ways to avoid injurious overwork, as well as because of the improvements in their manufacture by employing a finer grain of sand, enabling the blower to produce a tube thinner, evener, and freer from lead or other metal. Thuringian glass is said to be practically free from metal. The tendency of the tube to expand soon after it becomes energized from the heat generated has caused a number of breakage accidents, when the tubes were held in tight clamps which would not allow of sufficient expansion. Rubber or leather straps offer here an advantage over unyielding wooden clamps.

In the tube-holding shield which is figured elsewhere, elastic bands are used. Sudden changes in the temperature of the room in which the tubes are kept is a source of breakage that should not be overlooked. When a tube has been running for some time and has become heated, if the room is cold the tube may collapse as soon as the electricity is shut off. In the experience of the authors, tubes have collapsed with loud report and without the least warning, even when they have been standing at rest in their stands unmolested, hours after use. Taylor and others report like occurrences. In an instance related by Biddle, of Detroit, his assistant's face was badly cut. The current was not turned on at the time. Still, tubes may explode while running as well as after being a long time at rest, as we have seen, and this furnishes a strong argument for enclosing the bulb in a box-like arrangement to prevent injury of patient or operator from the myriad of minute fragments which fly off in various directions. Differences in the temperature by varying the pressure are frequently responsible. Anodes become perforated from overheating, and this, in many instances, renders the tube useless; but frequently does not interfere with its efficient working. New platinum anodes may be placed in these tubes. Tubes occasionally, though rarely, develop a condition which, for want of a better term, may be called porous, in which they get continually lower, and cannot be pumped into a satisfactory condition of vacuum.

Resistance of Tubes. The resistance of the tube depends upon the degree of the vacuum, primarily, and secondarily upon the position of the anode as related to the cathode.

It is impossible to maintain a constant vacuum in any but a self-regulating tube while running. Much has been said of maintaining a balance between the generation and radiation, but no one has as yet demonstrated that it is possible to do so.

While it is true that tubes grow continually higher with use, occasionally the reverse is true, the tube growing steadily lower. These vagaries are various, and cannot be annotated nor classified. When a tube is too low to produce x-rays, the cathode stream is readily visible as an orange-violet luminosity.

The vacuum may be lowered by wrapping the tube in cotton and baking in an ordinary cook oven at a temperature of 350° F. for from thirty minutes to ten hours. Another method, not to be recommended, is to hold the tube in the hand and subject it to the greatest heat of a lamp that the hand can bear for ten minutes. Müller tubes are lowered by heating the end of the palladium wire that protrudes from the tube. Other adjustable tubes are lowered by passing the current through the annex containing chemicals. A bianodal tube may be lowered by detaching the anode from the anticathode and attaching the positive wire from coil or static to anticathode and run until vacuum is lowered.

Without spark gap, and on high amperage as some coils require, when some tubes are used they are ruined by the drawing out of the gas from the metal terminals within the tube, thereby raising the vacuum beyond all repair.

There must be a certain amount of gas in the metal, and this once driven out makes re-exhaustion very difficult. The extra terminals act, as it were, as gas-storage tanks. This reserve gas enables one to pump the tube to a point of greatest working efficiency.

When tubes get so high that they are filled with fluorescent ring fluctuations, giving a very unsteady glow, they can be regulated to a certain extent by arranging a condenser on the outside of the tube, consisting of a piece of cardboard lined with a sheet of lead or tin about six inches square with a small hole in the centre. This is slipped over the terminal of the anode, which is then connected up in the usual manner.

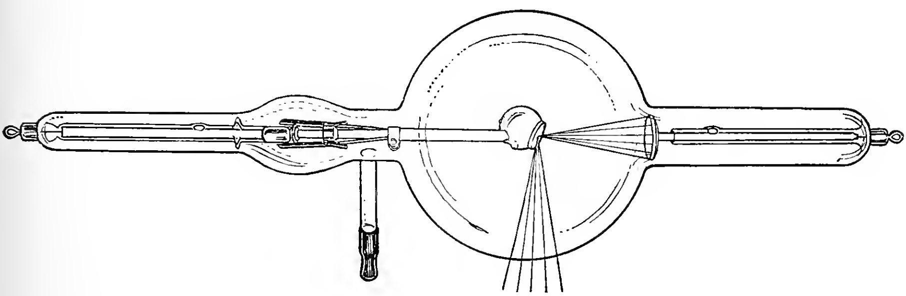
If a tube is too low it may be raised by running for a few minutes on a static with an open-spark gap, or by using a multiple-spark gap.

The simplest method of raising the vacuum in a tube is by passing the current through it in the wrong direction—*i. e.*, from anode to cathode—by attaching the negative wire to the positive pole.

Extremely low tubes can be made to give moderate penetration by connecting Leyden jars in multiple, or by inducing Leyden-jar current.

Luminosity in Tubes. M. S. Leduc, in a paper read before the Association Francaise, at Boulonge, says that a Roentgen tube after working remains luminous in the dark, with a uniformly distributed white light. This luminosity can be started afresh by heating the tube, and is maximum at a particular temperature. It is not due to rarefied gas in the tube, for the result is the same even when the tube has become filled with air. The glass of the Roentgen tube before being used does not present this phosphorescence; it is an acquired property, apparently due to the action of high-tension electricity. The property is lost on repeated heating.

FIG. 29



Wagner tube.

Adjustable Focus Tube. Dr. Wagner,[1] of Chicago, has devised a target whose position can be changed at any time (Fig. 29). This is accomplished by having the anode mounted on a threaded stem which can be magnetically operated through the glass so as to move the anode up or down or circumferentially with the surface of the tube. The platinum on the anode is especially fortified at the focus, and is electrically welded to the metal forming the body of the anode. This the author claims will enable it to stand an unusual degree of heat and unlimited usage, even with the sharpest focus.

[1] Journal of the American Medical Association, March 26, 1904.

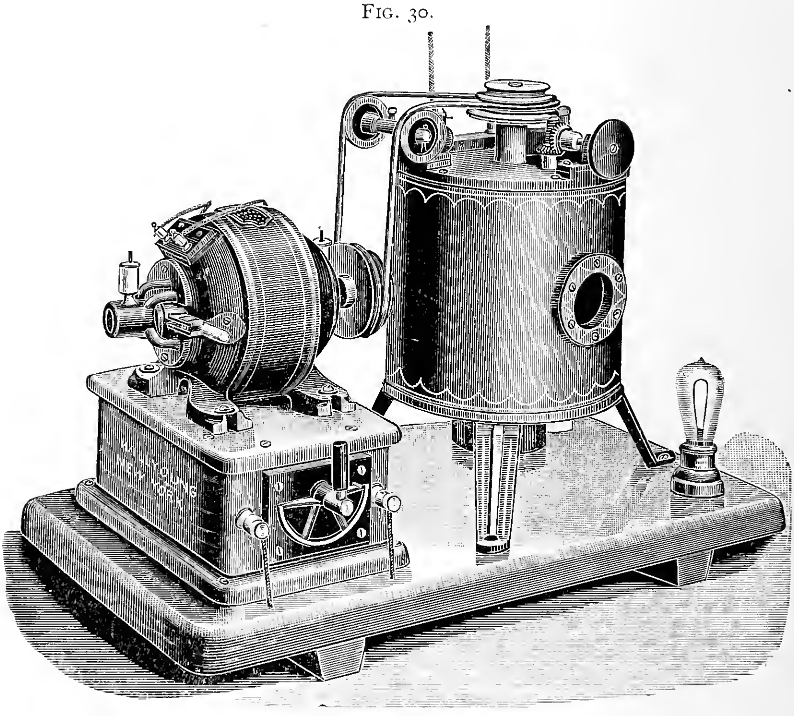
ACCESSORIES.

Interrupters. These are instruments for making and breaking, that is, for interrupting the primary current.

The chief obstacle in the employment of most of them is the fact that it is necessary to use a current of high voltage, which wears them out rapidly.

They are divided, according to the principle which is at their basis, into (1) mechanical, (2) electrolytic, (3) mechanico-electrolytic, and (4) thermo-electrolytic.

FIG. 30.



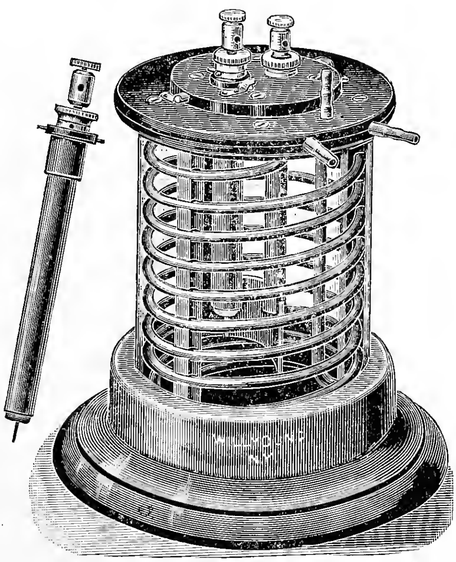
Mercurial interrupter.

The mechanical interrupters make and break the circuit through a metallic contact. One of the simplest and best of these is the slate-wheel interrupter, which breaks and makes the circuit by coming in contact with a copper segment.

The interrupters which are perhaps the most used are the mercury interrupters, a form of which is the apparatus devised by Levy, in which an Archimedean screw pumps up and forces out laterally the mercury through tubes. The mercury strikes the fingers of a rotating metallic disk connected with one of the poles, but insolated from the other. The current is interrupted as the flow of mercury passes from one finger into the other.

The Cunningham is similar to the Levy interrupter, but differs from it in that here the screw and arms revolve while the fingers are stationary on their insolated segment.

FIG. 31.



Wehnelt electrolytic interrupters. (Willyoung-Cunningham type)

A favorite in England is the Mackenzie-Davidson interrupter. In this machine the contact piece is rigidly attached to the shaft of a motor. This shaft is placed at an angle arranged so that at each revolution the contact piece dips into the mercury.

The electrolytic interrupters may be placed directly on the 110-volt circuit, making and breaking the circuit very rapidly and producing a powerful secondary discharge.

The one constructed by Wehnelt consists of a glass tube through which passes a small platinum wire, a very small portion of which projects through the sealed end of the tube. This is immersed in a mixture of sulphuric acid and water, which also has a lead plate dipping into it. The platinum wire is connected with the positive and the lead plate with the negative end of the supply current, thereby completing the circuit.

The current is broken by a bubble of hydrogen passing through the opening interrupting the circuit. In Crane's modification there is a short but thick platinum wire inserted in the end of a glass tube, from which it is separated by a piece of rubber tubing. A copper wire connects with the platinum through the medium of a layer of mercury, in which the end of the platinum wire is exposed.

These interrupters cannot be used with a current below 50 volts. Their disadvantage is that they may stop working at any time.

To obviate this, Williams has been using a commutator on the circuit with the interrupter. This lessens the severe strain on the coil and tube.

There are a number of modifications of the Wehnelt interrupter on the market, but the principle on which they work is very much the same. Among these we may mention an apparatus to be used with an alternating current described by Gaiffe and Galliot. In this apparatus a platinum electrode slips easily through a porcelain tube resting upon an insulated support beneath. As the wire wears away, a new surface will be exposed by gravity, thereby assuring approximately the same amount of wire exposed at one time.

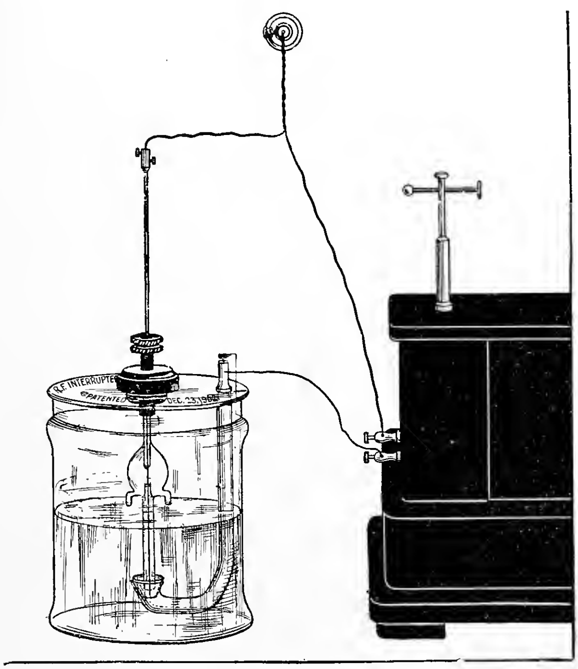
To regulate the frequency of the interruptions, the porcelain tube can be raised or lowered by means of a screw, thereby exposing a smaller or larger surface of platinum to the liquid.

Another form that has been gaining in favor is the Contremoullin interrupter. Its main advantage lies in the fact that the spark can be adjusted for any length, and that it can be used directly from the main up to 250 volts. It consists of an insulated circular plate with two metal strips around its margin, leaving two intervals between the ends. This revolves in paraffin, and the contact is made by means of two carbons, the distance between which is easily regulated, determining the length of spark obtained.

Another variety of electrolytic interrupters is seen in Fig. 32.

One of the first forms of electrolytic interrupters was the one devised by Spottiswoode, who was one of the first to observe that if a current is passed through two electrodes,

FIG. 32.



Electrolytic interrupter. (Friedländer.)

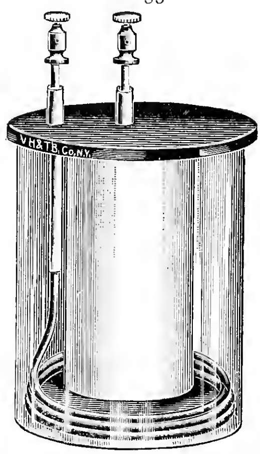
one of which had a small area, the collection of non-conducting gases over the small electrode would interrupt the current.

Among the other forms of instruments belonging to this type we might mention the Newton interrupter used with an alternating current, but which may be also used with the constant current.

The Heinze interrupter is one of the mechanico-electrolytic type, combining the slate wheel with the copper segment and the perpendicular dip interrupter.

The Caldwell interrupter belongs to the thermo-electrolytic type. In this apparatus the interruptions are produced by the tension of the current as it passes through a small opening in the partition which divides its two chambers.

Fig. 33.



The Caldwell liquid interrupter. (Loaned by Van Houten & Ten Broeck Co.)

The liquid is heated to the boiling point, and the bubble of steam destroys all electric connection between the two chambers.

The Bario Vacuum Regulator. This is a hard-rubber tube enclosing two terminals producing a spark gap. It is connected in shunt with a regulating tube. When the resistance through the tube is greater than across the gap, the current passing through the chemical in the tube's extension lowers the vacuum.

A sliding rod enables careful adjustment of the spark gap corresponding to any degree of vacuum.

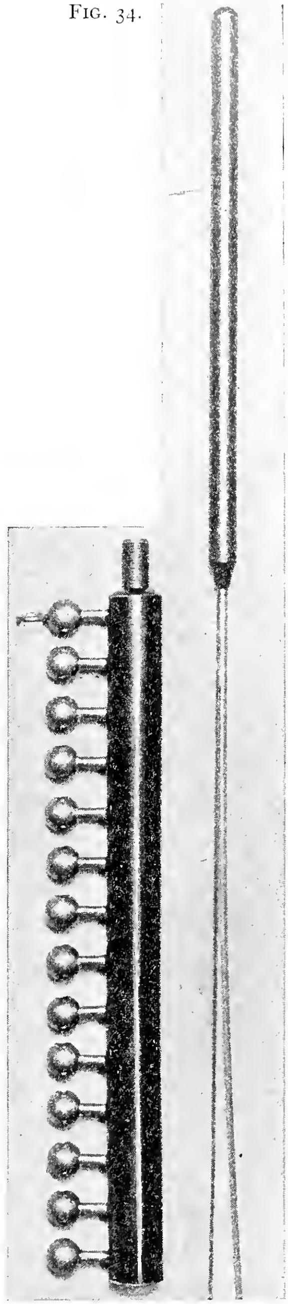
Dielectric. Pitkin, of Buffalo, has designed an apparatus on the principle that many small air gaps in series are superior to one long interval. The apparatus consists of a glass rod about twelve inches in length and three-quarters of an inch in thickness, which projects horizontally outward and forward from the arm of the positive prime conductor, between the great ball and the handle of the discharging rod. On this rod are slipped several plain brass band rings which are freely movable to form intervening air gaps. In this way the *x*-ray is greatly intensified. This spark gap multiplex is especially adapted to use with low-vacuum tubes.

Indicator of the Incidence. This consists of two metallic crosses placed one in front of the other parallel to the screen. The two shadows become one when the normal ray traverses the points of intersection. To secure this the bulb is raised or lowered on its supports.

Multiple Spark Gaps. Static machines are usually supplied with a spark-gap attachment in circuit. Low tubes often give better fluorescence with one or sometimes both spark gaps open. In the accompanying figure is shown a recent device for attaching to the insulated handle of the discharged rods.

This is based upon Williams' series spark gap. It consists of an insulating support and a sliding rod which permits any given number of gaps to be put in circuit. The effect of spark gaps in general is to decrease brush discharge, increase the penetrating qualities of

FIG. 34.



Multiple spark gap.

the ray in some tubes, and to give steadier interruptions and consequently a steadier flow of rays.

The Fluoroscope. The fluorescent screen employed for observing the ray and making examinations is constructed from cardboard or similar material, coated with the crystal of some fluorescent substance and mounted in a suitable frame with a light-excluding eye-piece. The crystals utilized, because of their fluorescent qualities under *x*-ray stimulation, are usually either calcium tungstate or barium platino-cyanide; the latter, having greater brilliancy, is mostly employed.

The calcium salt has its greatest field of utility in radiographic work.

Two fluoroscopes will be seen in Plate I., one with a Benoist radiochromometer attached.

Recently a number of operators have reported injury to the eyesight from the continuous use of the fluoroscope. To obviate this, Dr. Loring[1] suggests attaching a thick piece of glass to the back of the fluoroscope.

[1] Medical Record, October 10, 1903.

CHAPTER III.

METHODS OF ADMINISTRATION—MODES OF PROCEDURE—PROTECTIVE MEASURES—RADIOSCOPY AND RADIOGRAPHY.

POSING THE PATIENT FOR RAY TREATMENT.

While it might seem that posing the patient is a matter of small significance, it will be found upon experience that the question is one of considerable importance, and that the comfort of the patient as well as the efficacy of the treatment depends upon the skill with which the position of the patient, with respect to the tube, and the direction and control of the rays are arranged. The varied localities to which it is necessary to apply them and the impossibility of focusing the rays, often render it extremely difficult to proceed successfully.

One of the most important points in this connection is the shielding from the ray those parts which it is not desired to affect. This must be accomplished by means of shields or protecting screens, several of which are upon the market and described in the succeeding chapter.

It is also well that other portions of the body in a line with any of the rays be protected, it being remembered that the rays form a hemisphere whose centre is at the point of the target bombarded by the cathode stream and whose circumference is infinite. The method of covering the patient with metallic sheets has been used, but is, however, never entirely satisfactory, because of the difficulty and necessity of protecting the entire body, and most operators use one or the other of the numerous protecting screen devices designed for that purpose. These consist essentially of a shield of opaque material having only a sufficient opening, usually in the centre, to permit enough rays to go through to cover the area it is desired to treat. These shields have the advantage of permitting only a single pencil of ray, if desired, to pass through, whose diameter may be varied at will, and it is thus equally as convenient as a focused beam.

Any attempt at protection in treatment by the rays should be devoted to the tissues surrounding the diseased area, as any protection of the area treated can only be at the expense of the beneficial effects, because anything that will lessen the liability of burning will also lessen the liability to cure.

In the therapy of internal conditions the overlying skin can at present not be amply protected without cutting off the efficient rays. Paraffin coating, which has been recommended, absorbs a portion of the ray and makes the treatment weaker.

The Efficient Ray. In posing the patient we must take cognizance of the portion of the tube from which the most efficient rays are probably given off. In other words, we must aim the weapon. The sphere of greatest activity is perpendicular to the plane of the anode. Dr. Franklin[1] has shown this (see Figs. 26 and 27) and Rudis-Jicinsky[2] reiterates it. Recent experiments seem to cast some doubt upon this, or at least in as far as quantity of rays is concerned; but in substance the rule is a safe one to follow, especially where the tube is placed at any distance from the subject.

This is important in making the opening of the protecting shield correspond, not to the centre of the globe as now made, but rather to the side toward the cathode extremity.

PROTECTION BY SHIELDS.

Protection from Burn. There are two methods of protecting the patient from the deleterious effects of the rays with especial reference to burn: by covering the whole body excepting the portion it is desired to treat with a material which will not transmit the rays, and by enclosing the tube in a box or hood which will permit the passage of the rays

[1] Journal of Cutaneous Diseases, April, 1903.
[2] New York Medical Journal, May 23, 1903.

in a small beam whose diameter may be varied at will, and which may be directed to any portion of the body that it is desired to affect, or suspending the tube behind a fenestrated disk or metallic plate before which the patient sits or lies.

Other methods of averting burns have been suggested, depending on various hypotheses as to their causation. The most common of these is that the burn is caused by the projection of different substances, as bacilli, etc., encountered in the air by the rays, and their subsequent irritating action on the tissues. With this theory, the principle of prophylaxis, is to interpose between the tube and the patient a screen which will absorb all of the foreign bodies and at the same time not interfere with the transmission of the rays. It does not seem at all probable that a medium which does not interfere with the rays would interfere with the passage of minute bodies such as described, and at the same time there is not the slightest evidence that the rays have any appreciative impulse.

Shields of the latter sort were made of aluminium, celluloid, and of foil, but it is probable that if there was any effect from their employment it was due to lessening the efficiency of the rays rather than to direct protection. The therapeutic effect of the rays is similar to the burning effect, and any agent which will lessen the one will lessen the other in like proportion.

The method of covering those portions of the body it is desired to protect is subject to certain disadvantages.

Shields to cover portions of the entire body should be made of lead-foil, as that is the most impervious substance to the rays commonly available, and they should be fitted as nearly as possible to the part to which the ray is applied, being padded if necessary, or for the face applied over a mask of soft material. A method of shielding the face and head during treatment which is very popular, and has been very widely used, is that of forming a mask out of sheet lead or Dutch lead, a mixture of lead and tin, roughly fashioned to fit the face. This is accomplished by means of moulding the lead upon a wooden figure of a head having dimensions somewhat larger than the average human head. In this mask holes are cut to permit exposure of the various lesions to the rays. These openings can be cut so that a door-like piece may be turned back and afterward replaced and soldered up, leaving the mask practically intact for subsequent use. Around the edge of the inside of the mask, and at various other points, should be placed blocks of felt, or rubber, to prevent the metal from coming in contact with the face. Holes should be cut to admit air to the nostrils. Such masks must be carefully sterilized after each use or new ones made for each patient.

It is generally recommended to insulate the mask where it touches the skin, or to attach a grounding wire, as the tiny induction currents that are continually being generated in the shield give uncomfortable shocks or annoying tingling sensations to the patient. Sheet rubber or paper can be used.

Among other methods suggested for preventing the development of burn might be mentioned applying vaselin to the skin before exposing to the rays.

The application of methylene blue to the skin has, perhaps, as good an effect as any other of the simpler methods. A saturated watery solution or a blue collodion is used and applied by means of a swab or brush. I have never seen dermatitis occur in the surfaces thus protected.

Applied over an open ulcerating cancerous surface I have thought an added therapeutic effect was secured from the methylene medication which the author originally suggested.

Besides these, it has been suggested to cover the parts with rubber, vulcanite, celluloid, or with paraffin shields, through which the rays are allowed to pass; it being supposed that these substances intercept the element in the rays which cause the burning. Most of these methods are now but little used; still I often employ a vulcanite disk in connection with one of metal, either separated or superimposed, the rubber being next the skin. Holzknecht and Grunfeld have had made a tin protective covered upon both sides with hard rubber. It is flexible, easily adapted to uneven surfaces, and capable of being sterilized.

Pratt interposes celluloid to prevent microbes being driven in along with other impurities.

The hair may be very readily protected at the same time as the eyes, by folding a strip of sheet lead three inches wide and twenty-four inches long in a towel, and fastening about the head with a safety pin. Another plan is to apply a cap made of very thick rubber, or vulcanite; a large rubber ball or football cut in half will answer the purpose. Another simple method, possessing the advantages of economy, adaptability, and of being readily prepared, is the bandbox shield which I occasionally employ. This consists of an ordinary bandbox thoroughly covered on the outside with lead-foil and placed over the head. This gives complete protection to the head and neck, and a partial protection to the shoulders. Opposite the point it is desired to treat, a small opening is cut in the box and the lead covering, just large enough to admit the rays to the diseased area. To avoid the pressure upon the head I have suspended such a cage from the chandelier or ceiling. A separate box can be kept for each patient.

It should not be forgotten that, as Scholtz has pointed out, the strongest action of the ray is at the point of entrance and at the point of exit upon the skin. In this connection, it is well to remember that when the skin of the face is exposed to the ray the buccal mucous membrane may possibly be affected, as also the inside of the nose. When the ears are rayed, the skin upon both sides, as well as the skin surface which is apparently protected by the ear, is likely to be affected.

When the skin over the abdomen is exposed, the omentum may suffer. Exposing one side of the nose in profile may cause ray dermatitis on the opposite side. A peculiar instance of this transmitted effect or manifestation at the point of exit was that of Mr. C., whom I was treating for epithelioma upon the left side of the forehead, above and posterior to the eye. He was exposed to the rays from this side only, and suddenly developed a rather severe bullous dermatitis, which manifested itself upon the right side of his face and side of the nose opposite the tube.

In one other patient I have noticed an erythema upon the surface of the body opposite that on which the ray was given.

In a patient being rayed for tuberculous nodes in the neck by Neiswanger, the head was protected by four thicknesses of lead-foil extending over both sides like a sunbonnet. Despite this, both sides of the face were burned as though, he says, the rays had gone around the corner, and he asks for an explanation of the phenomenon.

This, I think, can be given in the same way as for my own case just related, especially since others have observed a similar effect at the point at which the rays would seem to emerge from the body. There is also a possibility of effects from objects made radio-active.

Protection of the Eye. While in treating many cancerous growths and other diseases involving the eyelids, and even cancerous growth upon the globe itself, I have found that the eyeball can, as a rule, be rayed without apparent injury; still, the lids may burn and swell readily, the lashes and eyebrows fall, and conjunctivitis may occasionally develop with prolonged exposure unless a protecting shield is used, which shuts off all rays excepting those directed to the actual limits of the disease. It is at times necessary to cover the globe when the growth is adjacent to it, as upon the lid, or near the inner canthus, as is so often the case.

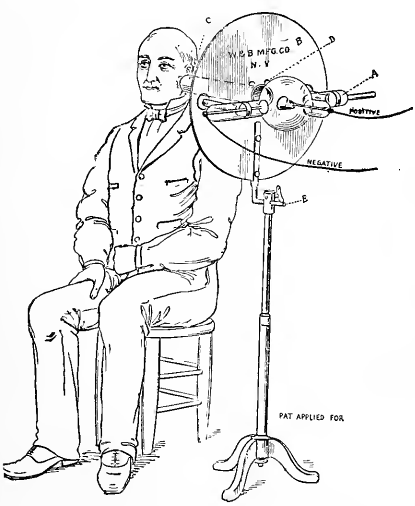
Williams has suggested soldering a piece of metal to the silver-wire instrument, such as ophthalmologists use for raising the lid. This covers the globe, while the outer shield protects the head in general.

Stationary Shields. Several years ago I suggested a funnel-shaped shield and tube-holder, combined, having slots in the sides to support the annexes or arms of the tube. This I published by describing it at the Lenox Medical Society about June, 1901. The features of the apparatus were for the tube and shield to move as one, so that the target would be always opposite the exit for the rays and that the opening for the rays to pass should have an adjustable tubal prolongation for applying the treatment to such cavities as the mouth, throat, vagina, and rectum. A shield was perfected by the manufacturers, Messrs. Waite and Bartlett, carrying out all the requirements excepting the funnel shape, which presented numerous serious obstacles.

This shield (Fig. 35) I have used constantly for about two years with much satisfaction. It is a great saving of time, as the patient has only to sit before the opening in the disk, and is also saved the discomfort of a mask or metallic covering to the body.

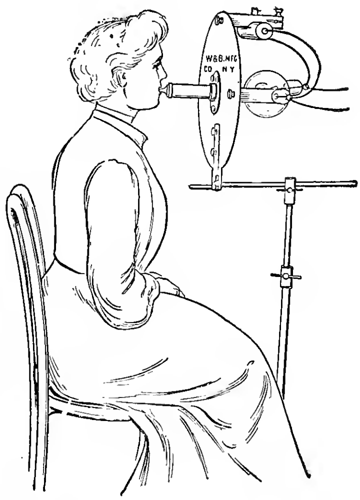
In my office I have two shields, one arranged with a large central opening and provided with hooks from which small disks with various-sized openings can be suspended; the other fitted with metallic tubes of various calibre and length for use in the various cavities of the body.

FIG. 35.



Allen shield, with ray applied to small area.

FIG. 36.



Allen shield, with rays shut off from all but a limited area of tongue or lip.

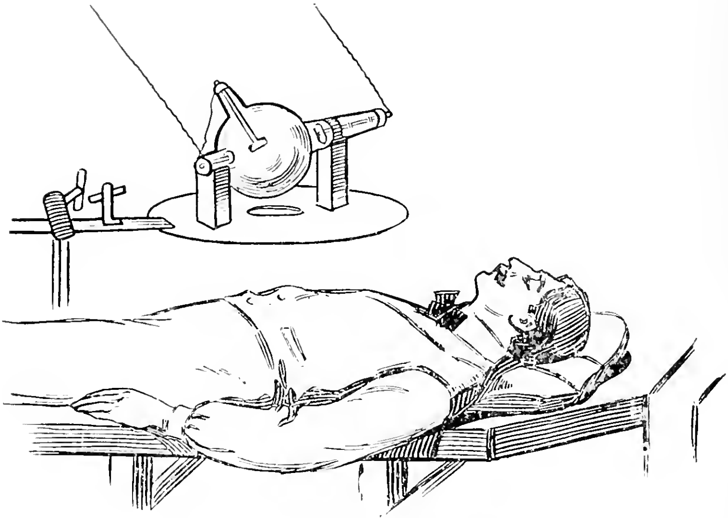
I have found the smaller-sized tubes useful in excluding the rays from surrounding parts in treating limited areas about the eye, nose, ear, tongue, throat, etc.

The advantages over masks and other devices are obvious. There is no contact or pressure, no soiling, no sterilization required, no time lost in constructing individual and temporary coverings.

Treatment can be applied to any area in any position of patient.

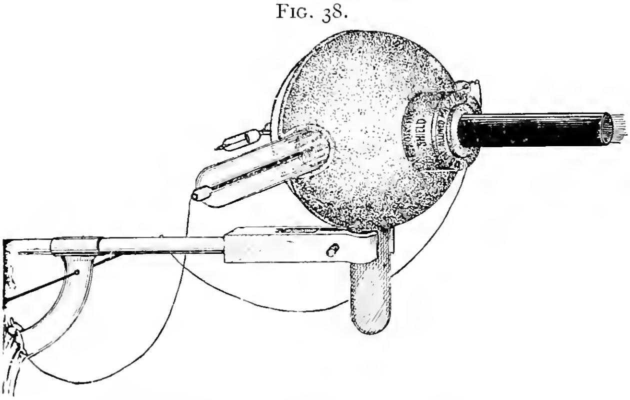
Fig. 37 illustrates the method of using the shield with the patient in a reclining position.

Fig. 37.



Vertical position of protecting shield.

Fig. 38.



The Friedländer protective x-ray tube shield in action.

In Fig. 38 is shown a hood-like tube-holder which carries out my original idea of a funnel to include the tube as one piece in a very practical way. The manufacturers, Messrs. Friedländer & Co., have kindly placed one of these at my disposal, and so far its use has been very satisfactory. It consists of some substance opaque to het rays covered with felt. Were it possible to construct the outer covering of vulcanite or hard rubber it would be better. In the earlier hoods there was sparking on near approach, but this has now been remedied. It has the advantage of protecting the operator and others besides the patient, since most of the rays are shut off.

The foil encased in hard rubber, already mentioned as being used by Holzknecht and Grunfeld for shield purposes, might be adapted to such a bulb hood. This shield will be seen without extension tube in Plate I. The chief objection to the hood is that the anode and quality of ray are not so well under the operator's eye.

Stelwagon has depicted and described[1] a shield originally constructed by Pfahler from a photographic head-rest to which a circular board eighteen inches in diameter is attached (Fig. 39). This has a central opening five inches in diameter over which three circles are arranged to make an adjustable diaphragm. This shield is constructed somewhat upon the lines of that which the manufacturers have been pleased to designate by my name. In this connection I would call attention to another similar shield, recently advertised as the "Allen" shield, which might mislead. This is a shield which was devised by Dr. Custer,[2] and while it is based upon much the same principle and possesses many excellent features, it differs from that originally designated by this name some time previously.

A glass funnel is used by Deming[3] as a shield when it is desired to expose only a small area to the action of the rays.

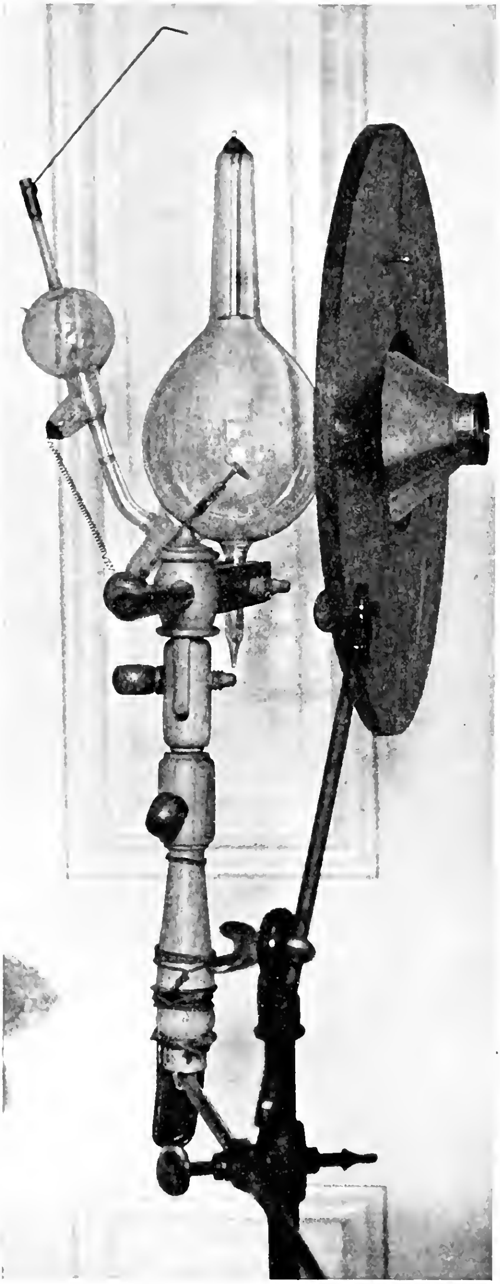
Protection of the Operator. Protecting methods for the operator should interest all ray workers, since more than one has fallen victim to cancer superinduced by the rays' injurious influence upon the skin, and the number who have suffered in various degree short of this has been legion. Thick rubber gloves, gloves fortified with sheets of lead-foil or tin-foil, or, as Stelwagon has suggested, two pairs of mit-

[1] Journal of Cutaneous Diseases, August, 1903.

[2] American Roentgen Ray Society, December 10, 1902.

[3] Fort Wayne Medical and Surgical Journal October, 1902.

FIG. 39.



Stelwagon's x-ray shield.

tens can be used, one several sizes larger than the other. The smaller is covered with foil and the second is drawn over the outside and fastened with stitches. The foil between can be renewed as often as it cracks and crumbles.

Even in standing behind the plane of the anode in supervising the treatment, the operator is often in a powerful beam, as the fluoroscope will demonstrate.

I have at times placed an ordinary three-piece room screen covered with thick lead-foil between the bulb and the coil, so that in going back and forth I would not be continually under the ray's influence.

The physician, as well as all others who are exposed much to *x*-rays, should use at least ordinary care for their own welfare. I know of no less than four instances of cancer developing in tissues irritated by the ray. I have also been consulted by many *x*-ray workers because of injury to the hands, have seen perhaps a score, and have received verbal reports of many similar accidents. Having been myself almost incapacitated for a season, I may be permitted to speak feelingly.

Besides enclosing the tube in an unradiable box, hood, or similar device, or placing a screen between the bulb and the operator, ray-proof gloves, or gloves with a supplementary back of rubber sheet one-eighth inch thick, can be worn when holding the cryptoscope or experimenting in the line of ray outflow.

Tube-makers should wear unradiable face- and hand-coverings, and during the pumping and tuning the tube should be kept in an oven with unradiable walls.

To guard against contagion from cancer patients, Rollins advises the proper fumigation of the room and the keeping of the cryptoscope and other appliances carefully sterile. He suggests using formalin vapor for fumigation, and that the instruments be made of such material that they can be sterilized by heat. He falls into the error against which I have cautioned, of arguing that cancer developing in those who treat cancer with the ray points to the contagious nature of the disease.

While I have leaned toward the contagious or infectious nature of some forms of cancer, I find little in these cases to strengthen this position. The tube-maker who developed cancer in the ray-changed tissues of his hand, and whose case I reported at the American Dermatological Association in 1902, so far as I can learn, had not come into contact in any way with cancer cases. Carcinoma or epithelioma, it seems to me, arises after irritation of the ray just as it may follow the irritation produced in a great variety of other ways. We have an analogy in arsenic given for the cure of cancer or psoriasis, as Hartzell has shown. By producing keratotic and other changes in the epidermis an irritation is set up in the tissues which favors carcinomatous changes.

An authentic instance of direct infection would, I believe, be the first on record, and would go far toward doing away with the inquiry into the causes of cancer by investigating committees.

Screen Tube-holders. The essentials in screen tube-holders that have for an object the occluding of all rays excepting those coming through a certain specified opening are: that the material be impervious to the rays, that the opening be in a position so that the rays of greatest intensity may be utilized, that the material of which the screen or box is constructed be of non-conducting nature and at such distance that there will be no sparking across the spaces within, and that the whole be perfectly adjustable so that it may be utilized in any position.

Such a tube-holder as that devised by Williams[1] consists of a wooden box mounted in an adjustable clamp upon an upright, so that the height may be regulated at will. The clamp also admits of regulating the distance from the upright to the box within limit, and revolution upon a horizontal and vertical axis. A circular disk of thick lead having a number of holes cut into its substance so as to constitute a ring of different diaphragms is pivoted at the edge of the opening in the cover through which the rays come, in such a manner as to allow any of the diaphragms to be used by revolving the disk upon its centre. The interior of the box is lined with thick sheet lead to prevent the penetration of the rays.

[1] The Roentgen Rays in Medicine and Surgery, 1902, p. 50.

METHODS OF PROCEDURE.

Method of Administration. Naturally methods of dosing and applying the ray must vary with the object to be accomplished and will be considered under each pathological condition taken up. Different observers and workers usually have settled upon a more or less routine method, as regards the time of exposure and the intervals between sittings. In a general way it may be stated that the length of exposure has been gradually decreased in recent years, and that a ray at moderate distance and for a brief time is preferred to the long exposure formerly in vogue.

In view of the decided dangers, it is far better to act upon the side of safety even at the expense of prolonged treatment or of increasing the expense. Two methods are chiefly to be considered: (1) that of making the first exposure of full strength and full length, or what has been designated a "normal" sitting of fifteen or twenty minutes, then allowing a sufficient interval to permit of visible reaction if it is to occur and proceeding with frequent short sittings; (2) that of starting in the case of a new patient with very short exposures at a distance from the tube, gradually lengthening the first and shortening the latter, and stopping at the first manifestation of decided effect. Between these extremes various modifications may be introduced. V. Lion uses medium tubes, begins with an exposure of five to ten minutes at a distance of 30 to 50 cm., gradually decreases distance to 5 to 10 cm., and increases time of exposure up to thirty minutes.

Caution. The latter sounds almost incredible, and I strongly warn against this procedure. I can scarcely imagine any condition which would to-day justify our giving thirty-minute exposures with a medium tube at a distance of 5 or even 10 cm. Oudin, in employing a soft tube, begins with half-minute exposures, increasing rapidly to five. Gaunt has given hourly sittings at a distance of twelve feet.

Naturally one turns to Freund and Schiff for guidance, since the experience of these pioneers extends over the greatest length of time, if not over the largest number of patients.

These observers advise placing the new patient at 15 cm. and exposing for five minutes, gradually lengthening to ten minutes and diminishing to 5 cm. In using low tubes the Scholtz method is followed, beginning with longer exposures and shorter distance, gradually diminishing the length of exposure and increasing the distance.

The reaction, which must be our indication for withholding entirely or greatly diminishing the strength, consists in a tingling, itching, or burning sensation in the skin, slight erythema, slight turgescence, beginning pigmentation, falling of the hair, or a decided change in its appearance. These possibilities should be enumerated to the patient, with a request to report should any of the signs occur.

We have found in our experience that a method which gave considerable satisfaction was to begin in the majority of cases with exposures of five minutes at a distance of about three inches from the surface of the tube—that is, about six inches from the anode.

The character of the tube generally depends on the nature of the case to be treated. In skin diseases we generally use a soft or a medium tube, giving a spark length not longer than four inches. In cases that require a deeper penetration we use tubes to correspond with the depth of effect aimed at in the particular case. The strength of current is, as a general rule, about three ampères for the soft tubes, and rarely above four ampères for tubes of a higher vacuum. In cases of epithelioma, etc., where we aim to get a reaction, the exposure is somewhat lengthened, but we very seldom find it necessary to extend it beyond ten or twelve minutes.

In accordance with the law that the intensity of a ray varies inversely as the square of the distance from the radiating point, but that as the distance increases the surface exposed also increases, it is advisable, if the surface to be acted upon is large, to let the patient sit at a longer distance from the tube, but also to proportionately increase the time of exposure.

The distance of the tube from the patient is a matter that has received a good share of attention. There are diversified opinions at the present time, and almost every operator of any experience has a fixed rule of his own to go by. There are operators who have a certain distance for each tube that they use, and others who have a distance for each class of disease. There are certain rules by which some operators are governed as to the distance for different types of persons, as to the apparent susceptibility to the rays.

Beck advises, when the ray is to be used for therapeutic purposes in non-malignant disease, to begin with a first exposure of five minutes with a low tube, just strong enough to show the carpus of the operator black. In a week, repeat same procedure for ten minutes. If after a third exposure and two weeks after the first no reaction is observed, then the patient may be irradiated every second or third day or even every day for ten or fifteen minutes until some reaction is seen. He places the distance between the tubal wall and the skin at four inches.

Buchanan says the tube should never be nearer than twelve inches.

In therapy Scholtz advises tubes of large volume supplied with regenerators or regulators, especially when a ray of great intensity is desired. He favors those with oil or water-cooling attachments. The distance between the two poles should depend upon the size of the bulb, varying from 5 to 10 cm. If the tube becomes too hard the current should be increased to bring the ray up to the same intensity. The only measure of the therapeutic usefulness of a tube is its proneness to burn. It has been stated the tendency of a tube to burn is not a measure of its curative strength, but we must take exception to this view. We cannot see that the ray has more than one effect on the body at one time, and it seems at least logical that the effect produced is the same whether it results in a burn, in the sloughing of tissue, or leads to the absorption of waste products into the circulatory system. Many operators at the present time are of the opinion that it is necessary to produce a burn before any therapeutic action of the tube can be manifested. There are, on the other hand, quite a formidable array of champions of the theory that a burn is a calamity under any circumstances, and should be shunned. It is probable that the production of a decided burn at any time is an indication that the rays have been pushed too far.

Many lesions, it is true, do not show any sign of reaction until the effect of dermatitis is attained. On the other hand there are a number of pathological conditions which heal or become very much better from a mild application of the rays. There is no rule which governs all cases, and there certainly are individuals who do not in the least respond to the treatment until there has been sufficient exposure to cause decided reaction. The readiness with which skin lesions or the normal skin will respond to the action of the rays will depend, in a great measure, on the idiosyncrasy of the patient, but, unlike the normal skin, the skin which is the seat of a pathological lesion will exhibit a susceptibility to the rays that apparently has no relation to the subject's susceptibility to sun burning.

Caution. Patients should not be given the ray in a standing position, as severe effects referable to the heart are at times noted, and sudden dyspnœa, faintness, vertigo, or even fainting and collapse might result.

When some trophic disturbance exists, as in various diseases of the nervous system or in anæmia or hysteria, or where there is partial or total anæsthesia, great care is necessary to prevent too severe action, on account of the conditions being so altered as to render the ordinary warning signs useless.

A growth should be exposed from as many different directions as possible. The pulse and temperature should be carefully watched, and if there is any rise, treatment should be discontinued.

Measure the fluorescence excited; this gives, according to Williams, a measure of the activity of the tube—that is, the amount of effective radiation. There is no definite rule we could formulate that would govern every case; the element of experience and effect in the given case must always remain an important factor.

Selection of Tube. The ideal tube to select in any case would be one whose rays will just penetrate the growth to be treated and no more, for it must be kept in mind that all, or at least a portion, of the rays that escape at the posterior limit of the diseased mass, are absorbed in the unaffected tissues of the body lying beyond. It is not desirable to subject healthy tissues and organs to the rays when it can be avoided. This will readily suggest that the more superficial the condition the softer will be the tube needed, and *vice versa*. Note carefully all of the factors in the patient which tend to effect the issue. The length of exposure will be given for each disease separately based upon what experience has demonstrated to be most advantageous, but the nature and size of the tubes, exciting apparatus, and the peculiarity of the patients will play an important part.

T. G. Beckett suggests that the reason why so many get unsatisfactory therapeutic results from the use of the ray is because the tubes they use are unsuitable for the work. They are mostly constructed for radiographic purposes and are, as a rule, too high for any other work.

Kienböck claims that the high vacuum (hard) tubes give exclusively electric discharges and rays of such a strong penetrating power that they pass through the body with very little effect on the skin. They penetrate with such ease that there is very little absorption and exchange into chemical energy. The middle vacuum tubes work the strongest. The low vacuum tubes somewhat less. If the vacuum is too low, then the rays have often not sufficient penetrating power to even enter the skin.

Scott, of Kansas City, uses a series of tubes, one for each day of the week, to make an average of therapeutic result.

Tousey,[1] in giving long exposures, advises shutting off the current a few times to prevent the tube from getting too hot. He thinks there is more chance of *x*-ray burn from a hot tube.

Shields, among others, claims that a new tube is more effective than an old one. Delphey advises that if we want to get good penetration the target should be brought up to a white heat.

Tubes in Series. Guthrie, of New Orleans, speaks of placing tubes in series to apply treatment to different portions of the body simultaneously.

Calling the tubes *a* and *b*—the cathode of *a* is connected with the cathode of generator, and the anode of tube *b* to the anode of generator, the anode of tube *a* is then con-

[1] New York Medical Journal, July 11, 1903.

nected with cathode of tube *b* by flexible wire. Each tube takes the current it needs and allows the excess to pass on to the other. A high and low tube will both glow simultaneously if their aggregate resistance does not exceed the sparking capacity of the generator.

Scholtz has termed rays emanating from soft tubes with small penetrative powers x_1-rays, those from hard tubes with strong penetrating powers x_3-rays, and the medium soft tubes, between the two, x_2-rays.

The Keeping of Records. I have found, and others must have had the same experience, that it is unwise to trust to the memory for the details of history, technical or other data connected with ray work. In diagnosis accurate recording, and in skiagraphic work at any time likely to be brought into court, definite details written at the time are absolutely essential. The negatives may be numbered and packed away in envelopes, the reference number being placed in history. Record books are to be preferred to cards, each patient having a page ruled for date, tube number, spark-gap distance, time, quality and quantity of ray, and remarks.

METHODS OF EXAMINING VARIOUS CONDITIONS OF THE HUMAN BODY.

The position of the patient during an examination or the making of a radiographic record should be immovable. The importance of this is made evident in any attempt to make comparisons between the conditions in different patients and conditions in the same patient at different times. To accomplish this, the simplest way is that suggested by Williams, viz., a canvas cot, sufficiently large to support the body comfortably, and of a height that will permit of tubes being placed under it at the proper distances for the different requirements. Plates may be placed upon any portion of the anatomy it is desired to make a record of, and screen examinations may be made with fair satisfaction from above or below the table. An ordinary hospital stretcher supported upon two carpenter's horses will answer the same purpose.

Owing, however, to the fixed height of the table and the absence of any lateral or angular adjustments, it is very

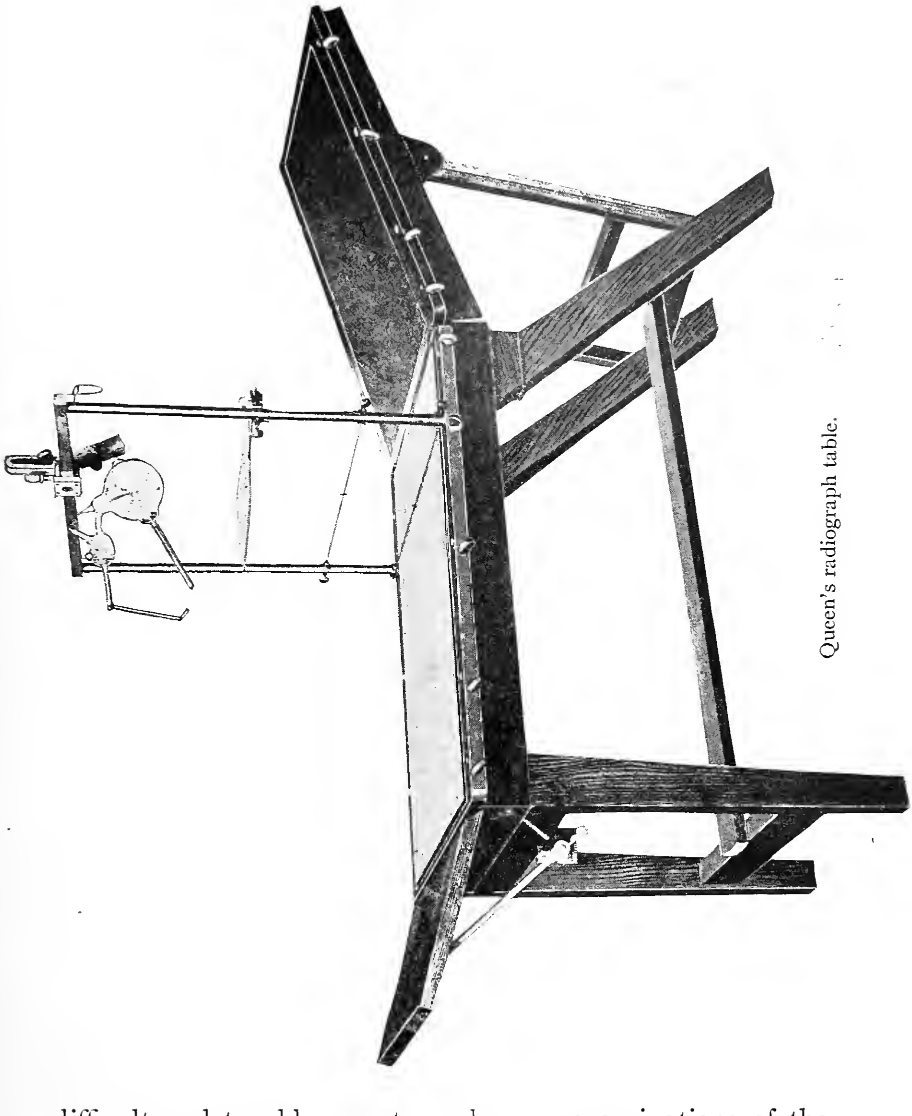


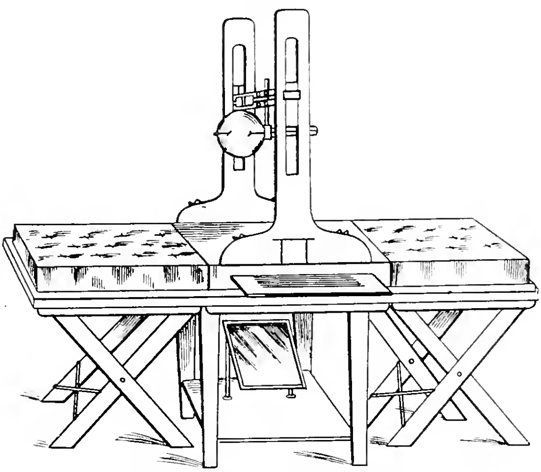
Fig. 40.

Queen's radiograph table.

difficult and troublesome to make any examinations of the patient at any distance, or at any angle other than at right angles to the anteroposterior diameter of the body. To overcome these difficulties and render all examinations more facile, several tables, more or less elaborate and complicated, have been placed upon the market.

The Queen radiograph table is a good example of a universal table. The table is jointed in the middle so that the patient can be placed in a flexed position, and examined with great ease in various directions. The most important feature is the arrangement of the plate holders, allowing the plates to be removed and replaced at will without in the least disturbing the position of the patient. This facilitates the making of two exposures wherever it is

FIG. 41.



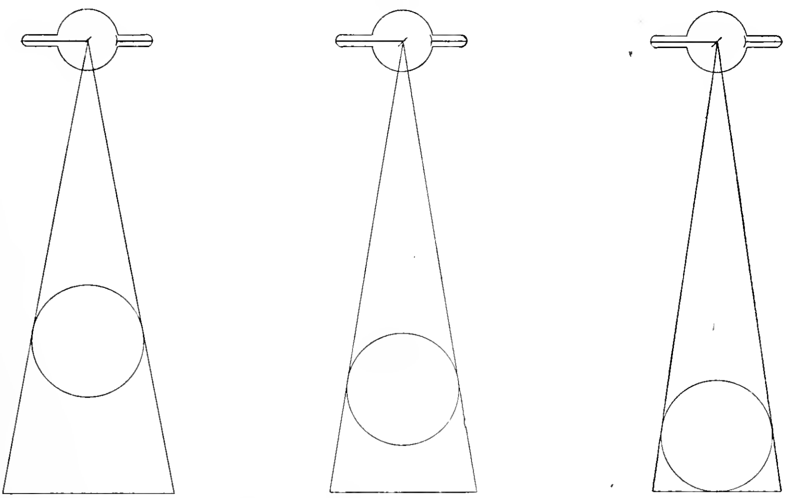
Another form of radiograph table.

necessary to locate the position or a condition in more than one plane. The table is covered with thin fibre sheet which is much stronger and stiffer than canvas, and is quite pervious to the rays. (Fig. 40.)

The Macintyre couch (Fig. 41) has two detachable end pieces, making it convenient in limited space. By a reflecting mirror placed beneath the couch the part being skiagraphed can be watched.

The relative positions of the tube, patient, and screen or plate will require careful consideration, as great difference in the result will follow alterations in these relations. The position of the patient may be assumed as fixed and as forming a fulcrum for the lever of the first degree, formed by each ray in its passage from the anode to the plate or screen. Now, as the rays emanate from a point on the anode, and are constantly diverging until they meet the plate, it will be seen that the longer the arm of the lever, represented by the distance from the part to be examined, to the plate, as compared with the length of the arm represented by the distance from the body to the tube, the greater will be the size of the shadow cast; and conversely, the

FIG. 42.



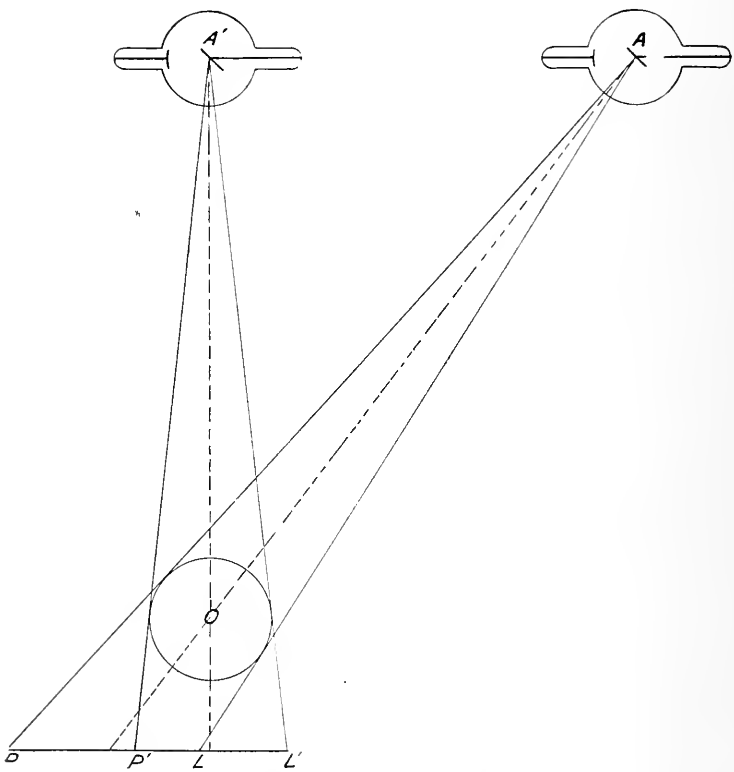
Showing distortion for distance from body.

greater the distance from the tube to the body as compared with the distance from the body to the plate, the smaller will be the shadow, until the distance represented by the short arm of the lever becomes *nil*, and then the size of the shadow is equal to that of the body radiographed. These different conditions are represented in the accompanying diagrams. (Fig. 42.)

It is therefore of advantage, in order to secure a good radiograph, to place the plate at the nearest possible distance from the object and to place the tube at the farthest distance.

If the tube were placed at an infinite distance beyond the parallax, the rays would become theoretically parallel and the image would be the same size as the object, but we are limited to a definite distance governed by the time allotted to the exposure and by the strength of the tube. The distance or rather nearness of the object to the plate

FIG. 43.



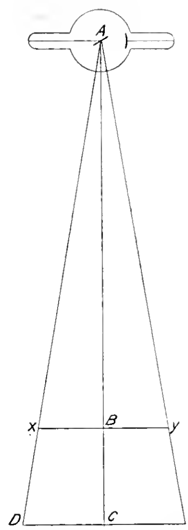
Illustrating distortion of image.

that can be commanded is limited by material considerations.

Another cause for difference between the object and image is the distortion resulting from the plane of the plate not being normal to the line drawn from the centre of the anode through the centre of the object to the plate. In

Fig. 43, *A* represents the anode and *P L* the plate, *O* is the object to be observed; then it will be readily seen that the shadow *P L* will be greater than the shadow *P′ L′* when the plate is perpendicular to the central ray.

FIG. 44.



Showing distortion for distance from plate.

The size of the shadow will always bear a definite ratio to the size of the object, varying with the value of these two differences; thus, if the distances be known, the exact size of the object may be calculated from a single shadow picture. In the case of the heart, for instance, if the distance of the greatest diameter to the position of the plate, while the patient is in the correct position for the exposure, be measured by a fluoroscopic observation, the tube may be placed at a point whose distance from the plate has an exact mathematical relation to its distance to the heart, and the size of the shadow will bear the same ratio to the actual size of the organ that the distance of the tube from the plate bears to the distance of the tube from the heart. In Fig. 44, if *A B* be the distance from the tube to the heart, and *A C* be the distance from the tube to the plate, and *D E* be the width of the shadow, then *X Y*, the actual width of the heart, may always be found by the equation, providing that the line *A C* is perpendicular to *D E*.

$$\frac{A\,C}{A\,B} = \frac{D\,E}{X\,Y}.$$

Briefly speaking, the cause of distortion in *x*-ray photographs is the fact that it is a case of uniplaner projection of multiplaner objects, and that the *x*-rays form a cone of light, thus producing magnification and distortion.

There is no element of uncertainty or chance for error in the rays themselves. No scientific aid to diagnosis has ever been more governed by inexorable and immutable laws. They cannot be tampered with, so far as we know, nor deviated from their path. We can neither bend, break, deflect, nor reflect them, and most ordinary materials and objects offer no obstacle to their straightforward course. When they encounter substances more or less impervious to them they cast an exact shadow of this object upon a fluorescent screen, and it rests with us alone to arrange the object so that this shadow will, when rightly interpreted, teach us only the truth. If examinations prove unsatisfactory the fault must lie in the method of employment of the rays and not in the rays themselves.

One should be well grounded in the normal appearances to be regarded as a trustworthy interpreter of abnormalities. The anatomy of the articulated skeleton, and even that of the dissecting table, is not identical with the more modern radioscopic anatomy. In examination, or radiographing, the parts must be placed in their normal anatomical position, so far as this is possible. This is especially true of the region of joints where flexion, extension, abduction, or adduction would give an unusual picture susceptible of malinterpretation.

The actual distance of the tube from the plate will be determined by several different considerations. The liability to produce burn may be considered as of minor importance, as few persons are likely to suffer injury from one sitting. Removing the tube to a greater distance from the patient does not, as is sometimes stated, have an appreciable effect upon the liability to burn, as the necessary prolongation of the exposure compensates, as is clearly seen in the production of the same result, on the plate. The distance of the tube, therefore, should be governed by considerations of purely technical nature.

The object being placed as near to the plate as possible, and this distance being fixed, it has been shown that the farther the tube is placed from the plate the less distortion of the image there will be; but the farther we put the tube from the plate the longer will be the necessary exposure, and as the length of exposure increases as the square of the distance, it will be evident that beyond the distance absolutely necessary to remove distortion it is not desirable to increase the distance for any small gain in accuracy. The greater the power of a tube, the longer the distance at which it may be from the plate without rendering the exposure inconveniently long. It is, therefore, a good plan always to select the largest tube at one's disposal and excite it with the greatest possible source of power within the limits of safety, and place it at the greatest possible distance at which an exposure can be made in a reasonable time, or at which a satisfactory image can be secured on the screen. Only when haste is of prime importance should the distance be lessened. By adhering to a fixed distance for every case a uniformity of results will be established which will prove of the utmost value in estimating relations between various cases and conditions.

As the rays from the tube practically emanate from a point and diverge in all directions, one ray and only one can strike the plate perpendicularly, and one ray will always do so, provided the tube centre is included within the prism formed by the plate, moving in a line perpendicular to its plane. It is therefore evident that only one point of the object can be depicted upon the plate by a vertical ray, and that all other points will suffer distortion in the picture, resulting from displacement, in a definite proportion, which varies as the distance from the central ray and the distance from the plate. Under the circumstances the best results are obtained when the important part of the object is disposed so that the ray passing through its centre strikes the plate perpendicularly, and its distance from the plate is rendered as small as possible—*i. e.*, the distance of the tube is made as great as possible.

Diffusion and Secondary Rays. A potent cause for lack of definition in radiographs is the phenomenon known as diffusion. The exact nature of this is not known, but there are various hypotheses which, while they do not satisfactorily answer the question, put us in a position to lessen somewhat the evil results due to this cause. Professor Roentgen showed that most solid bodies, and even air in a measure, act upon the rays as turbid bodies act on light. But we cannot believe that the *x*-rays are refracted within these bodies, although the results are very similar. It is more probable, as Roentgen himself observed, that the effect of the rays was to produce secondary rays which have an action on the plate in proportion to their strength. It has also been pointed out that a very wide region surrounding the tube is filled with rays that can influence the plate, and the location of these rays have been roughly mapped out.

Dr. Franklin, who has given some attention to the subject, is inclined to believe that the secondary rays are the result of a fluorescent action on the tissues and the air through which the rays pass. This opinion is strengthened by the fact that if a plate be "backed" the image will be improved, and it is probable that the rays that are thus proved to be absorbed supply the disturbing element. Now it is accepted that the *x*-rays are not reflected at the back surface of the plate, so the disturbing rays are generated there and are absorbed by the "backing." These disturbing rays may also be *x*-rays, as it is known that the cathode ray in a measure follows the course of the *x*-ray, and at any point of impact these would generate *x*-rays. Other causes of faulty definition are given under the sections on Tubes and Apparatus.

Intensifying Screens. The light rays that are the result of fluorescence of the *x*-ray on some substances have been observed to possess greater chemical qualities than the *x*-ray itself, and this fact was taken advantage of in the utilization of "intensifying screens." These consist of fluorescent screens, usually of calcium tungstate, which is placed in contact with the plate, and the exposure is thus made with the visible rays resulting from the fluorescence. By this means exposure may be reduced to a fraction of what it would be without the screen. The *x*-rays are not all altered in the screen, as may be seen from the following experiment: An object is placed in contact with one fluorescent screen and illuminated by the ray in the ordinary manner; the image upon the screen may be seen in a weakened condition on the screen of another fluoroscope, which proves that some *x*-rays pass through the first screen and form an image on the second. The intensifying screen has fallen into comparative disuse with the increased efficiency of coils. They are still in use with some static machines, whose power is not sufficient to give quick exposures. The objection to the use of the screen is that there results a coarse granularity of the image owing to the nature of the screen which cannot be overcome.

Position of the Tube. It is of the utmost importance that the rays which traverse the essential point of the object to be recorded should pass through it in a line perpendicular to the plate. The rays, as has been shown, emanate in all directions from the anode in straight lines, and in any position of the anode there will be one straight line perpendicular to the plane of the plate. If the tube be so placed that this line fall within the plate, in the centre, preferably, and the object to be radiographed be placed over the centre of the plate, then the ray passing through the object will cast a shadow of the centre of the object on the plate without distortion. The linear distortion of the boundaries of the object will vary as the size of the object and the distance from the plate. The size may then be computed from the formulæ given in the chapter on Posing the Patient.

Position Finders. A method and an instrument for finding the position of the vertical ray when the tube is placed above the plate was devised by Mr. Lynn Thomas, and consists of a plumb line and lead which is suspended from the tube in a position under the anode. The line is attached at one end to a short hard-rubber wand and the other end holds the lead, which consists of a small shot which is fastened by splitting and then closing upon the line. The wand is held to the tube in a position vertically below the anode, and naturally the plumb will fall in the line of the vertical ray from the tube. The results with this arrangement are very satisfactory and quite accurate, but depend upon being placed near the centre of the anode for correctness.

A position finder devised by Monell consists of a metal tube about twelve inches long and about three-quarters of an inch in internal diameter. The substance of the tube should be thick enough to be almost impervious to the rays. The instrument is used by placing it between the tube and the screen, and the direction of the rays will be indicated by the position of the tube when the shadow cast is represented by a clean ring with an illuminated centre. If the tube is not parallel to the direction of the ray, at any point, the shadow of the ring will be distorted or lost in the shadow of a bar. The results thus obtained are absolutely correct, but the application of the instrument is almost *nil*. It is almost of no practical importance, and the few cases in which it may be used are screen cases.

Radiographs of Deeply Seated Structures. When it is desired to secure records of the kidneys, spine, or other portions of the body near the plate, the patient being in any particular position, as prone upon the back, the distortion that takes place in the structures that are far away from the plate, as the sternum, etc., will cause the latter to become almost extinct. This is of advantage in some cases, as by placing the tube nearer to the body, the object to be photographed may be clearly pictured without interference in the picture from the other objects.

The many factors which might influence diffusion, and whose action has not been satisfactorily explained, make the use of boxes, which will exclude all rays other than those which actually are of use in producing the picture, of great assistance in securing good, clear records, and their use will remove much of the diffusion that is inevitable under almost all circumstances. The air, the action of the body on the rays, the objects in the room, and other rays, perhaps, that may be generated in different parts of the circuit of the rays themselves, are to be taken into account.

THE ART OF SKIAGRAPHY.

The skiagraph is very much superior to the fluoroscope in the diagnosis of all bone and joint conditions. If we can use the expression the photograph has often been shown capable of seeing things which the human eye cannot detect or cannot so well discern. This is equally true of the skiagraph. Slight fractures in bones which cast only a faint shadow may escape wholly the eye aided by the fluoroscope, while the shadowgraph will make it plainly evident. Two pictures should be usually taken in two different planes. One must be constantly on the alert to avoid mistaking buttons, pins, etc., in the clothing for substances within the body.

The best skiagraphs are made in the field of the greatest ray activity—that is, in the segment of the tube giving off the most penetrating or strongest rays, which is probably in the straight line passing through the centre of the hot focus point upon the centre of the anode. Just as the photograph is capable of being so focused as to show parts with seeming deformities or abnormalities, so can the radiograph be made to represent shadows of too great or too little amplitude. The rays diverge from a small point, hence the nearer the object the greater the magnification. Posing in itself requires much study in reference to the illumination and is of vital importance.

In the making of a picture, and especially when the exposure is one at all likely to produce injury, the amount of surface exposed should be as limited as possible.

Among other things to be avoided are overillumination as well as overexposure. The tube must not be too near the plate, never less than three inches, or the film will be "burned."

Some claim that the best skiagraphs are obtained by long exposures with tubes of low vacuum and an intense current.

A tube of high vacuum requires only a short exposure, but the details of the skiagraph are not so clear.

With the aid of the Wehnelt interrupter the longest exposure (the pelvis) for diagnostic purposes does not require more than ten minutes.

Caution. When these exposures are repeatedly necessary there should be an interval of about a week between them.

Reading the plate is many times preferable to printing from it, because of the possibility of errors in reproduction. This is especially true of the shades of difference in radiographs of the head where increased or decreased permeability to the light, although perceived with difficulty, may, when properly interpreted, point to an anatomical basis for even such affections as traumatic neuroses or so-called "shock neuroses" after injury to the head.

The proper interpretation of the shadow can only be arrived at by the physician whose mind is open to all the possibilities.

Rees mentions a shadowgraph which might have been interpreted as stone in the bladder, but which was in reality a ring pessary in the vagina.

Sketching from the Negative. It has been the experience of a great number of men that very often, in publishing pictures taken with the ray, the copy will show none of the points of interest that may be clearly defined on the negative. To obviate this, Kienbock,[1] among others, advises sketching, from the negative instead of printing it. He has a competent artist, who has had some experience in this class of work, make an exact copy of the negative. He has found that outside of the advantages this offered for the purposes of reproduction it is of immense value in very often showing conditions that might have possibly escaped observation if a mere print were made.

In this respect it is very similar to microphotography, where an artificial copy of the negative is often far superior to an ordinary print.

The accompanying illustrations show sketches made from negatives taken by Kienbock, representing different affections of the bones of the finger as shown by the *x*-ray. Fig. 45 represents the bones of a normal finger; Fig. 46 shows a chronic arthritis of the joints; Fig. 47 represents an arthritis nodosa (with senile atrophy); Fig. 48 shows an atrophy of the bones (osteomalacia), and Fig. 49 represents a condition of gummous (syphilitic) ostitis.

Instantaneous Skiagraphy. Our methods of taking skiagraphs are becoming so perfected that we find absolutely no necessity of subjecting our patients to unnecessary danger by long exposures. Under proper conditions we can take pictures practically instantaneously, the length of time depending largely upon the size of the apparatus employed; whether it is coil or static, upon the degree of vacuum of the tube, and upon the thickness of the part to be photographed.

Kassabian[2] has established a standard of time of one

[1] Wiener klinische Rundschau, October 26, 1902.

[2] Transactions of the American Roentgen Ray Society, December 10 and 11, 1902.

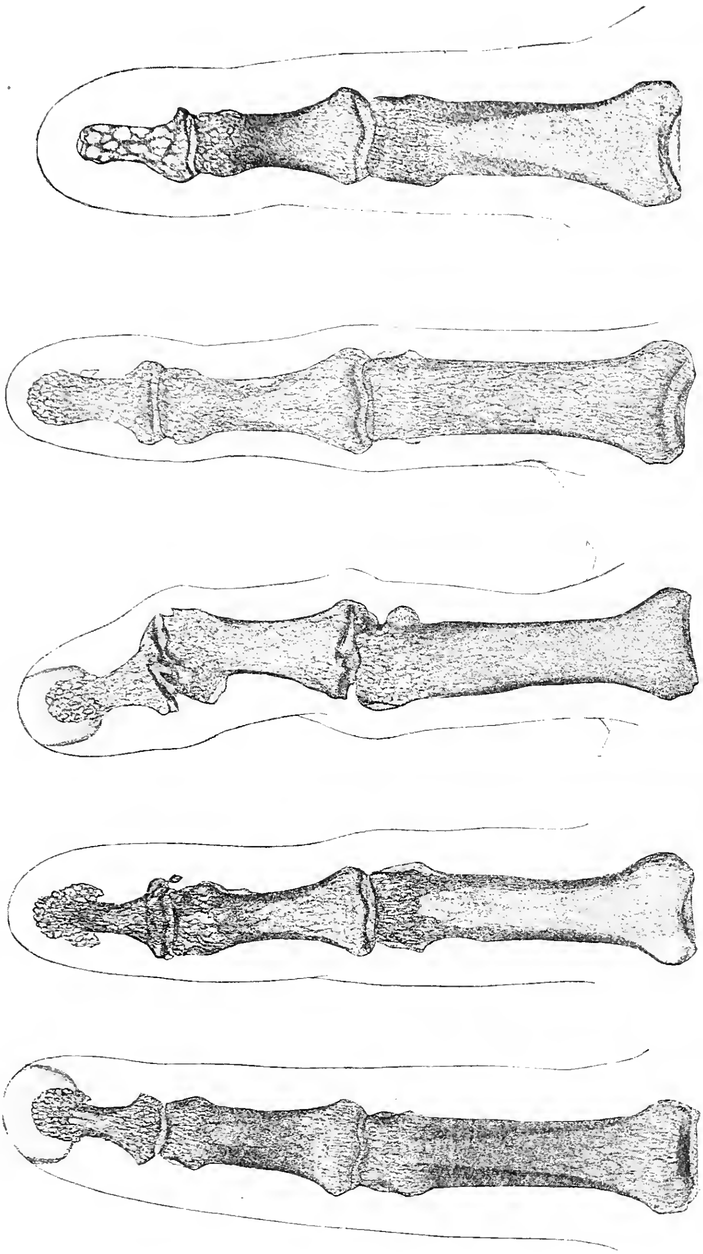


Fig. 45. Fig. 46. Fig. 47. Fig. 48. Fig. 49.

Diseases of bones, sketched from the skiagraph negative.

second which is the time required to skiagraph the hand, and the length of time necessary to photograph other parts of the body will be in direct ratio to their thickness as compared with the hand. The time exposures he uses are as follows:

Upper Extremity. Hand, 1 second; forearm, 3; wrist, 2; elbow, 3 to 5; shoulder, 10 to 15.

Lower Extremity. Foot, 5 to 6 seconds; knee, 10 to 15; ankle, 5 to 6; hip, 40 to 60; leg, 5 to 7; skull, face, 10 to 15; thorax, 20 to 30.

Cranium, 40 to 60 seconds; *abdomen,* 50 to 90.

This was established for individuals weighing from 125 to 145 pounds; for those weighing more we must make additional allowance from 1 to 2 seconds for every 5 pounds.

The apparatus used was a 15-inch spark-producing coil, run with a 110-volt current. The tube should be of high vacuum and the distance from the anode platinum plate to the surface of the part from 12 to 15 inches. The plate used is especially prepared for *x*-ray work. All clothing must be removed, and the time is estimated from the moment the rays are penetrating perfectly, to be ascertained by the fluoroscope, and from the time the protecting lead sheet is removed. When a static machine is used, the time of exposure should be increased by one-fifth to one-third, depending upon the size and number of revolving plates and the number of revolutions per minute.

The advantages of short exposures are: less danger of producing burns, prevention of secondary rays; in chest exposures the effects are not marred by the movement of the ribs, lung, and diaphragm.

In radiographs of calculi the rays will not penetrate them and more differential detail is obtained.

Radiography without Plates. Kronecker[1] has produced fine radiographs, obtained by the use of silver bromide paper in place of plates. A much longer exposure was required, and the exposed parts of the paper become shiny black before the picture is complete. But, once taken, the advantages of having the paper instead of a plate are obvious. The radiogram can be taken and completely finished in an

[1] Berliner klinische Wochenschrift, June, 1903.

hour or so. Another advantage of the paper is that as large an area can be photographed as desired. By combining two of the large sheets it might be possible to take the entire skeleton of an adult at one operation.

He finds that ordinary sensitized paper will not do, as it is too coarse-grained and a special paper must be made, such as is used for meteorological work. The picture can be taken, developed, mounted, and presented complete in thirty minutes. The only drawback is that it cannot be manifolded as with a plate. The radiogram, however, can be easily photographed when a number of copies are desired.

M. Eykman, of Amsterdam, has published a method of x-ray photography by which the movements of the pharynx and larynx are shown. To get a distinct picture the movements had to be repeated 120 to 130 times.

Stereoscopic Pictures. The great objection to radiography is the fact that while it shows the exact state of affairs it does not show the exact locality where the difficulty may exist, or where a foreign body is located. The picture represents all the parts lying in one plane. In cases of foreign bodies it is impossible to tell whether the object lies above or below the bone. In fractures it has generally been found necessary to take two pictures at right angles to one another. Even this is very often unsatisfactory in showing the exact location of injuries, especially if they are situated in the various joints.

To obviate all this, it has been suggested to apply the principle of stereoscopic vision to these pictures.

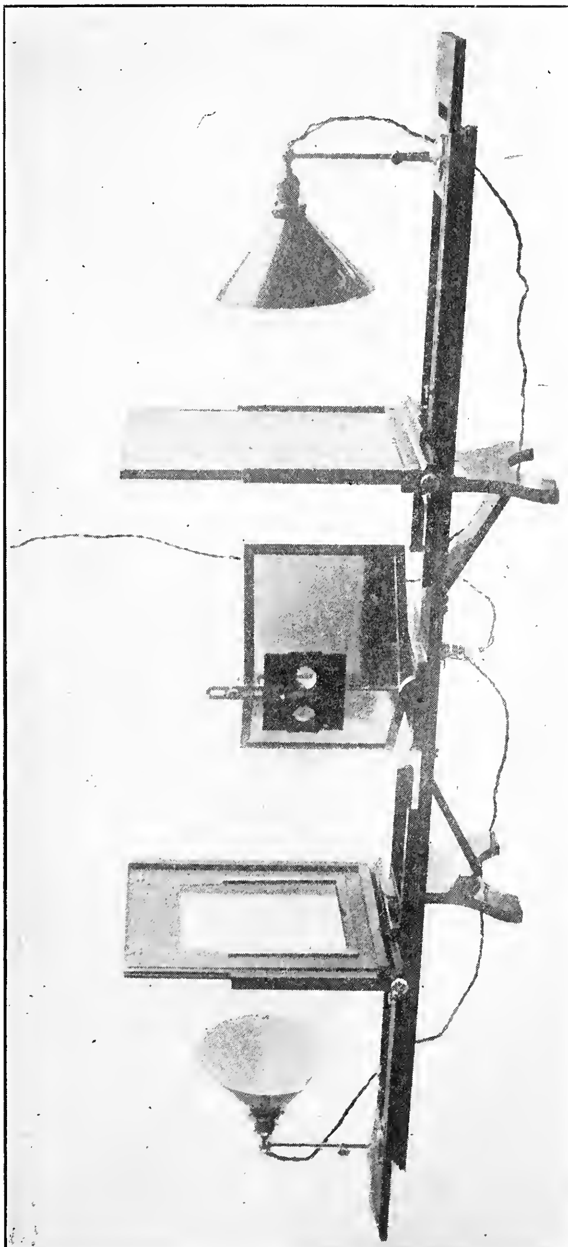
Weigel's stereoscope was first described in the *New York Medical Journal* of November 16, 1901, and was designed to overcome the difficulty met with in taking skiagraphs of bodies and pathological conditions at variable distances below the surface. Ordinary skiagraphs give the relations of such bodies or conditions to the lateral boundaries of the tissues in which they are located, but do not in any way indicate the depth below the surface or the proximity to either of the horizontal boundaries. The stereoscope is on the lines of that of the Wheatstone reflecting stereoscope, and is designed to enable the observer to view two skiagraphs, taken from different points of view at the same time, one with either eye. The result is a reconstruction of the original in space. To use Dr. Weigel's own words in the description: "As seen in the illustration, it consists of a bed piece upon which, at its centre, two mirrors, inclined to each other at an angle of 90 degrees, are mounted on a slide having a forward and backward movement to facilitate adjustment. At the angle formed by the mirrors a screen with opening for the eyes is placed.

"Two grooves for holding the negatives face the mirrors and are adjustable in two directions by a simple sliding motion—one at right angles to the base and the other parallel to it. In the base of the frames there is also a mechanism controlled by a milled screw for vertical adjustment. By means of these various adjustments the image of the two negatives reflected in the two mirrors may be quickly adjusted until they are correctly superimposed, and stereoscopic relief is obtained.

"Transillumination of the negatives is necessary, and this is best secured by artificial light. A sixteen-candle-power lamp is placed behind each negative. Flexible conducting cords from these lamps are wired in parallel to a single key-socket, attached to the under side of the bed. . . . For concentrating the light on the negative an ordinary metal shade, or reflector, surrounds the light bulb which should preferably be of ground glass. An even diffusion of the light is still further obtained by having one side of the negative frames covered with a sheet of ground celluloid, which is lighter and less fragile than ground glass. The lamp brackets are adjustable vertically, and, as they are attached to an independent base, the distance between light and negative may be easily regulated, according to the varying density of the plates. Where an electric-light plant is not available, Welsbach gas lamps or acetylene bicycle lamps may be substituted for the illumination.

"The negative holders are square and large enough to take in plates of all sizes, and may be placed in the frames either vertically or horizontally. For the smaller-sized plates it is advisable to use masks of black press-board, or other material to cut off all extraneous light. The left-hand frame,

Fig. 50.



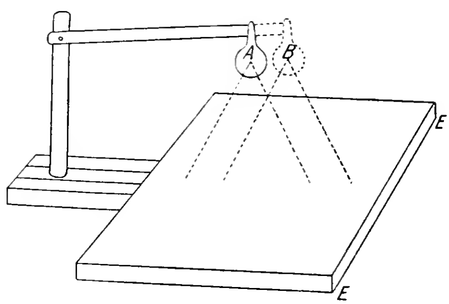
Weigel's localizing apparatus.

in the illustration, shows a mask for an eight by ten plate in position."

Hickey,[1] of Detroit, suggests the method of procedure as follows:

A tube-holder is so arranged that the *x*-ray tube can be moved any measured distance desired. By means of a suitable plate-holder, the plate which has been exposed is removed without disturbing the parts and a fresh plate substituted. The tube is then moved in the same plane a distance of two and one-half inches (corresponding to the pupillary distance of the eyes) so that the rays from the target will impinge on the parts at a different angle. (See Fig. 51.) A second exposure is now made, equal in time

Fig. 51.



A. Crookes' tube in position for first exposure. *B*. Crookes' tube in position for second exposure. *E*. *E*. Plate-holder.

to the first. In order to secure similar density in each negative, the plates are developed for the same length of time. In order to produce the stereoscopic effect, it is necessary to either combine these two negatives in the stereoscope or to combine the prints made from the negatives. Wheatstone's stereoscope, as described in the chapter on Accessories, is used; the negatives are placed one at each side and properly illuminated by electric lamps softened by an intervening ground glass. Viewing the negatives in this way, there results a picture of the denser structures which is truly startling. With properly made stereoscopic nega-

[1] Detroit Medical Journal. August 15, 1902.

tives of the wrist, for example, the osseous structures stand out in their true relations and we see, as it were, the joint stripped of its soft tissues.

Another advantage of using stereoscopic negatives is that the image from one negative reinforces and strengthens the other, so that independently of the stereoscopic effect the eye receives a stronger impression. This feature is valuable in radiographs of the heavier parts of the body or when the tissues are enveloped in dressings which obstruct to some extent the passage of the ray.

In fractures of a joint, the size and relation of the fragments can be made out in a way never before shown. In the study of the anatomy of the normal joints, stereoscopic radiography will undoubtedly be of great value, as the relation of the articular surfaces, the angle at which the bones are joined together, and the depth at which the smaller bones are placed are shown in a manner which cannot be approached by any method of flat illustration or dissection.

Skiagraphic Errors. In an excellent paper devoted to this feature of the subject, Dr. L. G. Cole[1] illustrates by diagrams how distortion of shadow can readily be a source of error. The fundamental principle must not be lost sight of that in making a radiograph some rays are absorbed by the object, while others pass through and are registered on the plate beyond. The skiagraph is the registration of the rays which have penetrated. The shadow of the interposed body may be made to vary at will by varying the distance and direction of the tube from the plate and from the body, both surfaces of a solid body being shadowed upon the plate, and in reading any plate the relation of the various shadows to one another must be rightly interpreted.

RELATIVE VALUE OF RADIOSCOPY AND RADIOGRAPHY.

In numerous instances the fluoroscope will fail to indicate in a satisfactory manner what the actual conditions are, both in medical and surgical cases, and the radiograph must

[1] New York Medical Journal, March 26, 1904.

be resorted to before a final opinion is justifiable. In studying the chest, the results of radiography are imperfect and unsatisfactory, as compared with studying the conditions disclosed by the large fluoroscope. If we wish to preserve a record of the condition found we can make a tracing upon a sheet of celluloid placed upon the patient's chest in front of the screen, or by using a dermographic pencil we can map out areas on the skin and subsequently retrace them on transparent paper.

Radioscopy is almost always untrustworthy in kidney stones; a radiograph must always be taken. The operator should be familiar with shades of density produced in healthy skin, fat, cartilage, muscle, bone, and the relation of parts in varying positions.

Linear fractures, when there is no displacement, can be accurately diagnosticated only by the skiagraphic method.

PART II.

DIAGNOSIS.

CHAPTER IV.

GENERAL MEDICAL DIAGNOSIS.

INVESTIGATIONS OF THE THORACIC CAVITY.

From the moment it was discovered that the transparency of the lung area varied with the occurrence of the inflammatory or other products causing density of tissue, a wide field for investigation was presented and promptly occupied. It was argued that sclerous conditions, thickenings, tuberculous deposits, and fluid collections might be detected. Experience has demonstrated that these suppositions were based upon good grounds.

Not only has it been possible to map out diseased areas of lung tissue and to detect hypertrophic conditions of heart muscle, deposits in vessels, aneurysmal dilatations, but also to base a diagnosis upon the movement of the heart and diaphragm, and upon the dilatation of the heart's cavities and of aneurysmal sacs.

The patient should stand, if possible, for fluoroscopic examinations of the chest; if this is not possible he should sit on a revolving stool. The ray which strikes the chest perpendicularly has been called the normal ray and should be directed upon the part under examination. To locate this ray an indicator of incidence may be used. Due allowance must be made in examining muscular individuals, in whom the rays would pass less readily.

For securing good results in chest examinations a shutter in the orifice of the protecting shield is almost essential, or some device whereby the irradiated area can be promptly increased or diminished. It is also essential, as Béclère, to whom we are indebted for so many excellent suggestions, has pointed out, that the quality of the ray should be under our control.

Chest examinations for the army, life insurance, etc., should take into account the symmetry of the two sides, as it relates to transparence, position of the bony parts, position of opposite sides of the diaphragm, and whether shadows pointed to infiltrations, hypertrophies, or thickenings of any soft parts, as well as the form, area, and rhythm of dilatations corresponding with the heart beats.

Radioscopic examination of the chest, Béclère[1] says, is only to be considered complete when the anterior, posterior, lateral, and oblique surfaces of the body are presented to the screen and are successively traversed by the rays in different directions, while for each of these directions the bulb is placed at different heights from the top of the head to the lower strait of the pelvis.

Thoracic affections have been carefully studied by Béclère, in a report to the International Congress of Electrology and Radiology, Paris, 1900.

Radiography of the Chest. The position of choice is the sitting posture, so that the direction of the rays may be controlled and the fluoroscopic examination may be made immediately preceding the radiographic. It also has its obvious advantage when pleuritic effusions are present. A special table or chair can be arranged to act as plate-holder, as will be found illustrated in a preceding chapter.

Examination of the Lungs. While the comparative elasticity of the parenchyma of the two sides and the changes in the level of fluid collections in the pleural cavities are detected by the fluoroscope, the radiograph gives only a fixed image and does not permit the study of the physiological changes. Besides, the chances of error of a single picture are decreased and we are empowered to examine the chest in every direction and diameter. The direction of penetration and distance of the ray cause the same distor-

[1] La presse médicale, March 1, 1902.

tion of image as one produces in throwing shadow pictures of the hands making various animal forms upon the wall.

The Diagnosis of Pulmonary Tuberculosis. In the pre-tuberculous period, besides the methods already in vogue, Dr. Bonnet Léon[1] advocates a radioscopic method. In patients in whom radiography, auscultation, and the microscope show neither opacity, modification of the vesicular murmur nor the bacillus, an attentive study of the diaphragm and of the muscles of respiration by radioscopy may give valuable information. If anomalies are found in the functional working in the synchronism and the degree of displacement of the two sides of the diaphragm, in their ascent and descent and in their curvature, one can, in the absence of all other signs, diagnosticate tuberculous predisposition unless some other cause is found for these anomalies. In the absence of other cause, it almost always has to do with diaphragmatic pleurisy which has escaped observation, with imperceptible bacillary changes in the pulmonary tissue, or of paresis caused by the toxin of disseminated tubercles. In six hundred observations, the diagnosis was confirmed ninety-eight times out of a hundred. A large number of subjects in apparent good health, examined from 1897 to 1900, were subsequently examined, and found to present other manifest evidences of tuberculosis. Léon thinks a radioscopic examination should be made of all subjects exposed to tuberculosis by heredity, alcoholism, contagion, or environment. In view of the widespread effort now being made to combat this most distressing affliction of humanity, it would be highly desirable to utilize the *x*-ray in every way possible for early detection, so that methodical exercises of the diaphragm and the muscles of respiration, out-of-door life, and other measures appropriate for combating this early tendency could be instituted.

Williams, in his book, has pointed out the diminished descent of the diaphragm on the side implicated by pneumonia or tuberculosis, but only in connection with advanced stages of these affections.

[1] La méd. orientale, September, 1901

J. E. Stubbert[1] speaks very highly of the value of the rays in the early diagnosis of phthisis. He points out that density in a very slight degree will produce a shadow, and that it will frequently do so when it is far from sufficient to produce physical signs. He further speaks of a haze, often seen at the apex, which is of the utmost importance as seen in the picture. The condition causing this gives absolutely no indication of its presence, with the usual methods of examination.

This haze is so slight in some of the pictures that it is not safe to trust the eye alone, but a metal rod should be placed across both apices, and its shadow upon the plate closely examined for differences in distinctness of outline. In some of these very incipient cases the edges of the clavicle upon the affected side appear a little ragged, and the bone itself does not stand out quite so prominently.

Patients showing these signs should be closely observed and placed early under treatment.

Oudin and Barthélemy made a serious study of this question in 1896. They found that the shadow corresponding to the area which could be detected by other methods bore a definite relation to the depth of the lesion; also that there was a possibility of detecting early deposits before the older methods gave any indication, and others have confirmed this advantage of the ray. In making fluoroscopic examinations of the chest it is well to employ such a metallic screen as that which goes by my name, for example, having a circular orifice for illuminating the chest area by area. The normal movements of the diaphragm are approximately from the sixth rib in expiration to the eighth or ninth in inspiration. It is this continued change going on within the thorax, as well as the heart's movements, which gives to the radioscopic an advantage over the radiographic procedure. The limits of these movements, as well as the outlines of the shadows, can be traced upon the skin as they are observed. For the permanent record the radiograph is necessary. The operator's eye must accustom itself to its unusual task, and to increase the sensitiveness of the

[1] Post-graduate, November, 1902.

retina a stay of some minutes in a dark room before using the screen is advisable and often absolutely necessary.

Béclère[1] finds that twenty minutes in darkness increases the fluoroscopic vision 225 times above that immediately succeeding exposure to strong daylight.

The importance of detecting cheesy deposits lies in the fact that acute miliary tuberculosis is often due to the breaking down of these latent lesions in subjects in whom their presence has not even been suspected. In these examinations the normal changes in transparency of lung tissue according to the age of the subject must be remembered, being greater in youth as well as in spare and debilitated individuals and in women. Also that it varies from moment to moment, being clearest under full inspiration. Unfortunately, the most important area in incipient deposits, that corresponding to the apex, is normally least transparent.

Williams believes the right apex is less clear than the left. Corresponding regions upon the two sides must be carefully compared, bearing in mind the points mentioned.

Healed areas in chronic tuberculosis show as a deep shadow, which contrasts with the surrounding clear tissue.

It is particularly in the undiscovered cases, suspected rather of neurasthenia, dyspepsia, or one of the various causes for anæmia, that fluoroscopic diagnosis must come to play a valuable role; diminished transparency may antedate the physical signs or pronounced subjective symptoms by a considerable interval. As a rule, however, men of such wide experience as Béclère have full confidence in the method only as it confirms pronounced suspicions arising from former knowledge and recognized diagnostic signs. Combined with the radiograph and physical diagnosis a screen examination may render clear an otherwise obscure case.

Naturally leprous and luetic infiltrations would have to be further differentiated.

Cavities show as clear spaces, quite circular in outline and of varying dimensions, contrasting by their brilliancy against a dull background.

[1] Communication to the Fourth Tuberculosis Congress, Paris, 1898.

If the cavity be filled with fluid or pus it is opaque, while in generalized emphysema or pneumothorax the transparency is increased beyond the normal. To distinguish from pulmonary congestion we must take into account that the shadow diminishes or almost disappears under deep inspiration, and subsequent examinations will show a variation. At times a swelling of the tracheobronchial glands, a thickening of the pleura, or diaphragmatic adhesions may cast confusing shadows. In chronic fibroid phthisis we get an irregularly mottled light and dark shadow.

Emphysema. This is shown by increase in size of the clear lung areas, by the brevity of respiratory movements of the diaphragm, and the permanent lowering of the latter's shadow. By lateral examination the retrosternal space appears enlarged and clearer. The size and situation of the heart are better indicated than by percussion and palpation, hidden as it is by the emphysematous lung tissue.

Pyopneumothorax. Here the upper limit of the shadow is very clearly defined owing to the air-containing tissue above it.

Bronchial Stenosis. Unilateral constriction has been detected by Holzknecht by the inspiratory displacement of the median shadow toward the affected bronchus.

Œdema. This gives about the same diminished transparency over a variable extent as in congestion.

Cylindrical Dilatation of the Bronchi. This does not usually give definite signs. The ray aids by showing the whole of both images relatively clear.

Pulmonary sclerosis shows diminished clearness of the pulmonary picture, restricted area, and more or less complete lack of change in its different diameters under inspiration and expiration.

Interlobar pleural sclerosis has been studied by Béclère[1] in a patient with chronic fibrous phthisis; the ray disclosed a deep induration extending to the whole interlobar partition.

Pneumonia. As Béclère[2] puts it, "all foci of lung condensation, all lesions, which drive air out of the vesicles, sub-

[1] La presse médicale, March 1, 1902.

[2] La radioscopie et la radiographie des organes splanchniques, Bern, 1902.

stituting for it a substance whose density is analogous to that of water, show as an abnormal opacity on the screen." Whatever their nature, be it pneumonic, gangrenous, purulent, tuberculous, an infarct, an hydatid cyst, or a neoplasm, provided they attain a size varying from a filbert to a walnut.

Infarctus has a predilection for the border of the lung; *abscess* which has opened may present a clear spot in the centre; *metastatic neoplasms* show usually as rounded shadows distinctly limited; *hydatid cysts* have a rounded shadow with a very distinct outline, showing like a ring with clear centre when it has opened into a bronchus; *peribronchial adenopathies* are ill-defined, with perhaps polycyclic outline.

Empyema. In this condition the area filled with pus is quite dark at times; the shadow is almost black.

Gangrene of Lung. The area involved is darker than in pneumonia. The use of the ray in this condition is mainly of value as confirmatory to diagnosis made by other means.

Pleuritic Effusions. In the differential diagnosis of pleuritic effusions from empyema it is important to note that in the former a change in the position of the patient from a vertical to a horizontal attitude will cause a change in the location of the shadow. This is not true when there exists an adhesion or other reason for the maintaining of the fluid in one place. The shadows cast by effusions into the pleural cavities are less dense than in the case of pus, and may be distinguished by that difference alone in most cases. When the depth of the shadow is uniform throughout its extent, or when the density changes gradually and evenly from one portion to another, and the outlines may be recognized as natural anatomical boundaries, it may be assumed that the process is a simple effusion and that pus is not present. When, on the other hand, there is marked differences in the shadow at different locations within the boundaries of the shadow, distributed indiscriminately and without relation to anatomical landmarks, it is an indication that there exist adhesions and involved inflammatory changes, and it has been noted that in these cases there is frequently tuberculosis present.

In any apparently simple pleurisy, the lung apex should be rayed to make sure of a non-tuberculous origin.

Thickening of the Pleura. This shows as a deep shadow, and is characterized by darker stripes, probably due to folding or puckering of the pleura.

Dyspnœa. Adhesion between the costal pleura and the diaphragm was diagnosticated by Benedikt in a case of dyspnœa after supposed pneumonia.

The shadow of the heart and diaphragm showed no change in position of these organs during inspiration and expiration pointing to adhesion, the dyspnœa being due to interference with the diaphragm's action.

Diseases of the Heart. Radioscopy, according to Béclère, permits a differentiation between acquired and congenital dextrocardia. The latter alone is indicated by a true inversion of the organ accompanied by inversion of the arch of the aorta, which is shown by oblique examination. The momentary increase in the distended right auricle during inspiration can be detected by screen examination.

The Aorta. This is best studied by radioscopy, showing dilatation, aneurysmal sacs, decreased calibre, etc.

Oblique examination is required for small aneurysms of the arch. Osler finds that this examination is of most value in cases that give symptoms, but show no physical signs.

Caution. That we must always be on our guard in interpreting shadows is shown in a case recorded by R. Kuckein[1] which had all the appearances of an aneurysm, and on autopsy was found to be a carcinoma of the middle third of the œsophagus.

Among the conditions observed by Grünmach are compression of the bronchi by aortic aneurysm, strumous swellings, tumors of the lungs, pneumonic infiltration foci, etc. A dark shadow moving with a distinct impulse differentiates it from ordinary tumor.

If the walls of an aneurysm are excessively thick the pulsation may be lacking.

In the case of femoral tumor, osteosarcoma might come

[1] Deutsche med. Wochenschrift, November 6, 1902.

into question under these conditions until the shadow of the intact bone was made out.

Aneurysm. Béclère reports a case of a man, forty-eight years old, who had an enormous aneurysm at the arch of the aorta, situated between the sternum and the posterior mediastinum. Physical examination failed to reveal the character of the affection, and a radioscopic examination with the fluorescent screen showed an enormous mass which looked like a second heart superimposed upon the first.

The radiograph, however, showed that the second tumor possessed a much greater and denser volume than the heart.

Wassermann made out an aortic aneurysm in the first intercostal space, which gave no pulsation and could not be diagnosticated by physical signs. The dilated aorta was also seen beneath the aneurysmal sac.

Examination of the Œsophagus. Here the radioscope is probably the best means at our command.

Œsophageal deglutition is best studied in this way: The best position for examination is observing from before backward and from right to left; the clear line is then seen between the shadow of the spinal column and that of the heart and aorta, and foreign bodies are seen outlined against the medium clear space (that between the shadow of the spine and the heart). The patient faces the screen rotating at an angle of 45 degrees. The œsophagus is invisible, but a bismuth tablet swallowed or an œsophageal catheter containing a metal such as mercury brings the parts into view.

The bismuth tablet shows not only the calibre but the functional integrity of the muscular walls. Examination for stricture necessitates three tests corresponding to the degrees of stenosis. When the calibre is narrow the patient may swallow a mixture of fifteen grains of bismuth in two ounces of water. This is swallowed slowly so as to cover the walls over the whole extent of the constricted area. For wider strictures a tablet or powder in cachet which will be arrested and throw a shadow is preferable. Or the patient may masticate and swallow a mouthful of bread; when this gives a sensation of becoming arrested bismuth powder may be swallowed. The passage of a bismuth tablet shows also the energy or weakness of muscular activity—spasm or paresis. Blum[1] has pointed out this method for detecting œsophageal diverticulum.

INVESTIGATION OF THE ABDOMINAL ORGANS.

Abdominal ascites shows much the same as hydropneumothorax, especially in children.

Intestinal stenosis is explored in the same way as œsophageal stenosis.

The liver sometimes shows rhythmic elevations synchronous with the apex beat in tricuspid insufficiency (von Criegern).

OBSTETRICS AND GYNECOLOGY.

It seems to be the opinion of most observers that the use of the ray in diagnosing conditions concomitant with pregnancy is extremely limited. In studying the dimensions of the pelvis the value of the ray is almost lost on account of the great difficulties attending its use, and, when performed by a skilled operator, mensuration and palpation give results more accurate and less inconvenient. Portable outfits for generating the ray at the bedside may be used.

A good field for its employment lies unopened in diagnosticating obscure conditions, such as ectopic pregnancies, double pregnancies, and the presence of deformed and abnormal monsters. This field, however, has not been extensively explored and much development of technique and verification of results is necessary before it can be placed upon a suitable basis of scientific utility.

Bouchacourt finds the ray unsatisfactory in studying the fœtus in utero. The liquor amnii, membranes, mass of the womb, movements of both mother and fœtus, opacity of bony walls, unequal distance of various portions from the skiagraphic plate, etc., combine to interfere with good results.

[1] Wiener klinische Wochenschrift, No. xi., 1900.

The use of the rays in the diagnosis of gynecological conditions has not fulfilled the promises which some operators believed it held forth in the early days. In this branch the results have been disappointing.

Delphey[1] finds the ray of limited utility in the field of gynecological diagnosis.

Tumors or internal growths in which opaque objects like teeth or bone or such-like substances are present may be diagnosticated by the ray. Thus dermoid cysts and tumors due to extrauterine gestation may be diagnosticated when other tumors fail to cast a shadow. Psoas abscess has been diagnosticated by means of the ray. Dr. Bodog F. Beck reports a case in his practice in which an operation had been performed confirming the diagnosis.

The abscess is easier penetrated by the ray, and shows as a circumscribed light area in the pelvis.

Urethra. Loewenhardt succeeded in securing a good radiograph by passing a catheter into the urethral canal.

A bismuth injection can be used to indicate position of tight stricture, etc.

[1] Annals of Gynecology and Pediatrics, Boston, February, 1903.

CHAPTER V.

GENERAL SURGICAL DIAGNOSIS.

WHILE it can scarcely be claimed that the use of the Roentgen ray has enabled us to diagnosticate conditions that could not be detected with former means at our command, it can be stated with absolute certainty that the aid of the ray has enabled us to eliminate the elements of chance to which diagnosis was formerly always subject.

It has put surgery on a much more scientific basis by excluding much of the circumstantial evidence that is always regarded with some degree of hesitation, no matter how conclusive it may appear. In a great many instances it has put surgical diagnosis on a positive basis.

Diseases of the bones, and under some circumstances tumors of the brain, are rendered comparatively simple of detection. Besides these and the detection of foreign bodies there are numerous conditions whose exact determination has been rendered possible or at least less difficult.

In determining the nature and condition of fractures the ray apparatus is the most valuable armamentarium of the surgeon. In a paper devoted to the treatment of Colles' fracture, Beck states, after saying that the laws of treatment and the final result are entirely determined by a correct diagnosis, that "such complete and correct diagnosis could not, as a rule, be made before Roentgen's great discovery. It can safely be maintained that in most cases skiagraphy has revealed conditions that were not expected and required the original diagnosis to be more or less modified."

We are in a position to-day of making a differential diagnosis between ostitis, tuberculosis, syphilis, and any lesion that may impair the usefulness of the joint, without affecting the bone proper. The signs of periostitis and osteomyelitis are quite well marked, and abscesses can be readily localized.

It does not only enable one to diagnosticate these various lesions, but also acts as a trustworthy guide for operative procedures.

Supposed sprains and strains of the wrist and knee have now in innumerable instances (many of which were long after the injury) been shown by the ray to be fractures. Fracture of the carpus has actually become a frequent occurrence where formerly it was considered extremely rare.

The surgeon now finds at times a practical interest in the detection of gangrene of the lungs, pleuritis with effusion, empyema, and tuberculosis.

The action of the diaphragm is in most of these conditions a point of great importance, since it can be watched and the restricted range of motion always present, as pointed out by Williams, can be studied.

Tumors have occasionally to be differentiated from exostoses or bony growths.

Here it is well to go into the history, searching for preceding fracture or bone injury, lues, etc.

If the exostosis has resulted from fracture it may be larger than it appears by ray diagnosis, the external portion being of softer tissue and not throwing so dense a shadow.

It is not very long since surgeons possessed many illusions as to the infallibility of radiodiagnosis, and undertook operations for the relief of conditions which it was thought the radiograph clearly demonstrated.

We have now learned that unless we secure skiagraphs in two or more planes the exact localization is uncertain. Lucas-Championnière operated upon the cranium to extract a bullet whose location was apparently well defined. At the autopsy it was found embedded in the bones of the face. Many similar experiences could be related. Now, however, localization has been carried to such a degree of perfection that in the hands of experienced operators such mistakes should not occur.

Tumors of the Chest Wall. It is at all times a question whether to operate in tumors of the chest wall. The impossibility of knowing exactly the extent of the involvement of the thoracic viscera clouds these cases with uncertainty and renders the work of determining whether operation will benefit the patient very unsatisfactory and complicated.

By means of the rays the relations of such tumors may be readily understood and a much more valuable opinion may be given as to the necessity or otherwise of adopting measures of intervention.

Ainhum. Among other interesting demonstrations made by the ray is that in the condition known as aïnhoid leprosy or the aïnhum-like atrophy and final amputation of the small toe, the constricting ring of tissue does not cause amputation by strangulation, but by a progressive atrophy which involves all tissues, including the bones lying beyond the ring.[1]

This point has been demonstrated most strikingly in a case presented at the meeting of the American Dermatological Association in Boston in September, 1902.

Foreign Bodies. Just as in medical diagnosis by the rays we find often decided aid upon the negative side. Thus, in bullet wounds of the head Lucas-Championnière finds that most projectiles fired into the mouth are shown not to penetrate the cranium, and the surgeon's mind is relieved of the apprehension of cerebral complications. In other instances the location is shown to be so inaccessible that attempts at extraction would be ill-advised.

When it is necessary to know the relative position of a foreign body to the bones, some other method of localization must be resorted to than a single radiogram.

METHOD OF LOCATING A FOREIGN BODY. S. P. Cramer, of Cincinnati, has devised a method which, though rough, should be of considerable help in locating foreign bodies which have proven elusive. The object is first roughly located with the fluoroscope, the distance in two directions is measured, a needle is then inserted under the guidance of the fluoroscope into the tissues until the shadow of the needle point corresponds with the shadow of the foreign body when viewed from two different directions at right angles to each other. Another needle is now inserted at 90 degrees to the first, until its point seems to touch the foreign body. Both are now firmly secured, and it will be found upon dissection that the foreign body is at the point of inter-

[1] Lardy, Soc. méd. de Geneva, 1901.

section of the two needles, which are used as a guide in dissection.

Foreign Bodies in the Thoracic Cavity. It is difficult to make correct diagnoses between the different tumors that invade the thorax, and in the differentiation of these the rays have proven of exceptional aid to the other methods that are in common use. It is now possible to determine the condition in every case of aneurysm of the different portions of the aorta with certainty where there existed doubt in the past; and in the cases that might have been diagnosticated by the ordinary methods in use, the assistance of the rays in making possible a rapid diagnosis has been very potent.

That it is not infallible in locating foreign bodies is illustrated in a case shown by Weil, of Zurich, in which the ray failed to show a large false-tooth plate in the left bronchus, where its presence was revealed by bronchoscopy.

Crile,[1] of Cleveland, reports a case where a patient thought he had swallowed a plate of artificial teeth. A radiograph seemed to show that it was located at a level with the superior internal angle of the scapula. An operation was performed in that region and nothing found; some time after the stomach was opened and the upper incision reopened again with the same result. The patient died shortly after this operation, and the plate was found in some obscure part of the patient's sleeping-room.

Autopsy showed that the misinterpretation of the shadow was probably due to an atheromatous aorta.

A similar case is reported from the clinic of Prof. König, where a girl of twenty-two thought she swallowed some artificial teeth. The fluoroscope showed a shadow in the ileocæcal region, and as some tenderness developed there a laparotomy was performed. The entire intestinal tract was explored with negative result. Some time after, the plate was found under the patient's bed. There are two cases reported from Mikulicz's clinic where artificial teeth were swallowed, and a careful examination with the ray gave negative results. In both cases they were promptly located

[1] Cleveland Medical Journal, December, 1902.

in the œsophagus by means of a sound. There are a number of similar cases which have been reported at various times, mainly of foreign bodies located in the thoracic portion of the œsophagus. This is due to the fact that the heart in front and the vertebral column in the rear produce such dense shadows that it is difficult to distinguish any intermediate objects. To obviate this Wilms suggests applying the ray obliquely. Some anatomical bodies at times cast shadows that may be mistaken for foreign bodies; in this way the cornua of the hyoid bone has been frequently mistaken.

Foreign Bodies in the Stomach. Mayou[1] describes a method of extracting objects of iron or steel from the stomach without a cutting operation. He employs the *x*-rays in connection with a small round electromagnet 8 mm. in diameter and 5 cm. long. The ends and centre are made of soft iron and wound in the usual way. This instrument has, when connected by stiff wires to a 4-volt battery, a lifting power of one-quarter pound. This magnet is inserted in a celluloid tube having a smooth inner surface so that the magnet can be drawn up and slipped back with ease, or a stomach-tube with the extremity cut away will answer the same purpose. A narrow silver band is placed on the outer side of the end of the tube which enters the stomach. This is to enable this portion of the tube to be seen by means of the *x*-ray when it is within the stomach. The remainder of the tube casts no shadow. The patient is placed upon the back with the *x*-ray tube below the couch, and the fluorescent screen upon the abdomen. Preferably under anæsthesia the stomach-tube containing the magnet which protrudes from its extremity is passed into the stomach. The current is made to flow through the magnet and by means of the connecting wire the foreign body is drawn into the tube. When it is shown through the screen that the foreign body has passed above the silver band, the tube now containing the magnet and the foreign body is withdrawn.

Tubes and magnets suited to the size of the foreign body to be extracted can be employed. A hairpin located by the

[1] The Lancet, December 6, 1902.

ray across the pyloric orifice, but which subsequently passed into the duodenum, was successfully extracted in this way from the level of the umbilicus.

Foreign Bodies in the Œsophagus. It is a suggestion made by Gibson[1] that in attempts at removal of coins or other objects swallowed the movements of the instrument or coin catcher be watched through a fluoroscopic screen. In a number of instances this plan has succeeded and its originator considered it the least dangerous to the patient of all methods.

The patient may be seated with the *x*-ray tube behind him or be on a canvas couch with the tube below. A very interesting case was recorded by Dr. J. W. White,[2] of Philadelphia, where a child swallowed a jack-stone, which was located in the œsophagus by means of the ray and was successfully removed by an operation.

When a sufficiently dense foreign body is to be extracted from the nose, œsophagus, larynx, or trachea, this fluoroscopic oversight should be carried out with the aid of an assistant.

Foreign Bodies in the Bladder. In the case of a young woman who suffered from a vesical catarrh, which had proven very refractory to treatment, and at the same time was very painful, Sieffart[3] found by means of a sound that there was a strange body in the bladder. Upon examination, the young woman admitted that she had "swallowed" a hairpin. The bladder was then examined by means of the Roentgen rays, the sensitive plate being placed in the vagina. The radiograph showed a hairpin in the bladder, which was readily removed without difficulty.

Foreign Bodies in the Eye. In Sweet's[4] method of triangulation of the shadow of the foreign body a skiagraph is taken from two different positions; the relation of the shadow on the photographic plates to two points previously known assures the necessary accuracy, all precautions having been taken to avoid error. In this method we have the most

[1] The Lancet, December 13, 1902.

[2] Annals of Surgery, 1896, vol. ii. p. 238.

[3] Centralblatt für Gynäkologie, 1901, No. 1.

[4] Philadelphia Medical Journal, February 1, 1902.

certain way of detecting and then of accurately locating foreign bodies embedded in the globe.

Fox's[1] localizer consists of an oval band of metal 0.75 mm. in width, curved so as to conform to the outline of the eye, and crossed in front by two gold strands placed at right angles to one another so as to divide the oval band into quadrants. This is adjusted to the surface of the eye so that its geometrical shadow thrown upon the photographic plate indicates the location of the foreign body also shown in the skiagraph.

FIG. 52.

Dr. Sweet's appliance for localizing foreign bodies in the eye.

Technique. The plate is adjusted to side of the temple near the eye and the *x*-ray is so placed that the rays fall as nearly perpendicular as possible upon it. If the foreign body is within the shadow of the localizer, it is in front of the equator of the eyeball. If the foreign body is behind the shadow of the localizer it is in the posterior portion of the orbit. A second radiograph giving an occiptofrontal view identifies the quadrant in which the foreign body lies. In a recent modification Fox uses a band having a diameter

[1] Philadelphia Medical Journal, February 1, 1902.

smaller than 0.75 mm., the shadow being so small that a foreign body would not likely be hidden by it.

Cocaine may be applied to the eye to enable the patient to stand the inconvenience of the examination.

DIAGNOSIS OF CALCULI.

The diagnosis of renal and ureteral calculi has always been attended with great difficulties and uncertainties. The insidious development combined with the great ambiguity of the symptoms render the diagnosis very frequently extremely doubtful. When the condition has progressed to a danger point the diagnosis is the more readily made, but even in this stage it is still accompanied by many possibilities of error and is of less value than if it could be made at a very much earlier period.

Suppression of urine is a term which was very frequently heard a few years ago and even at present as a sole diagnosis for a cause of death. Kidneys frequently develop loss of function and necrotic degeneration because of occlusion of the ureter. In fact, so many diseased conditions have their rise in the unrecognized presence of a growing calculus, that their early detection is a matter of great importance. In a number of kindred conditions showing a close similarity of symptoms, differentiation cannot be made with certainty from these alone. Thus, variations in size and changes in position may readily be mistaken one for the other. Frequently cases which apparently give every symptom of true renal calculus have proven not to be due to stone upon operation, and *vice versa*. By the aid of the ray we are in a position in the great majority of instances to establish an absolute diagnosis, and thus to render operation or exploration either unnecessary or an almost absolute certainty. Not alone may we be certain that a calculus exists, but we may definitely know its exact position in the organ, and thus be able to operate with assurance.

Furthermore, of the many conditions which give similar physical signs, we may state with certainty which of them causes these symptoms. No mistake can be made as to which kidney or ureter is affected, and the necessity for introducing catheters with the attendant risk of infection or of making dangerous, unsatisfactory, and perhaps unnecessary exploratory incisions is done away with.

Where there is stone in both kidneys this is the one method, aside from double exploratory incision, by which a certain diagnosis may be made.

By this method one may diagnosticate the smallest as well as the largest stone, and Leonard[1] mentions an instance of three stones, each weighing less than one grain, detected by this means. This is the more important when we remember that small calculi produce few or no symptoms, and may go unheeded until a dangerous stage is reached.

We must exercise caution in making a diagnosis of stone, since intestinal concretions have been found to occasionally simulate them. The bowels should be emptied beforehand.

In a report of cases operated on in a hospital, it has been found that in 8 per cent. of those in which the ray had shown the existence of a stone, operation failed to reveal its presence. The radiograph should be taken with a very low tube, so that anything denser than the soft parts will show.

Statistics derived from numerous operations indicate that there is an enormous increase in mortality, in patients who have been operated after the ordinarily recognized symptoms have made their appearance, over those who have been operated early in the course of the disease, while there were still no definite symptoms. This proportion is stated as about ten to one. By means of the rays a calculus may be detected as early as there is any warrantable suspicion of its presence, or in a definite case where there exists a suspicion a negative x-ray result may often save the patient from an operation.

Altogether the results are better, surer than after older methods of exploration, and the evidence is almost absolutely reliable.

Negative Diagnosis. Leonard, who has written extensively upon the subject, bases his diagnosis upon negative rather than upon positive findings. He quotes many cases in which

[1] Annals of Surgery, April, 1901.

supposed evidences of calculus have disappeared when the ray examination had been negative. He cites other cases in which a negative ray diagnosis had been followed by operation, which proved the accuracy of the ray.

He says: "The absolute negative diagnosis and the exclusion of all calculi are based upon the axiom that if a quality of ray is employed which will differentiate between the shadows of tissues less dense than the least dense calculus, all calculi will be detected.

"The production of negatives showing tissue differentiation in the lumbar and pelvic regions is the basis upon which the negative diagnosis rests. They constitute a mechanically produced proof that a quality of ray has been employed which would detect and yet not penetrate all qualities of calculi. The only sources of error lie, not in the method, but in its proper employment and interpretation. Experience in developing and employing the various qualities of the rays must be combined with clinical experience in translating the diagnosis from the negative. The reading of the negative is often the most difficult part of the diagnosis, and especially in making a negative diagnosis it requires careful study of the plates."

Out of 206 patients subjected to *x*-ray examination by Leonard,[1] calculi were demonstrated to be present in 65, and in only 3 cases where the ray showed negative result was a calculus subsequently found. In 2 of these the calculi weighed less than one grain and were passed spontaneously.

As in all other applications of the *x*-ray, sole dependence may not be placed in it alone. The many difficulties in reading a shadowgraph and the many interpretations of which it is susceptible render the method unreliable, when unaccompanied by logical clinical adjuncts. For instance, a negative *x*-ray finding, of itself, means either that there is no calculus present or that on account of some peculiarity of position or condition of the stone, misplacement of tube, or peculiarity in the subject, no shadow was produced. But with every evidence present of the existence of calculus another examination is indicated, or at least a mistrust of

[1] Medical News, vol. lxxx.

the results, and other methods should be used for determining the accuracy of the first findings.

The exact number of calculi to be removed is determined before operation is commenced. The operative wounds may be very much smaller than formerly, on account of the exact knowledge of location and the exact direction and route through which the calculi are attacked may be determined to the best advantage before operation.

Leonard draws the following conclusions:

1. That both the negative and positive diagnosis by the Roentgen method are accurate and valuable.

2. That ureteral calculus is much more common than has been supposed, or about 50 per cent. of all cases of calculus.

3. That it is impossible to arrive at as accurate a diagnosis of calculus by other methods.

4. That this method is comprehensive and aids operative intervention by localizing all calculi and excluding calculi from the other kidney.

5. That non-operative treatment, without a negative diagnosis by this method, is irrational and dangerous in cases that are at all suspicious.

6. That this method is precise, because its results are mechanically produced, but that accuracy in its employment and care in reading the results are necessary to the avoidance of error.

7. That the data obtained by this method make non-operative conservative treatment rational in cases of small calculi low down in the ureter that can be expected to pass.

8. That the negative diagnosis does not preclude exploratory nephrotomy, but does make unnecessary the actual incision into the kidney in search for calculi.

9. The dilatation of the ureter with bougies, as has been practised in the female, may be employed in the male by utilizing a suprapubic cystotomy wound to guide the instruments from the urethra into the ureters.

Small stones (gr. j) can be seen at intervals along the ureter. Johnson has located kidney stones in over thirty instances, and confirmed the diagnosis each time by operation. For this purpose the quality of the plate must be perfect. Stout patients make poor subjects.

Skiagraphs of stones of various composition taken outside the body show: uric acid stones faintly permeable; oxalate of lime 10 per cent. cast a heavy shadow. All phosphates of fair size and urates of large size can be detected.

The symptoms of stone of the bladder are often caused by stone in the ureter.

Fenwick[1] insists on a radiograph of the pelvis being taken in all suspicious cases. He finds that nephritic colic is so frequent in children that he advises skiagraphy in every youthful patient subject to recurrent stomachache. Also in every child with painless hæmaturia the ray may show oxalate of lime stone of the kidney.

Biliary Lithiasis. Drs. Gastein and Yogue, of Madrid, report that they have radiographed a large number of patients, subsequently submitting their findings to the control of operation or autopsy. They found that radiography does not permit of differentiation between stones in the gall-bladder and dense pericystic adhesions or hydatid cysts. Thus it fails just where its aid is most needed.

When very large, these stones may be detected, and the ray is of special utility in the exclusion of cancer of the gall-bladder simulating cholelithiasis.

These stones are almost always formed of cholesterin, which is very unfavorable for ray examination.

Four out of five diagnoses of gall-bladder stones by Boggs were verified.

Prostatic and post-prostatic calculi may be detected by radiography when they cannot be felt by palpation. The method is also useful in detecting or eliminating stone from the diagnosis, especially if one is suspected to be hidden behind an enlarged prostate.

DIAGNOSIS OF BONE DISEASES.

In institutions the routine plan of subjecting every injury to radiographic examination is strongly to be commended. Where this is done it is no uncommon experience to find

[1] Medical Annual, 1903.

that the ray will expose bone injury where physical examination fails to show it. In the neighborhood of joints especially this method has a pronounced superiority over other exploratory measures. Fractures, fissures extending from joint cavities into the shaft of bones, fragments chipped from the surface of condyles, and bony projections can often be detected positively in no other way. It is also not uncommon while examining for one class of injury to find some concomitant condition of great importance. Never before have surgeons so keenly realized the defects of physical methods as they previously existed, and nothing gives us so just a realization of the benefits to be derived from radiography from its diagnostic side.

Dystrophy of Bones. In partial arrest of development the ray shows, according to Molin,[1] that the long bones especially present curvatures similar to those in rickets. He regards genu varum and genu valgum, as well as curving of the knees and other joints, as directly due to these bony changes.

Radiography alone has enabled us to learn the nature of these dystrophies.

In diseases of the hip in children three chief varieties are distinguished by means of radiography. Gardette[2] concludes that this method furnishes sufficiently accurate knowledge of the lesions to enable us to distinguish (1) hip-joint disease with diffuse lesions, (2) with localized long foci, (3) those in which deformities predominate. Localized bony changes can be recognized and their location, whether femoral or acetabular, can be determined but not the exact nature, whether sequestral or caseous.

Radiographic examination does not assist us in the treatment of diffused forms of hip-joint diseases, but when localized it may enable us to seek bony foci and operate.

The exact knowledge conveyed permits of earlier resection and the hope of securing better functional results. When deformity is present radiography teaches its exact location and extent, and points out whether intervention is required.

A sequestrum of bone which is causing pronounced

[1] Thèse de Lyon, 1900. [2] Ibid., 1898.

symptoms but which cannot be detected by probing may be located by ray examination.

Beck describes such an instance in which the sequestrum was found covered with thick fibrous tissue at the point touched by the probe, so that it did not respond to this time-honored test.

Osseous Cyst. Osseous cysts are easily overlooked in their earlier stages. The *x*-ray permits not only their detection but differentiation between them and osteosarcoma. In the former the line of the cortex appears narrow because it is thin but well marked and regular. The fluid centre of osseous cyst is indicated by a lighter shadow in the radiograph.

Syphilis of Bones. In syphilis of the bones, where the bone is protected by a thick layer of muscular tissue rendering palpation very difficult, the ray is of great advantage in demonstrating the differences in structural density of the affected bone. For instance, in examining the thigh, where palpation is inadequate to differentiate between muscular changes and bone disease, this is the only method by which a positive diagnosis can be made.

V. Petersen points out the value of radiography in syphilitic diseases of the bones. He suggests that a defective ossification in syphilitic infants may be advantageously studied.

Osteosarcoma. It is quite generally accepted that osteosarcoma is one of the most malignant growths known, and that the danger of the condition is in no way rendered less by the fact that the diagnosis is extremely difficult to make.

The *x*-ray offers the only means at our disposal of making a sure diagnosis. Old fractures with large amount of callus have a number of times been mistaken for this condition.

Periosteal sarcoma may be unmistakably recognized from its skiagraph, which is very characteristic. The fine trabeculæ that grow from the surface are well marked and are diagnostic. This condition, which is known to be most dangerous to life, may be greatly benefited by the therapeutic application of the rays.

Deformities of the Foot. One of the subjects that is destined to be greatly advanced by the use and application of the *x*-ray is the proper proportioning of shoes, to allow of a correct use of the feet without interfering with their natural position. This subject has received much attention lately. Skiagraphs have been used to illustrate the deformity resulting from the improperly made and shaped shoes.

Clubfoot. Dr. Willard has especially taken a skiagraph to delineate the width of the astragalus and to decide whether it could be replaced between the malleoli without tarsectomy.

The results give a clear outline of the deformity, and demonstrated that replacement was possible, and subcutaneous sections of all the contracted tissues proved the correctness of the diagnosis.

The radiograph showed the cause of the internal obliquity of the metatarsals and their relation to the tarsus when the foot has been walked upon for years. The second, third, and fourth metatarsals were actually dislocated inward, so that they overlapped to nearly half of their diameter.

Metatarsalgia. G. Bilhaut[1] finds that the spreading of the anterior arch or changes in the joint are not always present. He has found that Morton's suggestion, that the pain is due to a pressure of the fourth metatarsal on the nerve, is a correct one, and that the end of the bone is the seat of an ostitis. He has also found that in some cases the head of the third metatarsal falls below its neighbor and the under surface is the seat of an exostosis. These conditions are well shown by the *x*-ray.

LOCATING TUMORS IN THE BRAIN.

The recognized difficulties of localization within the cranium makes the ray method of interest. While little has so far been accomplished there is promise in the method.

Benedikt[2] was enabled to demonstrate a tumor at the base

[1] Annales de chirurgie et d'orthopédie, October, 1901.

[2] Deutsche med. Wochenschrift, June 5, 1902

of the brain by taking a profile skiagraph from either side. In many instances he finds the bones abnormally permeable over painful pressure points which he believes indicates some inflammatory process in this location. The inner layer of the bones of the skull in pachymeningitis may be less permeable than normal, while pachymeningitic hemorrhages show less permeability.

Mills[1] reports two cases in which he obtained a shadow of a tumor of the brain by means of the ray. He believes that this examination should be added to our other means of making a diagnosis.

Béclère[2] has recently shown that radioscopy is capable of revealing latent acromegaly. It does this by showing the abnormal configuration of the walls of the skull, the exaggerated development of the frontal sinuses, resembling those of an elephant, and by the enlargement of the sella turcica.

[1] Philadelphia Medical Journal, September 27, 1902.

[2] La presse médicale, Paris, ii., No. 98.

PART III.

RADIOTHERAPY.

CHAPTER VI.

GENERAL THERAPEUTIC CONSIDERATIONS.

All radiant phenomena have the same physical basis; one class of ethereal vibrations gradually pass into another of different wave lengths without any sharp boundary line. Radiant heat, light, electricity, and the Roentgen ray each affect cell life in a similar manner. The physical effect would appear to be directly proportionate to the duration of the application inversely to the square of the distance from the source of energy to the patient, and presumably inversely to the wave length.

In this method, according to Freund,[1] the effective factors are probably the ray itself and the electric surface tension of the tube. The process of cicatrization, or, more exactly, the regeneration of tissues which have been injured by having been exposed to the action of the ray, also the nature of the irritation produced by the ray differ in a marked degree from anything of a pathological nature heretofore known.

If the tissues treated be not vitally strong, or if the intensity, proximity, or duration of the raying be beyond the due proportion existing between the resistance of the tissues and the safety limit of the ray, untoward results will follow. Conversely, if due regard be paid to the power of the ray, the results may be wholly beneficial. In order to set a standard of tissue-resistance and ray-activity, Rudis Jicinsky[2] performed some experiments upon guinea-pigs and

[1] British Medical Journal, October 25, 1902.

[2] New York Medical Journal, November 15, 1902.

rabbits, exposing them daily for stated periods to the rays and carefully noting the results. Upon the death of any of the exposed animals, the tissues were carefully examined. He found that the longer the low vacuum tube backed by a strong current was continued the lower sank the resistance of the animals. Two of the guinea-pigs finally died after the fiftieth exposure. Upon dissection it was found that degeneration was present in the white matter of the posterior tracts and in the posterior horns; the spinal canal was dilated by hemorrhages.

The histological appearance of the so-called burn was that of a special inflammatory process involving the formation of new fibrous tissue; the walls of the bloodvessels, especially the intima, were thickened and the lumina almost closed; the nerves and a thin layer of tissue were destroyed.

The rays possess chemical, fluorescent, and electric properties. Their effects range from mere stimulation to actual destruction of the tissues. In weak doses they favor physiological processes, while in stronger doses they cause inflammation or necrosis.

According to some the ray is a powerful stimulant of all tissue, both normal and pathological. In applying the rays in long sittings and to large areas for specific purposes, as in skin diseases, it has been the observation of many that patients report a certain feeling of well-being after a number of exposures.

This may be due in part to physiological effect, but there are reasons for believing that the ray exercises a general stimulating effect. Elderly persons with stiffness of joints and muscles may tell of a certain feeling of unusual suppleness. Those of a nervous disposition who suffer from insomnia, indefinite nerve pain, depression, etc., may feel a buoyancy and report better rest at night.

The loss of tissue in prolonged exposures is attributed to overstimulation and consequent impairment. The supporters of this view point to the increased activity of the epithelium under the rays, and to the fact that so little scarring occurs in this method.

By the same theory it is assumed that all of the cells in the skin undergo the same stimulation and then overstimulation, including the nerve cells, which accounts for the anæsthesia produced. The cures that have been noted in all superficial ulcers, acne, lupus, and epithelioma are attributed to a stimulation of the cell function and consequent resumption of the healthy condition.

Whatever the ultimate theory to be adopted may be, it is probable that the first effect is stimulating and, if pushed beyond a certain limit, irritating and destructive.

Under the action of such an irritation the endothelial connective tissue and cells of the parenchyma are likely to swell and grow more granular. The additional granules, being albuminous, seem to be derived from the protoplasm of the cells involved. The degeneration which follows a prolongation of the action of the irritant may begin with destruction of hæmoglobin in masses of extravasated blood cells or with pigmentation of the skin, and may continue until a circumscribed area is destroyed.

The exact method of procedure will be given for each branch in which the ray is indicated, but it may not be amiss to give a few general hints more or less applicable to all radiotherapy. It is good practice as a means of personal protection against suits for damages, or at least charges that the possibility of ill-effects had not been explained to the patient, to have a blank form in the office which is signed by every person at the time of beginning treatment. All responsibility should be assumed by the party treated, relieving the physician from all blame in case of injury. One point of paramount importance in considering the general aspect of radiotherapy is the necessity of having trained and intelligent medical men in charge of all treatments. No electrician, however skilled in physics or even a knowledge of radiotherapy, should be considered a competent therapeutist. It requires good medical and clinical training, and tact besides, to enable one to safely and successfully conduct *x*-ray therapeutic operations, and, while it is all the better if the radiotherapist is at the same time a practical electrician, it is absolutely necessary that he be a finished clinician. He should be thoroughly able to diagnosticate all conditions likely to be amenable to the treatment. He should know what remedial measures to employ in any emergency and to add at any time the necessary adjuvant treatment. With a general knowledge of the management of apparatus, the conditions and variations of tubes, the use of shields and other protective devices, the physician is better equipped to treat by the radiotherapeutic method than the most expert radiophysicist can possibly be. Only a practitioner qualified by experience can properly estimate the dosage, and possesses the necessary knowledge to treat deep-seated lesions and the patient coincidently.

If we consider for a moment the unfortunate state in which surgical diagnosis would be placed to-day were skiagraphy removed by some magic means from our possession, we can well imagine that when radiotherapy has been practised for an equal number of years, we will be in a position to cast a retrospective glance filled with satisfaction.

Application of the X-ray to Therapeutic Work. There have been several claimants to the honor of priority in the application of the *x*-ray to the treatment of disease. The question will be difficult to settle with absolute certainty.

The Chicago Electromedical Society, at a meeting held on November 26, 1902, adopted a resolution which gives to Dr. H. Preston Pratt, a member of the society, the honor of having first made use of the *x*-rays for therapeutic purposes.

On April 13, 1896, Pratt began the treatment of two patients for cancer of the stomach, and a week later, of a subject of pulmonary and laryngeal tuberculosis. Despeignes, of Lyon (France), also applied the ray for the treatment of cancer, in 1896.

Freund, of Vienna, has been generally accorded the credit of demonstrating a decided therapeutic value for the ray.

As to the application of the ray to inoperable cancer of the breast, Alfred Cooper states, in his presidential address,[1] that so far as he can learn Mr. Andrew Clark recorded the first case of chronic cancer of the breast treated by the *x*-rays.

While it may not be definitely known who first suggested or carried out treatment in what we may term internal

[1] West London Medical Journal, October, 1901

cancer, to Gilman, of Chicago, must be given the credit of encouraging others, in this country at least, to an extensive trial of the method in such cases. It was in December, 1900, that he reported before the Clinical Society of Chicago an extensive breast cancer which had greatly improved.

Clinical Effects of the Ray. The effect of the rays on the human body is very much like the effect of drugs, that is, it varies with the strength of the dose given. Another similarity that they have with drugs is that in certain conditions of administration it shows the same cumulative effect. Used in weak doses they have a stimulating effect, in larger doses overstimulating, producing erythema and inflammation, and in overdoses they will produce atrophy and necrosis. Still another similarity is in the decided idiosyncrasy exhibited by some patients. The influence of *x*-rays on animal cell life is very similar to that of heat, light, and electricity. The physiological effects of rays are in direct proportion to their intensity and in inverse proportion to the wave lengths. There is generally a latent period between exposures and the appearance of reaction, the length of which period is inversely proportional to the wave lengths and intensity of exposure. The physiological action of the rays persists for a long time. The depilatory effect is the result of the ray's destructive action on the follicles, or is due to the alteration of their blood supply.

The ray exerts a powerful influence on the formation of connective tissue and cicatrices.

We can obtain a much more penetrating effect with the rays than with chemicals.

Seabury Allen claims that the clinical effects are not due so much to the *x*-ray as they are to some other unknown but closely allied phenomenon.

It is very difficult to decide whether the tubes should be hard or soft for the particular disease and patient concerned. Here the individuality of the patient plays an important role. About the same results can often be obtained by either, providing we adapt to the particular case in question the length of exposure, strength of current, and distance from tube. The reaction depends in a measure on idiosyncrasy; the region of the body exposed; the moisture of the surface; the amount of fatty tissue in the parts; a fatty abdominal wall being more apt to be effected than one not containing so much fat. Still we can produce a reaction, with rare exception, on any part of the body, and in any individual, by giving a sufficiently long exposure at close range.

Hard tubes are safer; with these we can go right on with the radiations until we get visible effects, while with a soft tube we must not forget that there may be a reaction long before it is visibly manifest.

There are several general effects that the ray will produce in the majority of cases, and on these a system of indications and contraindications may be built. No absolute reliance, however, can be placed in any of these, as the ray has been known to produce entirely opposite results in similar cases, and, indeed, very often in the same patient at different times.

Scholtz,[1] in a series of experiments on the effects of the ray, has come to the conclusion that they are manifested at the point of entrance and at the point of exit, that the rays affect primarily the cells of the normal skin, and that the cells of glandular structures, muscles, vessels, and connective tissue are influenced in only a mild degree. He goes so far in fact as to state that the skin alone is affected and that the inner organs are not in the least influenced. This can scarcely be accepted, however, in face of the evidence that many deleterious effects have been produced, manifested in headache, abdominal symptoms, and the benefit derived in many systemic and deeply seated conditions.

The effect on the skin is at first stimulating up to a certain point, and then degeneration takes place. It is probable, according to the same authority, that the changes that take place in the structures of the skin, other than the epithelial cells, are purely secondary and due to the inflammatory processes in the skin already going on.

When there is oozing from a surface the application of the rays has the effect of a styptic.

Some observers claim that women are much more favorable subjects for ray treatment than men.

[1] Arch. f. Dermat. und Syph., 1902, vol. lix. pp. 87, 241, 421.

In beginning treatment, especially in cancer of the skin, the patient should be very carefully examined to determine whether there is any involvement of the internal organs. The urine should be examined for albumin; its appearance in the urine during treatment, when previously it has been absent, is a signal to stop treatment until it disappears.

Causes of Therapeutic Effect. Freund finds that the therapeutic effect is due to one or more of the following forces that emanate from the surface and cavity of the tube: (1) heat; (2) ozone; (3) cathode rays; (4) ultraviolet rays; (5) rays of material particles from the anode; (6) Roentgen rays; (7) sparks and electric charges from the surface of the tube; (8) electric or electrodynamic waves; (9) rays of unknown character.

As a result of a great many experiments by himself and other observers, Freund concludes that from all of the above-mentioned effects the *x*-rays and the electric discharges from the surface of the tube are the only ones to be taken into consideration when studying its physiological effects. They both appear at the same time, their action is very similar in character, and they have the faculty of strengthening the action of each other.

ANALGESIC QUALITIES OF THE RAY.

If there is any one point on which *x*-ray workers are well agreed, it is that the emanations from an energized tube are capable of alleviating pain. This at times is only temporary, but oftentimes permanent, and is observed even in the excruciating degrees occurring in malignancy. This was first noted by Despeignes as early as 1896. He found that morphine which had been taken steadily could be dispensed with after a number of ray treatments.

Just what emanations effect this is not universally agreed upon. Shields believes it is due to the high-tension current and not to the *x*-ray at all. While it is true that high-frequency and high-voltage currents give at times wonderful relief, the *x*-ray, possibly together with the cathode ray, or at any rate something more than the electricity is active in the relief of suffering; a relief which at times is more pronounced than we could expect from any known method of applying electricity.

For the present it is perhaps better to say that the exposure produces the result rather than to claim it for the ray alone. The great advantage of this method over giving pain-relieving drugs is, that while the latter produce injurious effects and decrease the functional activity of organs, the anodynal effect of the ray is accompanied by the stimulation of healthy activity of various organs. There is besides no benumbing effect, no local anæsthesia, as we have in many analgesic remedies.

It is possible that in the production of pain there exist waves of vibration within the nerve cells, and that new vibrations are introduced through the medium of the ray, replacing the painful by painless vibrations.

Sweet,[1] among others, has recorded the effect upon nerve structures after long exposure. The skin shows loss of sensation, so that in cancer large portions of the tissue can be excised without any other analgesic.

Among painful affections which have been found benefited by the ray are painful joints, muscular rheumatism; intercostal, facial, and other neuralgias; hepatic colic and neuralgia attending and following attacks of zoster. In all of these conditions where the pain is severe the method occasionally fails. A number of accidental cures of painful affections have been recorded following application of the ray for diagnostic purposes.

It is quite as well known, however, that the analgesic effect of the ray, while it may exist as a rule, is by no means constant, and there are numerous instances on record in which the effect was the exact opposite. Cases in which the application of the ray gave rise to immediate pain are rare, but have occurred in the experience of the author. The usual way in which pain appears as an accompaniment of the treatment is as a sequel, and usually manifests itself in a day or two after the treatments have commenced.

The analgesic effect of the *x*-ray is accounted for by

[1] American Medicine, December 13, 1902.

Rockwell on the supposition that the rays set up a circulatory drainage, which diminish the pressure and consequently the pain. In view of the fact that the first action of the ray is stimulating, and that the rays generally cause the pain to cease at the first or second treatment, this theory does not seem tenable.

There are some operators who claim that they have never noted any analgesic effects due to the rays.

CUMULATIVE EFFECT OF THE RAY.

It is very evident, from facts observed, that there is a cumulative or rather delayed effect in the action of the ray. We are led to this belief by the occurrence of reactionary dermatitis after long periods have expired from the time of exposure, and by the fact that frequently, long after the treatment has been discontinued, sloughing continues in cancerous tissues.

The term cumulative effect is a very bad term; it does not say what it means. What we mean by it is, that very often after a number of short exposures the beneficial effects will show themselves for a considerable time after treatment has ceased.

Pusey reports a case of carcinoma of the eyeball and entire orbit; under the x-ray treatment the patient did very well for a time, but later there was evidence of extension of the growth to the brain. Treatment was stopped as hopeless; some time after the patient began to improve and has steadily improved—illustrating the cumulative effect; that is, the continuance of the action of the ray after the discontinuance of treatment.

CHAPTER VII.

TREATMENT OF CANCER.

The wide prevalence and the apparently undoubted increase of cancer in many parts of the world give to this new method an importance far beyond that accorded the ray in many other conditions.

Of the innumerable benefits conferred by Roentgen's discovery, none seems to equal the power of the ray to alleviate the many distressing symptoms associated with inoperable cancer and our ability to improve otherwise hopeless cases and in a limited number to effect a cure.

Unfortunately the decrease in the cancerous mass, at times going on to complete disappearance of the tumor, which led to extravagant hopes that the ray might prove an actual cure for deep-seated and internal cancer has not been followed in a sufficient proportion of cases by that restoration to health of the individual or the prevention of relapse or recurrence which would constitute a cure. If early hopes could have been realized in even a small percentage of severely afflicted individuals, it would have sufficed to exalt this discovery far above the many that have been made in the realms of medicine during the past century. As it is, the power of the ray is effective to a degree which warrants a certain amount of enthusiasm. When we pause to realize that beyond a certain point surgical intervention is useless, and that recurrence in particular situations after one or several cutting operations leaves the patient without further hope, unless from the ray, and that the latter has been abundantly demonstrated to do more than any previously known procedure or method, we must admit that an advance has been made.

A factor of real importance, and one which has not been sufficiently dwelt upon, is the benefit which may come from the ray method in bringing afflicted women under observation at a sufficiently early period to enable the surgeon to secure for them the best chances of recovery.

The ray holds out a justified chance of relief which might and ought, and, as I believe, actually does, lead cancer patients to seek relief early.

The well-known dread of the surgeon's knife and anæsthetics, the widely prevalent idea that all attempts are futile and that they give but temporary relief, deter hundreds and even thousands of suffering women from presenting themselves to the physician until they are practically beyond all hope. Lives innumerable are thus yearly sacrificed to procrastination. While refusal to accept operation has at times proven the part of wisdom, there remains no doubt at the present day that if cutting is done sufficiently early and in a sufficiently radical manner the average of life is greatly prolonged and the proportion of actual cures increased. This method, free from mutilating and disfiguring results often likewise shunned by some, should lead patients to consult their medical adviser early rather than to nurse in secret their suspected foe. Coming thus at the proper time under the right influence the necessary measures suited to the case can be readily and judiciously carried out in connection with the ray treatment.

Few patients having taken this initial step would refuse operation when it is explained to them that we cannot to-day rely fully upon the ray alone, but that administered before and after or in connection with operation a decided hope of success may be entertained.

This, in a measure, the ray has accomplished and is accomplishing, and far distant be the day when this hope is withdrawn from the cancer patient unless we have something in the meantime more promising to offer.

Let not the man arise who will cry, "Away with *x*-ray for inoperable cancer!" until he can proclaim a nearer approach to a cure.

Until some other method will better or so well cause cessation of pain, disappearance of offensive odors, arrest of the invading progress, destruction and casting off of morbid tissue masses, checking of hemorrhage, and that general improvement due to hope born of despair, let the ray continue to be offered to these unfortunates drifting toward a relentless doom. There is likewise a large class of cancer patients in the recurrent stage who cannot be induced to subject themselves again to the knife. In most the surgeon hesitates or says "No." In a certain small percentage success may follow raying. While few can justly hope for cure, almost all can be promised relief or decided amelioration, with freedom from most of the horrors of death from cancer whose details are almost as familiar to the laity as to physicians.

A further advantage, and one it seems to me not to be neglected, is the possibility of operating on otherwise inoperable cases, removing the greater part of the neoplasm and relying upon the ray to attack and destroy what remains. The arrest of hemorrhage is also of decided advantage. In two personal cases this effect was prompt, and so long as the rays were continued bleeding never recurred, though it had previously been frequent and severe.

The severity of carcinoma of the breast is indicated by Küttner's report of forty-one operations from 1880 to 1892, in which the supraclavicular glands were enlarged. Not a single case survived.

How the Ray Acts in Cancer. The ray seems to exert a selective action on the pathogenic growth, and the process by which it disappears seems to be one of drying and shrivelling rather than one of sloughing. The reason for the apparent selective action is not quite clear, but it is probable that it is owing to the low vitality of the neoplastic tissue as compared with the surrounding healthy tissue, which causes it to react most readily. This view is substantiated by the fact that the healthy tissue is very frequently also involved with the diseased tissue, but such involvement generally appears much later than the effect upon the new-growth.

Allen[1] says there is no microscopic change to be found in the pathological or normal cell elements. There is an increase of connective tissue and no strangulation of cells by its contraction, but a decrease in cellular elements. The

[1] Journal of Medical Research, June, 1903

shape of the cell is not apparently altered. Vacuolization is shown by the cells.

In this connection it is interesting to mention a case which was reported by Dr. Douglass W. Montgomery, and demonstrated before the California Academy of Medicine, April 29, 1902:

"The *x*-ray treatment begun October 10, 1901, was continued until the operation on February 10, 1902, that is to say, the *x*-ray was given three times a week for sixteen weeks. It had the effect of causing extensive sloughing, but the cancerous process proceeded as far as one could judge unchecked in the depth of the growth."

A microscopic examination was made of the tissues removed by operation. This showed a typical epithelioma. The superficial epithelial cells which were exposed by the *x*-rays were necrotic. Those in the depth of the tumor, however, were unchanged. The result of this examination would appear to support the assertion of Scholtz, that the therapeutic effect is on superficial tissues only.

Beavan estimates that the distance to which the effectual ray penetrates is only 1 cm. We must bear in mind, however, that having secured an effect upon this depth of tissue, by waiting until the processes of sloughing or disintegration has thrown off the mass, we can act by subsequent treatment upon this deeper layer and so proceed until the entire mass has disappeared.

The ray in cancer exercises stimulating influence upon tissues, and it is probably this action which accounts for the good cosmetic effect obtained, as compared with those from caustic pastes. Discharge, offensive odor, and in most cases pain are controlled early in the treatment. Examination of tissues taken from cancerous growths at the Jefferson Medical College showed intense leukocytic infiltration, over 90 per cent. of the leukocytes being polymorphonuclear, which were located around the bloodvessels in the cancerous tissue.

The condition of degeneration so frequently seen in the epithelium was present, the fine granular appearance of the chromatin and reduced staining intensity being also prominent features.

That trophic change occurs under the influence of the rays is evidenced by the lessening of pain and sensitiveness. Leukocytosis is probably a secondary causative factor in the cure. The action of the rays upon the smaller bloodvessels has been elsewhere noted, and the undoubted action upon the smaller nerve filaments is evidenced by the loss of sensitiveness in healthy skin too long exposed; also in cancerous tissue, where the rays have been applied, large portions being capable of removal without pain.

The power of the ray in lessening pain is almost constant. In nearly every case it disappears after the first few treatments, but in a few rare instances the application of the ray has seemed to be decidedly painful.

In strictly operative cases it seems that we are scarcely justified in substituting for an old method of proven utility a new one of which comparatively little is known.

The altogether incorrect opinion that the ray will speedily abolish the necessity of all surgical operative methods seemed for a time to be rapidly gaining ground. This view is fostered mainly by the quacks and charlatans who have in unusual numbers invaded the fields of electro- and radiotherapy. This can only lead to harm, and the method has much to fear from frauds and fanatics.

However, the opinion of the majority of observers is certainly in favor of using the ray in every inoperable case.

It is at present regarded as a rational proceeding to expose every case to the action of the rays after operation for carcinoma, to prevent recurrence. The rationale of this depends upon the supposedly small quantity but wide distribution of the carcinomatous tissue remaining. From a theoretical point of view there is much to recommend this method, as will be the more readily appreciated by one who has watched the slow dissolution of a massive tumor under the action of the rays. In the treatment of cancer of the breast, the idea at once suggests itself to the close observer that were the tissues less in quantity a great many benefits would accrue to the patient. It would mean speedier treatment, less danger from absorption, smaller quantity to be absorbed with less consequent danger of metastasis, less wear and tear upon the system by reason of the lessened duration of treatment, and a condition of vital strength which does not decrease in so great a ratio that the patient is unable to withstand further treatment just at a time when the greatest improvement is noted locally. All of these advantages are secured when an operation immediately precedes the ray treatment. When this is impossible, of course we must rely upon the ray alone.

On the other hand, it must not be forgotten that one of the most potent arguments in favor of the ray is the fact that the great majority of patients consult the operator because they are convinced or at least hope that there is a method of cure free from the dangers of the knife and an anæsthetic.

While we cannot advocate operation for every case of carcinoma, we can heartily recommend the use of the rays in every case after operation. There are undoubtedly instances in which the patient may escape operation by judicious raying, Harm may arise from stimulation which precedes the destructive action of the rays, and in some few cases this may be sufficient to stimulate the growth to renewed activity. If the rays cause the appearance of untoward symptoms there is always time to operate without danger; and on the other hand, there is a great probability that the tumor will diminish in size and perhaps disappear altogether. It has been suggested by Dr. Coley that we have no right to defer operation in any case where there is a tumor in the breast, because we do not know the nature of it, and we must not, therefore, run the risk of classifying any tumor without first having removed and examined it.

It seems an open question whether it is better practice to remove any growth from the breast for examination, being totally ignorant of its nature, or to expose it to the action of the rays, and thus give the patient the chance of its disappearing painlessly and with little inconvenience.

The permanence of this form of treatment depends essentially upon the nature of the cancer and not upon any action of the ray. This is very clear, as any measure which will cause the disappearance of the cancer will cure it, and if cancer is inherently recurrent in nature then it will recur, whatever the method of extirpation or removal. On the other hand, to indulge in speculative hypothesis, we may imagine that the ray will remove new-growth, but will have no action upon the germ or causative element of cancer. In that case cancer may recur as many times as it is removed by the ray. This, however, is pure speculation and is at least improbable.

There seems to be quite strong evidence that patients treated by the ray are prone to metastasis. The fact that in many instances the tumor mass grows rapidly smaller without the least external drainage or suppuration, shows that the tissue is absorbed and eliminated through the patient's system. It is evident that under these circumstances there would exist a tendency to distribution of cancerous particles throughout the body. It might be argued that the particles thus carried through the body are already rendered incapable of further growth, and that they are not capable of becoming nuclei of new tumors, but we have, unfortunately, too convincing evidence to the contrary. While it cannot be said positively that the occurrence of metastasis is more frequent in these irradiated than in the operated cases, it is no doubt true that many patients show new glandular enlargements while under treatment.

Selection of Cases. It is eminently proper that some discretion be employed in choosing subjects for this method.

In cancer of the cervix for example, seen early, operation should be the method of choice, taking into consideration the inaccessibility for ray treatment and the slight results which have been secured by it. There is not sufficient evidence as yet to warrant us in advocating the ray in primary cancer of the breast which has not gone beyond the operable point. There are certain epitheliomata which would better be treated by other measures alone or at least in conjunction with the ray.

For instance, in the case of a small, sharply circumscribed epithelioma in an inconspicuous location, where the time that the ray treatment would require would offer a serious objection, the treatment by the use of caustics would offer advantages that the ray could not. Other considerations aside, the ray is the most satisfactory method we possess of treating many superficial epitheliomata.

As a rule, nodular, dry-crusted lesions of a warty nature, those having pronounced and hard, rolled border, and those with non-ulcerating and unbroken surface, are among the more unfavorable forms.

Robinson,[1] in a careful consideration of the value of the ray in cancer, states that, for the intelligent treatment of any cutaneous epithelioma by any method, it is absolutely necessary to recognize not only the form of cancer present, and its tendency as regards rapidity of growth and the direction of extension, but also the probable extent of the cancerous infiltration into the neighboring tissues.

There have been two instances of epithelioma out of seventy-one cases treated by us in which the results proved the inadvisability of the method and in which operation had to be subsequently resorted to. One of these refers to a nodular growth beneath the eye, which is referred to at some length in another chapter. The tumor, which had after about six weeks' treatment almost completely disappeared, began suddenly to increase, and in spite of the most carefully regulated and energetic raying steadily spread both in superficial extent and in depth. After operation by a well-known surgeon there was prompt recurrence, and a second operation was speedily followed by death.

In the second case, which related to an epithelioma in the lower lip of a woman, as shown in Plate X., there was improvement almost to the point of complete disappearance, when there was a very marked and rapid increase in size and extent. Since this was not beneficially influenced by a short period of very energetic raying, the patient was referred to my friend Dr. Lloyd, who carried out an extensive operation, as shown in Plate X., Fig. 2. There were soon evidences of recurrence in the tissues adjacent to the cicatrix, and the patient was referred to the electric department of the Post-graduate Hospital for further ray treatment.

A close observation and careful consideration of these two cases, and of rapid and exuberant cancerous growths in a subject of xeroderma pigmentosum, which we will relate in another chapter, have led to the conclusion that the great

[1] Canadian Journal of Medicine and Surgery, December, 1902.

rapidity of development in these growths while under almost constant and so far as could be judged careful application of the ray was a direct result of the action of the rays, and not a natural activity of the diseased tissue which the ray was incapable of controlling. There is considerable evidence in the literature of the subject indicating that the action of the ray is capable at times of causing an increased activity in malignant growths. This could very easily be due to the stimulating action of the ray when the exposures are not pushed to the point of overstimulation and atrophy. As the resistance of every individual is different and we have no other means than direct experimentation to determine the factor in each person, and as the method is slow and at times uncertain, it can be readily comprehended that this untoward effect is a constant menace in every case, and the importance of long experience, careful observation, and extensive clinical knowledge on the part of the operator is emphasized.

Technique. The patient should be placed at 20 cm.; if there is no reaction after a few exposures, shorten to 10 cm. First exposure five to ten minutes; if much reaction, after a week or more shorten the exposure.

Varney gives two short exposures daily for a week or ten days. Some of the best results are obtained after powerful effect, or even the development of dermatitis. The tube should be at a constant distance from the body in order to preserve a uniform condition in treatment. Careful notes should be made, at every application, of the exact data governing the quantity and quality of rays, and the condition of the patient. In recording the latter careful attention should be paid to the appearance of the lesion, general condition, with regard to (*a*) appetite, (*b*) bowels, (*c*) general mental condition, feeling, etc., and comparative condition with reference to last sitting.

It is advisable that a photograph be made of each case before treatment is commenced and at some time during its progress, especially if marked improvement has taken place, and also when perchance a cure has been effected.

Positive improvement in these cases means much more than in many other diseases. It often means to the despair-ing patient what the timely arrival of the commuted sentence means to the condemned prisoner who sits already bound in the electric chair awaiting the signal for the button to be pressed.

Methods of applying the treatment vary within moderate limits with different operators, but all essentially agree that for superficial growths a low tube is to be used, and for deep-seated lesions tubes of a higher vacuum. The principle of finding a tube which will just penetrate the tissue to be treated, and no more, no less, should be our aim. In beginning treatment the exposures should be rather short, varying according to the normal amount of pigment in the skin, the sex, age, and other factors which are mentioned as operative in influencing reaction. The period between the first exposure and the second should be not less than three to five days, preferably longer, as seven to ten days, depending upon the physical condition of the patient and the violence of the effect produced. If the rays are continued at too short intervals, at first the general effect upon the system may be too great and cumulative effects may result in too severe action. When the initiative is too abrupt the liability to burn is greater, while if the treatment is begun gradually the skin may become tanned and thus offer a natural protection which in many cases may wholly prevent the appearance of burn. When the patient has become immune, so to speak, to the treatment, the number of sittings and the length of each may be prolonged up to six or ten minutes every day or every other day. In deep cancers or extensive mammary cancers presenting much ulceration and suppuration, treatment may be prolonged to ten or twelve minutes three or four times per week. It is seldom advisable to exceed this number of exposures, as the amount of waste and broken-down tissue absorbed by the system may embarrass the eliminative functions. During the whole treatment of such cases, the utmost care must be devoted to the hygienic and general constitutional condition of the patient. The bowels must be kept active by the administration of salines. The action of the kidneys must be observed carefully and record kept of the amount and quality of the urine. The first signs of distress of the kidneys is a signal to discontinue the rays. The liver should share these attentions with the kidneys and be kept in good working order. Especially should burn of unaffected tissues be avoided by proper shield protection. Ulcerating surfaces should be kept constantly dressed and free from pus.

Before as well as after raying, surfaces may with advantage at times be painted with methylene-blue solution (3 per cent.), so as to lessen the sensitiveness and to stimulate metamorphosis, destroy germs, and possibly prevent burn. Suitable dressings for sloughing surfaces are the L. L. L. ointment, mentioned elsewhere, which should be spread and applied quite thickly. Ointments containing aristol in 2 per cent. to 10 per cent. proportion are useful to apply to surfaces when evidence of new healthy tissue-growth is present, to assist the process of healing. Where tissue is composed of healthy granulations, a salve containing zinc oxide will be found useful to protect new healthy tissue alongside of old cancerous tissue which may still exist. When there is much pain, as is frequently the case, a 10 per cent. orthoform ointment containing equal parts of lanolin and lard will be found of value.

Surfaces should be cleansed before applying the ray, as it is possible that the absorption of pus and other waste products is markedly influenced by the ray's action.

Autoinfection. In a number of patients treated by us there have arisen at various periods, sometimes early, and once at least after a whole year's treatment, evidences of a general infection of the system by the products of sloughing.

In one patient who was progressing favorably there developed a pseudoerysipelas which extended gradually over the trunk and then the lower extremities, attended with fever, prostration, sweatings, etc.

When the skin is broken, large, cancerous masses necessitate very active irradiation, but it is essential to be on the lookout for manifestation of toxæmia, which necessitates immediate cessation of treatment. There is at first increased secretion and discharge and rapid sloughing of tissue, with subsequent diminution in discharge and contraction of the parts. When the skin is intact the condition is somewhat altered, there being a softening of the hard infiltrations.

PLATE II.

FIG. 1.

Recurrent Carcinoma at Beginning of Treatment.

FIG. 2.

After Treatment.

We have noted in a number of instances, and others have observed the same, that here too general toxic conditions may occur and a decided liability may exist to development of malignancy in the opposite breast. Besides the toxæmia, undue vigor of raying may favor generalized carcinomatosis.

Out of nine cases reported by Mosley[1] several involved the breast, but all resulted badly, the patients dying from exhaustion.

In recurrent cases after operation success will undoubtedly depend largely upon the promptness with which the ray is begun.

Newly Formed Tissue. In treating malignant conditions, a time may arise when the disease has been replaced by comparatively healthy tissue. This condition will be found to be in no way benefited by a continuation of the ray treatment, but, on the contrary, may become greatly irritated by it and retarded in the progress toward cure. The microscope may show an entire absence of cancerous tissue in specimens examined. Benign granulation tissue may be difficult of recognition. It is important, nevertheless, that its presence be noted as early as possible and the rays be discontinued. If the rays are persisted in at this stage, the condition may grow constantly worse and more recalcitrant to treatment, and perhaps develop into what might be called a condition of chronic burn, in which we are almost hopeless of ultimate complete healing. When it is seen that the area is covered with healthy granulation tissue and that a tendency exists in the skin to encroach upon the affected area, that the malignant appearance is gone, that nodules and other irregularities have given place to a smooth, granulating, normal-looking ulcer, then it is time to discontinue the rays and resort to the older methods of hastening cicatrization.

Cancer en Cuirasse. In several patients who have presented disseminated, multiple, and confluent superficial lesions over the chest walls, starting in or near the site of the original tumor, the ray has executed good work. It would seem that here the conditions were most favorable for a successful outcome.

[1] From American Medicine; in American Electrotherapeutic and X-Ray Era, August, 1903.

In the following case there were several interesting points: 1. Total disappearance of recurrent skin- and infiltrated lesions. 2. Disappearance of the hypertrophic scar of operation. 3. Development of jaundice and evidences of involvement of the opposite breast while under ray treatment, as mentioned on the preceding page.

Disseminated Carcinoma of the Chest Wall. Mrs. B., aged fifty-six years, was referred to me on February 17, 1902, by Dr. John Walker, he having removed the right breast on October 15, 1901.

There was almost immediate return in and along the line of incision, with dissemination over the larger portion of the anterior chest wall upon this side. The cicatrix was red and hypertrophic. The arm had been stiff and swollen since the operation.

After the first sitting of eight minutes' duration, the patient stated that the arm had lost all its stiffness and that the pain had vanished. Two days later a persistence of this benefit was reported by her. The patient had resumed work, which she had previously not been able to do for some time. The swelling gradually left the lower arm and hand and the patient felt much encouraged. One month later, after ten applications had been made, the axillary region was found decidedly softer. The open ulcers in the skin had all cicatrized and become covered with crusts, and the nodules had flattened. The patient had been at work, using the arm freely. About two weeks later the tissues became red, had a puckered-up appearance, with dry, glazed surface, and two days later, after decided burning sensations, a dermatitis bullosa developed, extending over the diseased area, and coincidently the skin of the entire body became intensely jaundiced, with accompanying febrile symptoms and chilliness.

When this ray-dermatitis had healed under applications of methylene blue, ichthyol, and zinc ointment, the skin appeared in a perfectly healthy condition, with no evidence of cancer, and the hypertrophic cicatrix from the axilla almost to the free border of the ribs had become so smooth that its location could scarcely be determined by the touch. Shortly after this, however, an induration occurred in the opposite breast, and some months later the patient was reported to have died from pneumonia.

Carcinoma of the Breast. This must be considered under the two aspects of primary and recurrent growths. It was as early as 1897 that Gocht made a report upon two inoperable breast cancers thus treated. In 1901 Hopkins succeeded in decreasing the size of a primary carcinoma and relieving all symptoms. During the past three years reports upon both primary and recurrent growths have multiplied until to-day a rather formidable list can be made from the world's literature.

While with scarcely an exception improvement both in objective and subjective symptoms are recorded by all observers, the number of patients with undoubted carcinoma who have fully recovered and remained well is extremely small.

We must remember that the proportion of primary and early cases is also extremely small, and that almost all coming under the ray during the early years were practically hopeless so far as other methods were concerned. This was true of my own series of ten recurrent cases.

Spring[1] has collected 67 cases from literature. Of these 23 are put down as cured, 5 as nearly cured, 17 as improving, 11 as cured by combined cutting and raying, and 11 as showing no result.

Many of these occur in duplicate in the reports of various operators, so must be considered apart. Of course, the percentage of cures is far too large.

Tracing the history of the supposedly cured patients shows that many of them did not long survive.

Williams reports that out of 13 cases under treatment all but 2 were improving, and in the experience of almost all, this early benefit is most pronounced and striking.

Coley[2] reports 21 cases; a slight improvement was noted in most of these, but none of the growths has entirely disappeared.

Johnson[3] (A. B.) reported upon 10 cases seen during the

[1] Northwestern Lancet, July 1, 1903.
[2] American Medicine, August 16, 1902.
[3] American Surgical Association, May 13, 1903.

past few years; 8 were dead, 1 was in a promising condition, and 1 he regarded as cured. This must be looked upon as really a favorable report, since all were beyond the reach of any other treatment.

Robinson[1] presented a patient in whom primary carcinoma of the breast of five years' duration showed marked improvement after four months' irradiation.

Winfield[2] reported a similar case which had recovered.

Varney reports 13 cases. With one exception, these were considered hopelessly inoperable. By exclusive ray treatment complete disappearance of the growth occurred in three instances; 2 were operated with subsequent ray treatment. There was partial disappearance in 5, and in 3 no effect. Pain was completely relieved in 6, temporarily in 3; 5 are recorded as clinically cured, 3 ended fatally; in 2 there was slight recurrence after one year.

Schiff[3] reports an inoperable carcinoma of the breast which was successfully treated with the rays. There were lenticular metastases on the left half of the thorax and large glandular tumors in the axilla. At present most of the tumors have disappeared and others are very much smaller. A microscopic examination shows a marked increase in the connective tissue.

Mikulicz and Fittig[4] report a case of carcinoma of the breast in a man aged fifty-two years, which showed very satisfactory results from four short sittings. The tumor was much reduced, and after six sittings, extending over four months, it had entirely disappeared. The cicatrix was light red, soft and movable, though the tumor had been rather deeply attached to the muscles and adjacent parts.

In the case of Mrs. E., referred to me by Dr. Arthur S. Bird as inoperable, which was a primary cancer of four and a half years' duration, ray treatment was carried out for five months. For a time there was decided improvement, and the sloughing out of extensive cancerous masses is well shown in Plate III. Severe systemic symptoms soon developed and the patient was unable to continue treatment.

[1] Journal of Cutaneous Diseases, May, 1903. [2] Ibid.

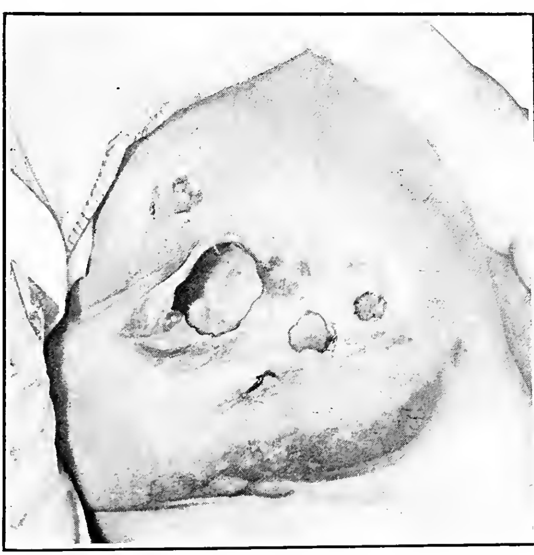
[3] Wiener klin.-therap. Wochenschrift, June 14, 1903. [4] Ibid.

PLATE III.

FIG. 1.

Primary Inoperable Cancer of the Breast.

FIG. 2.



Flattening and Loss of Tissue after Five Weeks of X-ray.

Primary Inoperable Cancer of the Breast. In the case of Mrs. A., practically no treatment had been instituted until a carcinoma of the left breast gland had assumed enormous proportions, about three years from its first attracting attention. She had then employed liquid air for about two years before I was asked to see the case with Dr. A. C. White. There had undoubtedly been very marked improvement from the liquid-air treatment, but its utility had reached a limit, and besides the applications were becoming too painful. Almost the entire left side of the chest was involved from the clavicle to the free border of the ribs, and from beyond the middle line to the posterior axillary region, the arm being almost immovable at the shoulder-joint. The patient was treated for a year with few brief intermissions, with the result of transforming a ponderous mass of malignant overgrowth in which hemorrhages were frequent, and from which the discharges were offensive, into a comparatively smooth, clean, flat, ulcerated surface, which diminished in diameter without cicatrizing to any extent at the margins. While the conditions were in a rather promising state there was a sudden erysipelatous inflammation, starting from the axillary region and extending over the back and down the right side, which in the course of a few days involved both lower extremities. The feet became very œdematous and large bullæ denuded almost the whole extent of surface below the knees. Death occurred with symptoms of profound toxæmia.

Besides these two late primary cases there were five in which the clinical diagnosis pointed toward cancer, but in which no tissue had been excised for examination. In one the tumor disappeared. In a second it had almost wholly vanished when the patient ceased treatment and left the city, but the growth has, I am informed, since returned. In a third there was softening and breaking down of a circumscribed mass the size of an English walnut, the base having a malignant aspect, which, however, cicatrized under continued raying.

The other two cases I have seen only in consultation, and the treatment is still being carried out in an adjacent city.

Of nine inoperable recurrent and all rather extensive cancers, as shown in Plates IV. and V., four have succumbed, and reports from the others indicate that they are, with one exception, gradually sinking.

In each of them, however, there was early improvement and alleviation of symptoms.

In several other cases seen in consultation, in which the ray treatment was advised to be carried out by others, I have no reports available.

A patient whose breast I amputated six years ago thought about a year ago that certain subjective sensations indicated recurrence. A deep-seated nodule was subsequently palpable above the clavicle. Under a short course of the rays all evidence of recurrence disappeared, and no further signs have shown.

Other Deep-seated Cancers. It is of the utmost importance that the question be decided promptly and as definitely as possible, whether we are justified in holding out any hope that the *x*-ray may cure internal cancer. In other words, is there here a cure for those cases which usually progress to a rather hasty fatal ending? At the present time it must be stated in all frankness that once again the high hopes entertained by physicians that in the *x*-ray a cure for such patients was at last found have been cast down. Marked improvement for a time led to a false hope on the part of some early operators that many otherwise hopeless patients could be cured. Such we now know is not the case, and though improvements in its administration may result in a larger percentage of cures, it is scarcely to be expected that more than a small number will ever receive lasting benefits. It is at the present time a mooted question whether the ray is of much value in deep-seated growths, such as those of the uterus, liver, and stomach. It seems a fair statement to make that the rays have a pronounced good effect in a limited number of subjects, but that the chances are slight of obtaining a cure even in cases that are selected as suitable for this form of treatment. It is generally accepted that relief of the most distressing symptoms and probable prolongation of life are fairly certain results, and that these are sufficient to warrant the employment of the method.

PLATE IV.

FIG. 1.

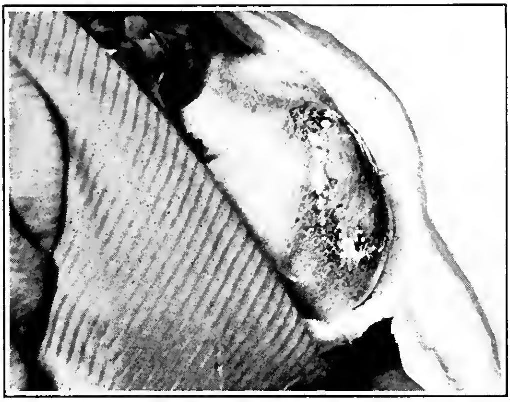
Recurrent Carcinoma of the Glands of the Neck, showing X-ray Burn of the Shoulder.

FIG. 2.

Recurrent Carcinoma after Considerable Improvement has taken place from Radiotherapy.

PLATE V.

FIG. 1.



Recurrent Carcinoma after Operation.

FIG. 2.

Recurrent Carcinoma.

One great disadvantage in the treatment of internal growths is that in most instances they have already attained considerable volume before treatment is begun. Another drawback to the efficacy of the ray is our almost total inability to control the supply of nourishing blood to the part. Here no inflammatory change, so far as we know, is occasioned in the vessels, as it is in the vascular supply of an epithelioma upon the surface. The only effect of the ray to be anticipated, therefore, is the setting up of a degenerative metamorphosis or necrotic destruction.

In internal growths much more careful oversight is necessary than when the mass is externally located. One of two things may occur if inadequate ray is administered. The growth is simply stimulated into increased activity and the fatal termination is hastened, or toxic products so suddenly begin to overwhelm the system that there is less chance of bringing this process to a termination than when an external vent, as it were, exists.

Up to the present time it must be said that the result in these deep malignant growths is not flattering. There is here, as in cancer of the breast, for example, an appreciable and often a pronounced diminution in volume. There is likewise amelioration in general health, in the relief of distressing symptoms, and in the decrease of pain which gives to the method a *raison d'être* which cannot be ignored. In ten deep-seated cancers treated by Skinner there was fatal ending in all, although very marked early improvement was noted in three. He finds the benefit proportional to the length of exposure, and prefers the static machine because he claims that with this a less time is required to produce dermatitis. Of my personal cases, six were of internal organs. While improvement was noted in three it was not permanent in any.

Carcinoma in Inguinal Glands. Of two cases reported by Mosley[1] one showed no improvement and in the other there was apparent cure. The patient had undergone four operations previous to the ray. The first recurrence was in nine

[1] From American Medicine; in American Electrotherapeutic and X-Ray Era, August, 1903.

months, the second in four, the third in four, and after the last, in which the glands could not be fully removed, the ray seemed to accomplish the purpose. Nine months later there had been no recurrence, and a striking feature was the disappearance of left inguinal glandular enlargement while treatment was being applied to the right groin. I have seen diminution in size in several instances.

Cancer of the Larynx. The literature of laryngeal carcinoma is extremely meagre. It would seem that here the ray might have a most valuable field of usefulness because of the slight distance from the surface and the slight obstruction which the tissues overlying should offer to the ray. A somewhat extended trial by many operators has, however, failed to result in any brilliant successes. Disappearance of the growth and of the symptoms has been secured in a number of instances, but this is not synonymous with a permanent cure.

W. Scheppegrell,[1] of New Orleans, reported cancer of the larynx cured by the rays in three months, the patient remaining in good condition up to the time of the report. This patient, I am informed, subsequently died from the disease.

In a second case by the same reporter, a man aged fifty-seven years presented an involvement of the left wall of the larynx, affecting also the corresponding cord. The treatment extended over about six months, the patient being at date of report without apparent disease. No microscopic examination was made, but the author expresses great certainty as to the correctness of the diagnosis.

Spring reports one case improved. One difficulty in treating these cases is in not being able to place the tube near enough to the lesion. Carcinoma of the pharynx was cured by Bibbins with thirty-eight applications.

In cancer of the fauces Grube reports twenty cases, with good results in six.

Technique. The ray should be applied directly to the front of the throat, care being exercised to protect the chin and chest from the possibility of burning or alopecia. The tube should be of moderate vacuum, rather high than low,

[1] New York Medical Journal, December 13, 1902.

though a very high tube will be as useless as a very low one. The same general rules as to time and number of exposures, attention to general details, apply here as in any case of cancer. Applications to the lesion of cleansing astringent or other lotions, provided they contain no metals, can be coincidently employed.

The tube designed by Caldwell for the treatment of cancer of the larynx will, perhaps, be better to use in these cases than an ordinary tube, for although the tube is not perfect, and possesses many disadvantages, the ray from an ordinary tube must penetrate the healthy tissues of the neck before reaching the diseased part, and this is a disadvantage that must be eliminated as often as it is possible in all ray treatments.

Cancer of the Liver. In one case treated by me for several months there was decided diminution in the size of the abdomen and apparently in the tumor.

In one of the gall-bladder, attended with intense pruritus of the entire skin surface, there was little improvement in either the growth or the symptomatic itching.

Cancer of the Rectum. Dr. S., aged fifty-seven years, had complained of hemorrhage from the bowels at different times since an attack of typhoid contracted during the War of the Rebellion. Recently the hemorrhage had increased. A localized pain causing him to consult a brother physician, a mass was discovered and the diagnosis of cancer was made. This was six weeks before the patient came under my observation, on March 26, 1902. The pain had been so severe that sleep was prevented unless large doses of codeine were taken. There was little control over the sphincters of rectum or bladder.

Examination revealed a tumor, preventing the introduction of the finger more than an inch beyond the anal orifice.

Treatment by *x*-ray was begun with a high tube in sittings of seven-minute duration. This was continued three times a week for about six weeks, with the result that all symptoms were improved and the rectal mass was greatly reduced. The use of codeine was given up. The sphincters regained their power so that rectum and bladder control, which had been largely lost, were regained. The patient could now stand up and urinate without defecating at the same time, which had been impossible for weeks before.

There was now a sudden stoppage of the bowels, for the relief of which he was put under chloroform by his physician, and a rubber tube was passed some distance into the bowels.

Following this there was collapse with severe symptoms, including stercoraceous vomiting, incessant hiccough, and total inability to retain fluids, solids, or medicines by the mouth. Several physicians, according to the statements of the family, said it was useless to attempt even to nourish the patient, as he would surely die within a few days. He, however, insisted upon receiving *x*-ray treatment in bed, so an apparatus was installed and his son was instructed how to administer the rays. Improvement set in, and the patient was soon enabled to dress, sit up, and eat a full mixed diet.

This improvement was no less a surprise to me than to all others watching the case. At the end of a month or six weeks, however, the patient died.

Coley and Cook treated one case by interstitial injections of mixed toxins coincidently with the ray for three months; the large tumor of the rectum and sigmoid greatly decreased, but pain persisted.

Coley reports one other sigmoid and nine rectal cases in all, Varney two, Grubbe one, Gibson one, Pennington one, all improved, the latter with the production of much fibrous tissue replacing the cancerous mass. Bryant (Thomas) had good results in a cancerous stricture treated through the perineum. Pusey saw two cases in which the tumors diminished. In all there was relief of pain.

The method of posing the patient is so similar to that to be described under cancer of the uterus that it need not be repeated.

Cancer of Stomach. Rudis-Jicinsky, Skinner, and Wheatland[1] report cases. In the first, while symptoms improved, the patient died. Skinner saw improvement in his case. Wheatland records one apparent cure.

Doumer and Lemoine report good results in two cases treated by them.

[1] American X-ray Journal, March, 1903.

Cancer of the Uterus. No disease is more unpromising to any of the older methods of treatment than is cancer of the cervix. It may be said almost with absolute truthfulness that if we make the proper time allowance for recurrence, no cases are cured by operation. It is consequently in such a field that one is encouraged to investigate most carefully the possibilities of any new procedure. So far as the experience has extended up to the present time, there is but slight encouragement from radiotherapy.

In a post-mortem examination by Phelps, the decided shrinkage in size of a large tumor indicated that the ray employed had a decided effect, though the patient succumbed.

Brandon reports two cases which appeared to be cured. Both patients died, however, a few weeks later with complete suppression of urine and albuminuria. This so well illustrates the futility of an effort to make a statistical table, which would need correcting from day to day, that I will not attempt to give one.

Dr. Cleaves[1] reports the case of a woman, aged forty-two years. The diagnosis was carcinoma of the uterine cervix, with infiltration of the anterior and posterior walls of the vagina and the broad ligaments. The treatment was continued for about six months and the progress was almost continuous and uneventful. When the patient was discharged all the symptoms had disappeared, and an apparent cure was obtained. The reporter states that the case is not presented as a cure, since sufficient time had not elapsed to fully determine that point. This is probably the same case which will be found mentioned again under ultra-violet therapy.

G. E. Pfahler[2] describes the case of a colored woman, aged thirty-eight years, who was brought to the Philadelphia Hospital. Local examination showed extensive involvement of the uterus, vagina, and peritoneum. The rays were passed at first through the abdomen and later through the vagina, using a high vacuum tube. The general health of the patient markedly improved. The ulcerating surfaces

[1] Medical Record, December 13, 1903.
[2] Philadelphia Medical Journal, December 12, 1902.

healed and the nodular carcinomatous masses lessened in size. The discharges lost their fetid odor. The patient being so much improved insisted on leaving the hospital, consequently she cannot be said to be cured, though it is significant that one so far advanced in carcinomatous disease as to be brought in on a stretcher should be able to leave the hospital two months later.

J. W. King reports a case of epithelioma of the cervix which was very much better for a time, but ceased to improve. He attributed his failure to the fact that an *x*-ray burn necessitated stopping treatment.

Technique. In considering the mode of application we must decide primarily whether the whole growth will be included if the raying is carried out through a speculum. If the growth is of limited duration and extent, the latter plan might be profitably adopted. If, however, there is wide involvement of the organ or its appendages the ray would better be administered directly through the abdominal and pelvic regions. This is preferable to the perineal route because burning of the orifices or mucous surfaces in this region seems prone to occur and to heal slowly, causing great annoyance. In Pusey's six cases of pelvic carcinoma he had reason to believe that a positive effect was produced in two.[1] In one case of my own, which this author mentions in his excellent work, there was decided improvement for a time, both in the symptoms and in the local condition, but I am informed the patient has since died.

In cervical cases a tube especially designed for the purpose may be used, having a long, slender projection which will pass through a celluloid, glass, or hard-rubber speculum.

Some advise a low tube with electric force increased to its full limit.

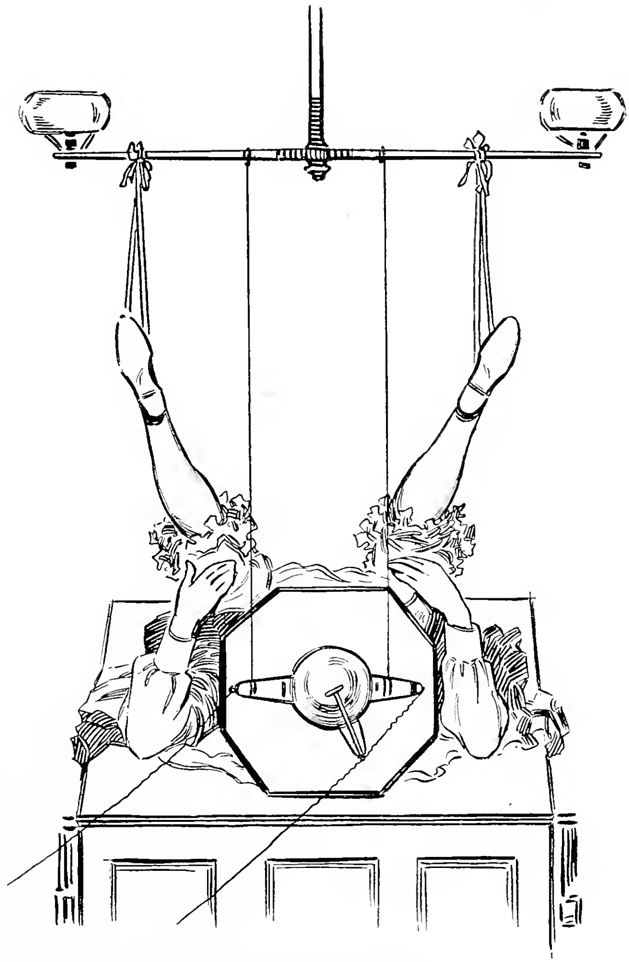
King has devised a special table for the treatment of these cases.

My own method is best described as follows (Fig. 53): The patient lies with the feet or legs supported in leather

[1] Pusey and Caldwell, The Roentgen Rays in Therapeutics and Diagnosis. Philadelphia, 1903.

straps or broad rubber bands suspended from the chandelier or ceiling. The speculum is introduced through the

FIG. 53.



Illustrating method of applying the ray in cancer of the uterus.

central opening in a pad of vulcanite, against which is placed the tube-holder shield with large fenestrum, or the *x*-ray tube is suspended in front of the shield by separate cords.

In many instances, especially when the body of the uterus and vagina are involved, it is better to irradiate the whole area through the lower abdomen and perineum, protecting only the vulva, which is prone to burn readily.

Statistics. Coley reports that out of five cases there was improvement in two: in one after a month's treatment, while one, considered inoperable, was supposed to be cured; cessation of discharges, pain and other symptoms having been noted.

Grubbe reports two cases of recovery. After a burn, lasting for three months, he witnessed recovery in one instance.

Dr. Byron Robinson, of Chicago, after two years' experience in treating cancer of the uterus, says (1) the pain is lessened; (2) the growth of the carcinomatous mass is checked; (3) it diminishes in volume; (4) the carcinomatous tumor softens, becomes more elastic; (5) the secretion lessens in quantity and offensiveness.

Spring treated a cancer of the vagina without benefit. In his collected cases there were four symptomatically cured, seven were improved, seven showed no results, and nine had died. In epithelioma of the vulva Grubbe saw lesions disappear in two cases.

Pfahler saw improvement in three and no result in three cases.

Rudis-Jicinsky is credited with one cure, and Boggs with one case which improved.

Stuver, Duncan, Hopkins, Hett, report improvement in cases treated.

Ultimate Results in Cancer. The test of the method naturally depends in great measure upon the permanency of supposed cures. I say in a measure because, in epithelioma especially, the predisposition or inherent tendency remains in the nature of things uninfluenced, and new lesions may occur after the ray, just as well as after any other method. Recurrence *in situ* must be the crucial test, and still, if the tendency to the production of new lesions persists, we are not surprised to see them develop in the cicatrix of previous lesion, knowing as we do the greater tendency the affection has for cicatricial tissue, no matter how the latter may have been produced. The conditions are therefore about equal.

The percentage of recurrences after cutting operations is given by one writer[1] as 52. To gather statistics for the ray to compare with this will require several years. Present indications would surely point to a much lower percentage of recurrence for all cancerous diseases treated.

[1] Van Allen, Boston Medical and Surgical Journal, June 25, 1903.

CHAPTER VIII.

EPITHELIOMA.

Considerable confusion of terms has occurred since the ray treatment has been so widely discussed. The term rodent ulcer is most carelessly employed at times, some writers showing unmistakably that they look upon it and lupus as identical; this is, of course, unpardonable. Others give statistics of skin carcinoma, superficial cancer, epithelioma, rodent ulcer, etc., in such a hap-hazard way as to lead to confusion. As I have suggested in some previous writings, the term rodent ulcer should be employed only in designating a certain type of epithelioma. This type is well known clinically, and possesses the features of slow development, slow growth, lack of glandular involvement, and little tendency to recurrence *in situ*, after thorough removal, and no tendency to metastasis.

It is especially in this form of cancer that the new method has scored its greatest achievements, and the nearer the type approaches the open rodent ulcer the greater is the chance of prompt success from ray treatment.

Malcolm Morris, who is a firm believer in excision in all forms of malignant disease, advises the use of the ray in many cases of epithelioma and rodent ulcer of the face on account of the excellent cosmetic results and destructive effects upon the insidious non-evident foci.

There exists at the present time still some difference of opinion as to the exact status of the ray, among the many recognized methods of combating this important condition. While it is almost universally acknowledged that the ray is the most nearly perfect and satisfactory of all the methods, for the majority of cases, it cannot be denied that there are factors which render the ray unsuitable in some instances. In the treatment of epithelioma, the Roentgen ray has come to be regarded by some almost as a specific. The fact that it leaves a scar often scarcely to be distinguished from the surrounding normal skin, while its action is painless, are points in its favor which, all else being equal, should place it above other methods.

While caustic pastes have many advantages, as usually applied they are uncertain in their action and painful.

A paste is to be looked upon as a simple cauterant, and, while it effects a destruction of the cancerous tissue and possibly an inflammatory reaction of especial kind extending to surrounding tissues and lymph nodes, antagonizing the cancerous element, is set up, it does not have any stimutlating effect upon the reconstructive functions so far as we know. While the scar may be better after pastes than after cutting and even at times almost imperceptible, it does not equal that obtained by the ray. Here there exists a peculiar power to excite fibrous growth which rapidly replaces the tissues lost. At times the ray causes a somewhat similar appearance to that produced in twenty-four to thirty-six hours' application of my arsenic-orthoform paste—*i. e.*, a vesiculating and charring effect.

The color and texture of the cicatrix leave almost nothing to be desired and the amount of deformity is often minimal. This latter no doubt is due to the stimulating action of the ray on tissue proliferation. The diseased tissue, being of low vitality, is overstimulated and caused to atrophy or become necrosed. The healthy tissue adjacent, being of higher relative resistance, instead of being stimulated to the point of injury, is merely caused to increase to the extent of filling existing cavities with almost normal tissue. This scar tissue possesses the remarkable quality of showing little or no tendency to contract.

In epithelioma of recent development and limited area and depth, the use of pastes will effect a speedy cure, and the resulting scar or permanent loss of tissue will be small, owing to the small extent of the cancerous tissue removed. For this reason it is perhaps better to treat such cases first by the use of pastes. In a location where it is of importance to minimize the deformity to the fullest extent, it is advisable to use the ray.

When the area of cancerous infiltration is larger, but the depth of infiltration is slight, and the growth is comparatively recent, the ray is to be given the preference, as it is not good practice to apply pastes over large areas at a time, while the ray may be applied to the whole area at once; operative measures are rarely to be considered in these extensive ulcerations.

Those cases of epithelioma, which present no broken or ulcerative surface, but a hard, firm nodule or node covered by firm integument, may be removed by the rays, but only after prolonged treatment.

Pastes may by preference be employed in these cases. If the skin be not first removed the action is slower. Besides there is the question of scar always to be taken into account. The method that has given the greatest satisfaction, and that seems the most rational for circumscribed firm nodules, is to apply a local anæsthetic and then carefully excise the tubercle as radically as may be without causing disfigurement. As much of the seemingly healthy skin or that not visibly infiltrated by cancerous tissue is saved and the tissue of the growth alone is carefully scooped out. The rays are then applied to the site until a mild reaction is produced, and it will be found that the result will be better and the total time consumed less than if either the ray alone or a paste had been used. It is not necessary where the ray is to follow to be so particular to take out all of the cancer by the knife, especially in regions of difficult dissection, as the ray will reach all that is left, but the more there is removed, the quicker will be the ultimate cure. Sometimes in these cases, if the rays are applied in the first place, without previous preparation or interference, the nodule will melt away under the ray without breaking down or otherwise disturbing the skin.

Epitheliomatosus. In those cases in which there is manifest a disposition to rapid spreading and the formation of new scattered lesions in different parts, or where the condition of the skin lends itself to the constant formation of such scattered lesions, Robinson thinks the ray may tend to stimulate the skin to healthier resistance of the encroachments of the disease.

In two instances I have observed the development of scattered lesions on different parts of the face and neck while the patients were under x-ray treatment. In one instance the ray was applied at a considerable distance over a long period, and in the other I have not been able to learn what strength of ray had been applied, but when I took charge the patient's eyebrows had disappeared under the ray's influence.

Epitheliomata involving parts adjacent to mucous membranes, as at the edge of the nostril or mouth, or involving the conjunctiva as on the lid or nose near the canthus, are to be treated by the ray, as the selective action is much more marked than that of arsenical paste, for example, and, while the ray is rarely found to cause damage to such membranes, caustics frequently do. When the eye is unavoidably included in the area exposed to the action of the ray, it should be shielded as much as possible, as the ray often causes a slight conjunctivitis when the exposure is prolonged. This is rarely harmful, and the condition responds readily to treatment or gets well of itself if the exposures are discontinued.

Selection of Cases. Generally speaking, the following cases are suitable for treatment by the ray:

1. Those presenting an extensive denuded or ulcerated surface.

2. Hypertrophic change in connection with the epithelial process giving papillomatous and nodular outgrowths may not respond promptly to the ray treatment and should be removed before the ray is applied.

3. When the process involves rather deeply the skin and underlying tissues including the bone, the ray should be given the fullest trial and operative measures be resorted to only when the ray has utterly failed.

4. When there are delicate structures involved, which render it difficult to confine the action of a caustic within safe limits, or where operation would certainly entail disfigurement, the ray is to be chosen as the best method available.

5. When an epithelioma in any location has been previously removed by means other than the ray, the latter should be used in removing the recurrent growth.

It has been remarked that when the malignant neoplasm is of long standing and has extended so as to involve deeper tissues and even to menace large bloodvessels, the ray is perhaps the only method that offers hope of cure.

In our own experience the affected glands in the neighborhood of a cancer may disappear along with the lesion itself. Hence the presence of involved glands need not be considered a sufficient reason for not employing the ray in any particular case.

RECURRENCE. We cannot agree with those who consider an epithelioma of the skin not cured if within a certain number of months or years there is recurrence *in situ*. There is a well-marked and usually well-known tendency for elderly people to develop multiple carcinomatous lesions, often in successive outbreaks or crops, and especially if they are subject to certain kinds of skin irritation such as produced by senile warts, keratoses, and the dry, scaly, and crusty forms of seborrhœa. Knowing as we do the pronounced tendency for carcinoma to develop in scar tissue, it would be rather more than could be reasonably expected that lesions should develop elsewhere and avoid this tissue of known predilection. I think it may be stated quite definitely that *x*-ray does not prevent subsequent outbreaks of carcinoma in skins peculiarly predisposed.

In several of my patients discharged with smooth cicatrix there has been a slight recurrence, but in each known instance treatment was applied at once and the small lesion or lesions were promptly removed, by the ray alone or by one of the combined plans.

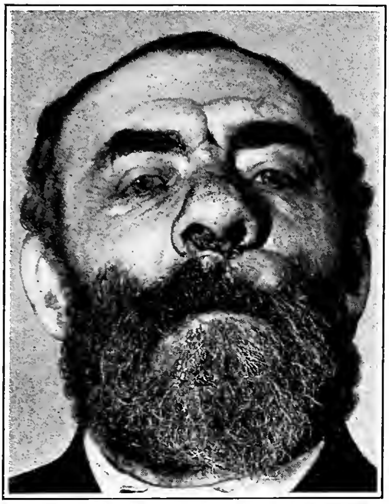
Williams saw several relapses within periods of two to three months. In a lip cancer there were three relapses within a year.

In Figs. 3 and 4, Plate VII., are illustrated an epithelioma of the nose which had promptly healed under the ray, but showed recurrence several months later. A second course of raying removed all signs of the disease.

In Figs. 1 and 2, Plate VII., we have a deep-seated involvement of the nares, recurrent after surgical operation upon the nose and lip, which promptly disappeared, as did also a lesion upon the side of the nose under the ray's in-

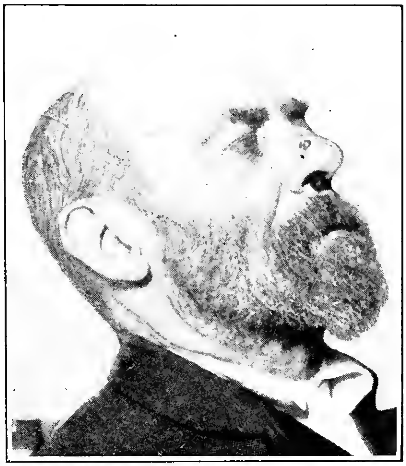
PLATE VII.

FIG. 1.



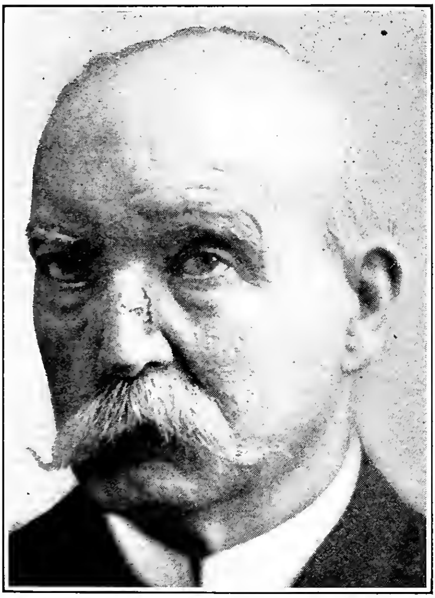
Carcinoma (Recurrent) Lesions within Nostrils as Well as External. Disappeared Under X-ray Treatment.

FIG. 2.



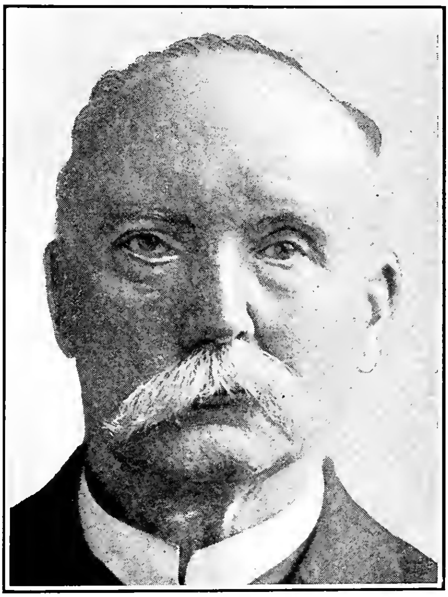
Same Patient showing Lesion on Side of Nose Removed by the X-ray.

FIG. 3.



Epithelioma of the Nose of Several Years' Duration after Partial Improvement by the X-ray.

FIG. 4.



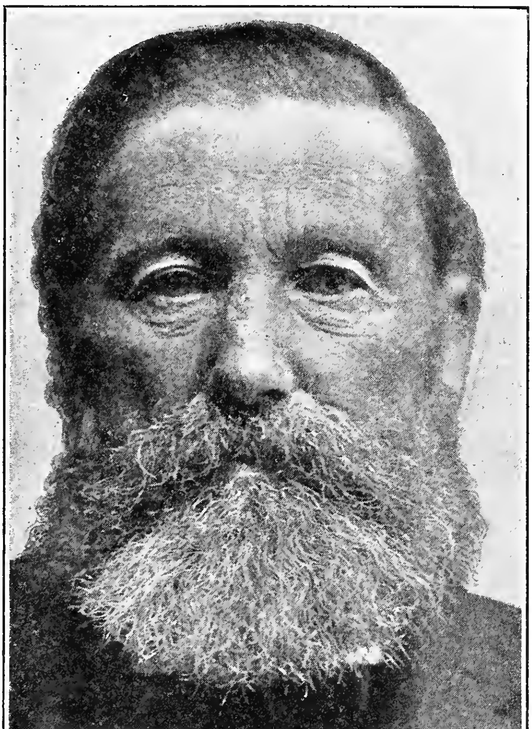
Appearance at the Time of Discharge a Few Weeks Later.

fluence. There was subsequent relapse deep within the nostril, and the ray was renewed with benefit.

A sign of early improvement is the greater tendency of the crust to remain attached to the ulcer.

In other cases without the intervention of dermatitis, the characteristic waxy rolled border flattens, assumes the appearance of a serpiginous vesicle and melts away; or it

FIG. 54.



Epithelioma of the nose removed by *x*-ray.

becomes actually transformed into a succession of vesicles whose domes become removed, leaving open surfaces which promptly heal under ray influence.

At times this outer limiting border of the lesion disappears and is replaced by a warty or rough papillomatous outgrowth which seems more promptly removable by salicylic plaster or the electrolytic needle than by persisting with the ray. Such a case is shown after successful removal of extensive rodent ulcers of the nose in Fig. 54.

DELAYED EFFECTS. It has been a matter of observation that in extensive breast and other cases improvement might continue for months even after the course of rays had been finished. This has been the result in several of those treated by me, and the possibility exists equally for surface epithelioma and, as seen in one instance, for cancer of the lip.

TIME REQUIRED TO EFFECT CURE. Rodman and Pfahler have collected and studied 234 cases. Of these 63 per cent. have been cured and 36 per cent. improved after an average of twenty-five sittings extending over eight weeks.

They find that rodent ulcer requires more time and patience than the other form.

STATISTICS. My personal statistics embrace seventy-one epitheliomas treated by the ray; not all exclusively so, some having been subjected to a combined plan of preceding curettage, application of caustic paste, or the use of electrolysis. The latter has also been employed in many of the cases after scar formation to destroy small vessels in the immediate neighborhood which might act in a stimulating way to favor recurrence. In 58 there was clinical cure.

I have endeavored to draw a comparison between a series of the first 50 of these and a series of 50 consecutive patients treated prior to the rays becoming a known therapeutic agent.

My notes are not sufficiently extensive to enable me to give exact data bearing upon many of the interesting points of comparison of time required, pain produced, appearance of scar, tendency to return, and sometimes even the results are not entered. The figures do not indicate much; still they are, from one point of view, of decided importance.

TREATED WITH AID OF X-RAY.

Number of cases	50
Cured	34
Improved	6
Died from cancer	1
Not improved	4
Disappeared or questionable	5
Recurrence observed	5

TREATED WITHOUT X-RAY.

Number of cases	50
Cured	31
Improved	4
Probably cured	2
Died from cancer	1
Not improved	10
Disappeared or questionable	2
Recurrence observed	4

They show that there is very little difference in the percentage of apparent or clinical cures; likewise in the number of those improved, deaths, and observed recurrences.

In the *x*-ray cases there were three instances of multiple disseminated lesions, many of which were removed, the patients being entered, however, among the improved cases. Two of the second series were subsequently relieved of their recurrent lesion under *x*-ray influence, so appear in both series. Three of the patients of the first series entered as improved were marked as almost cured when last seen; while two of the second series likewise figure as "probably cured."

While a number of those in the second list have been seen or heard from over a period of several years, the longest period for the first series is not over two years.

Thirty-seven cases were reported by Varney. Rodent ulcer type 19. Results: ending fatally, 1; clinically cured, 12; 4 were improved and 2 were referred for operation.

Spring reports 12 cases with 9 cures.

Grubbe[1] reports 123 cases, in 48 of which the results were considered satisfactory; the average time required was four months. He advises the use of medium-vacuum tubes, and believes that the high-vacuum tubes are more dangerous.

Johnson and Merrill[2] report 16 cases of epithelioma with 10 apparent cures.

Bowen reports for the Massachusetts General Hospital 55 cases with 27 recoveries.

Epithelioma of the Penis. In beginning epithelioma of the penis, the ray might prove of value, as the situation is one to which pastes cannot very conveniently be applied,

[1] American Roentgen Ray Society, December 10, 11, 1902.

[2] American Medicine, August 9, 1902.

and in which cicatrices caused by operative measures as well as by pastes might interfere with function. A desideratum in cases of this kind is a rapid means of cure with little danger of annoying scar. Painlessness is also a recommendation to the ray method.

The rules for treatment, and the selection of cases for this form of treatment, are essentially the same as for epithelioma in any other locality. One great advantage of the site, in this form of treatment, is the fact that shielding may be accomplished with perfect exactness, on account of the anatomical features of the parts. Any form of shield may be used, but the best is perhaps a simple foil shield with an aperture that will permit exposure of that portion of the penis only which is affected. The skin of the adjacent parts is to be protected with great care, since being usually covered by the clothing it is very prone to be affected by the ray. The same sensitiveness of the skin in these parts renders epitheliomata of the penis perhaps more sensitive to the treatment than those on the face or other exposed locations. Care should be exercised on this account that the treatment be not pushed too vigorously, as the lessened resistance of these usually protected tissues is misleading when one has been accustomed to the conditions prevailing in other more resistant tissues of the body.

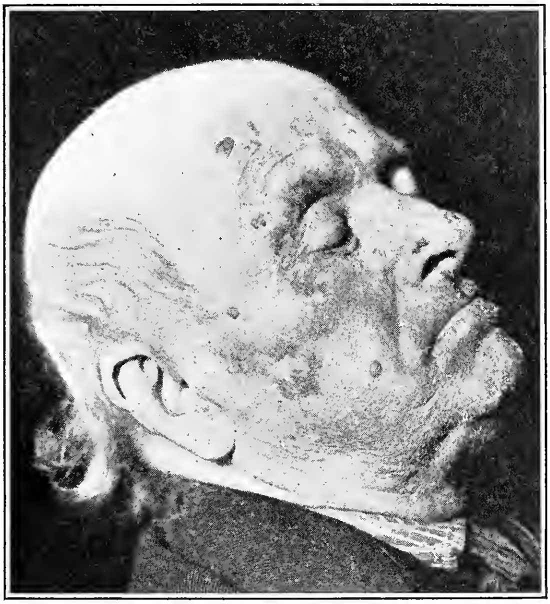
Two cases of epithelioma of the penis, which were treated by exposures to the rays, are mentioned by Turnure, of which one improved and the other did not.

Epithelioma of Nose and Eye Region. The advantages of x-ray treatment are well illustrated in the case of Mr. B., aged seventy-four years, in whom an epithelioma began on the tip of the nose about nine years before coming under my care in February, 1902 (Fig. 55).

This lesion had gradually extended until it occupied the region of the inner canthus and the eyelids to such an extent that surgical operation seemed to me out of the question. Besides this there are scattered over the forehead and cheeks numerous flat, wart-like lesions of disseminated epithelioma and lesions of seborrhœa crustea, which latter might at any moment degenerate in a malignant manner. There was also upon the side of the nose a dry, crusty lesion with waxy border, following a serpiginous course from the tip of the nose to the rodent ulcer above described.

The effect of the ray was here most strikingly pronounced after its first application. The serpiginous border of the dry-crusted epithelioma and of the waxy border of the ulcer were transformed into an appearance of vesiculation. That is, instead of retaining their waxy, solid look, the over-

Fig. 55.



Extensive epithelioma of nose and region of eye after complete disappearance under the ray. Lesions remaining are those of senile keratosis.

lying and adjacent epidermis was reddened and had a puckered look, and beneath this the appearance was that of fluid rather than waxy, firm tissue. In one month and a half from beginning treatment the patient appeared to be cured. He was not discharged, however, but seen from time to time.

Up to the time of the patient's recent death from apoplexy there were, I am told, no signs of recurrence.

Epithelioma of the Bridge of the Nose and Forehead. Mrs. R., aged forty-five years, came under treatment October 7, 1902.

The disease began fifteen years before on the upper part of the nose and spread upward between the brows. It had been removed twice with a knife, but had recurred each time. Ray treatment was begun at once and on November 13th it was practically well. In Plate VIII., Fig. 1, the appearances are those presented after a few weeks' treatment, when improvement was already marked.

The cicatrix is so slight as to be barely perceptible. A year has now elapsed since the last evidence of disease was to be seen, and there has been no sign of recurrence. The appearances now are those shown in Fig. 2, Plate VIII.

MacIntyre reports a case of epithelioma of the nostrils, where the patient regained the sense of smell after the mass disappeared.

Epithelioma of the Ala Nasi. Miss W. (referred by Dr. A. M. Léon on May 8, 1902).

A lesion upon the right side of the nose began twelve years ago as a small, white nodule. For the past three or four years it has become ulcerated and has healed up under treatment, but has never been thoroughly removed. The lower third of the side of the nose was studded with small, pearl-like bodies upon a scar-like base and separated by telangiectatic vessels. Rays were applied once or twice a week.

After the first application of the ray, each separate pearly mass was transformed into a vesicle and a blood crust subsequently formed in its place. When suppuration had occurred there were left small, round, red pits. One week later the condition showed great improvement, and two days after this the condition seemed so far advanced toward a cure that the patient shortly left for a vacation in Europe. On her return in September an ulceration the size of the little finger-nail was found occupying the site of previous infiltrated nodules. x-ray treatments were resumed at almost weekly intervals until March, 1903, when the condition appeared almost cured. I now left for my own trip abroad, since which time I have not seen the

PLATE VIII.

FIG. 1.

Epithelioma of Nose and Forehead of Fifteen Years' Duration, showing Improvement after Short Course of X-ray.

FIG. 2.

Same Patient a Year after Being Discharged Cured.

patient, but learn that she is under treatment in the Finsen Institute in Copenhagen.

EPITHELIOMA OF THE FOREHEAD. Mr. C., aged fifty-four years. The first evidences of epithelioma date back twenty years. He was seen by me in consultation six years ago. Various operations had been performed, in spite of which encroachment upon the orbital contents necessitated enucleation of the left globe, which was most skilfully performed with subsequent plastic operation by the late Dr. Van Arsdale. Three years ago there was recurrence in the region of the forehead. When first given ray treatment in May, 1902, there were two deep round ulcers, with hard, rolled, waxy borders, an extensive forehead lesion of silver-dollar diameter, a waxy nodule on the chin, one on the back of the ear, one on the side of the neck, and one in the middle of the back of the neck, corresponding in size and site to the region pressed upon by the collar-button.

Many lesions surrounded with telangiectatic vessels and brownish pigment deposits resembled somewhat xeroderma pigmentosum. Some of these lesions were treated at the same time by electrolysis. In all fifteen such lesions were treated until complete disappearance. x-ray exposures were made to the forehead with a low tube at a distance of six inches and of five-minute duration. Leaving town at this time for my vacation, Mr. C. was treated by Dr. Gaunt, who had originally referred him to me. Exposures of one hour were given daily at a distance from the tube of four to ten feet for about six months. Exposures were then made every second day at a distance of from ten to twelve feet of one hour average duration. I could see no appreciable change in the lesions from these long-distance exposures. There was at this time, besides, the original morphœa-like plaque of cicatricial tissue into which the electrolytic needle penetrated deeply without pain. Exposures were made for ten minutes, three times a week. There were other scattered lesions of epithelioma upon the nose, ear, and neck. From August 15th to September 10th no treatments were given; on this date a ten-minute application was followed within eighteen hours by an extensive dermatitis of the left side of the face and head; upon the opposite cheek, which was turned away from the tube, vesicles and bullæ developed, involving also the right side of the nose and the mucous membrane, indicating that the ray had passed completely through, affecting the point of exit equally with the point of entrance. This dermatitis lasted from two to three weeks, and when the skin had healed the epithelioma was found much improved. On October 1, 1903, the patient was discharged as cured. It is worthy of note in this most interesting case that after twenty years of almost constant combat, taking advantage of all known methods, it was only with the introduction of radiotherapy that a result could be obtained which approximated or promised to be a radical cure.

Fig. 56.

Cicatrix resulting from the removal of an extensive epithelioma of the forehead and region of the eye and ear by the ray.

Fig. 56 shows the appearances as presented toward the end of treatment. Unfortunately we have no illustration of the disease in its more unpromising stage.

Mr. J. P., aged fifty-five years, seen October 2, 1902, presented upon the side of the forehead a soft, waxy nodule of epithelioma which began about four years ago, but has only recently shown signs of spreading. The lesion had entirely disappeared after about a dozen sittings.

In the next illustration (Fig. 57) is seen the scar resulting from a deep cancerous ulceration of the nose which has been

PLATE VI.

FIG. 1.

Epithelioma of the Forehead, Probably following Lupus.

FIG. 2.

Appearance of Scar after Complete Eradication.

treated by me for many years in a number of recurrences. This time it has seemed that the ray has prevented perforation of the nostril and assisted materially in the process of cicatrization.

Mrs. M., aged fifty-two years. The history shows that at the age of ten years the patient fell and cut her forehead. There was left a red, raised scar. Twenty-four years ago,

Fig. 57.

Result in a long-standing cancer of the nose.

on rubbing this scar tissue, slight bleeding occurred, followed by a crust. This was picked, but instead of healing extended until it became the size of a twenty-five-cent piece, with a "seam-like elevation around the edge."

Since 1891 the lesion has been operated upon several times in a variety of ways by different physicians.

The lesion shown in Plate VI., she says, has been considered a lupus, but at the time she came under my observation the clinical features were those of epithelioma, the case probably belonging to the rather restricted class of cases in which lupus makes this change at some stage of its course. The ulcerated portion of the lesion is exquisitely tender and at times spontaneously painful. This was first treated by me in April, 1901, with an arsenical paste made with orthoform. In spite of decided improvement and healing over of ulcerated areas, there were evidences of recurrence in 1902 when the *x*-ray was employed. For over a year there has been a perfectly firm cicatrix, as shown in Plate VI., Fig. 2, with no evidences of recurrence.

The effects are far from being uniform in the various clinical types of skin cancer. The belief held by many that decided pathological differences in structure are likewise to be found is strengthened.

In my personal experience nodular non-ulcerating lesions frequently do not do well. Such a case is that following.

Epithelioma of the Cheek. The failure of the ray is markedly exemplified in the case of Miss C. There was a firm, dry, nodular growth with adherent central crust beneath the left eye which had existed for six months. The ray was persistently applied from June 20, 1902, to March 17, 1903, over sixty exposures being given. In spite of occasional evidence of improvement, there was extension into the deeper parts. The patient was then referred to an eminent surgeon by Dr. Léon, who had sent the patient to me, and the growth was deeply excised. Recurrence was prompt and a second operation was done with extensive removal of bone from the orbit and upper jaw, followed by a plastic flap operation. Following this there was further recurrence and death a few months later.

In a number of open cancers here located there has been healing which has persisted for over a year in some instances. In two only out of seventy-one has there been known recurrence.

In Plate IX. is shown the condition before and after ray treatment in an epithelioma beneath the eye.

Epithelioma of the Lip. The chief reason why epithelioma of the lip has not proven as amenable to the ray as

PLATE IX.

FIG. 1.

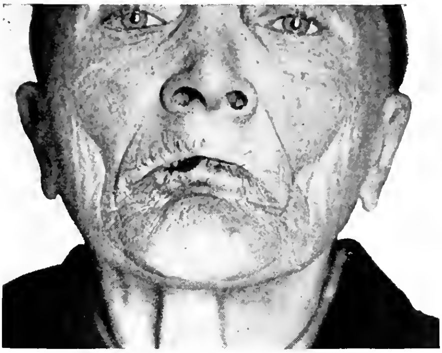
Epithelioma Beneath Eye of Eighteen Months' Duration.

FIG. 2.

Appearance after Two Months' Treatment.

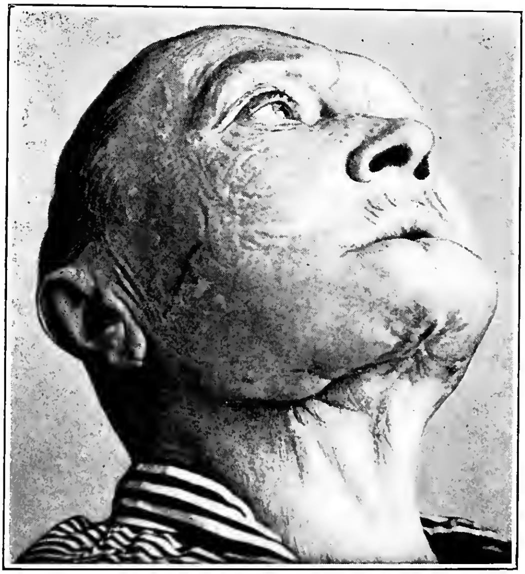
PLATE X.

FIG. 1.



Epithelioma of the Lip Treated without Benefit and then Removed with Knife.

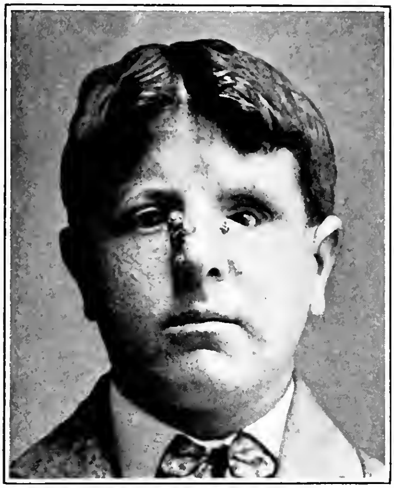
FIG. 2.



Recurrence in Scar after Excision Successfully Treated by X-ray.

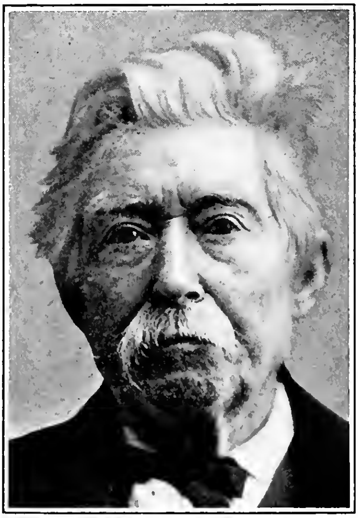
PLATE XI.

FIG. 1.



Epithelioma at and near Canthus in Xeroderma Pigmentosum.

FIG. 2.



Photograph Taken Two Years after Discharge of Patient as Cured of Extensive Epithelioma of the Nose.

similar neoplasms upon the skin surface proper seems to be because of the greater blood supply and more lax tissue.

If a stimulating effect of the ray is inadvertently given instead of securing a destructive action, the cancer may be excited to increased growth.

In eight personal cases of lip cancer, two have been of the skin surface only of the upper lip and in connection with lesions of the nose. Both of these did well.

Of the other six, four are regarded as cured. One was treated with caustic paste before the ray, and two were recurrent after cutting operations.

Varney finds this variety most obstinate. Only in the superficial variety can the ray be relied upon alone. If an operation is contemplated a preceding short course of x-ray may not be amiss, but, as I have mentioned above, there may be extension of the process. The first evidence of this should be the signal to resort to the knife or cautery.

In view of a number of eminently successful trials of caustic paste I am more than ever in favor of first eating out the cancer in this way and then using the ray.

Grubbe reports twenty-one cases of lip cancer with satisfactory results in ten. Mosley and others report single cases as cured. Pusey found no benefit if the glands were already involved.

In Plate X., Fig. 1, is shown an epithelioma of the lower lip in a woman. Although this is considered a rare location for cancer in females, I have observed several and have successfully treated one in this sex recently with my arsenic-orthoform paste. In the present instance the x-ray failed to produce good effects and the patient was referred by me to my friend Dr. Lloyd, who made a very successful extirpation. Agreeing with me that the ray should be applied subsequent to the surgical intervention, a course of raying has been carried out by Dr. Vincent at the Post-graduate Hospital.

I am informed by Dr. Branth that the patient showed some evidence of recurrence which disappeared under the ray. I wish to express my indebtedness to Dr. Morton for permission to use Fig. 2, Plate X., in referring to the subsequent course after the patient passed from my care.

Mr. J. B., aged forty years, came to me on August 1, 1902, with a lesion of the lower lip which had begun one year before. Patient smokes a pipe which he holds equally on both sides of the mouth. There are two lesions present: one near the centre of the lip, the other well to the side. The latter has a distinctly waxy border. The submaxillary gland is enlarged but not very sensitive. On August 22d the submaxillary glands were palpable on both sides; that on the right side and away from the lesions being the largest. Rays were given three times a week and patient was discharged clinically cured after seven weeks. At this time the submaxillary glands were no longer to be palpated as they were when the ulcer was open and inflamed.

In Plate XII., Fig. 1, is seen a picture of a patient referred to me by Dr. S. J. O'Neil. The epithelioma on the cheek was of two years' duration, and when first seen showed symptoms of great malignancy. Fig. 2, Plate XII., was taken seven weeks after treatment had begun, when the lesion had entirely disappeared.

In Plate XIII., Fig. 1, is seen the picture of a patient referred to me by Dr. H. C. Neer, with a long-standing epithelioma extending from the lower part of the lobule of the left ear to the angle of the jaw. In this patient a dermatitis was produced after three weeks' treatment, which healed rapidly. Fig. 2, Plate XIII., shows the condition six weeks after treatment had begun.

Cancer within the Mouth. Carcinoma upon the mucous surfaces of the mouth, tongue, buccal membrane, etc., do not do well as a rule under radiotherapy.

In a patient sent me by Dr. George Brewer, on whom he had operated about two months previously for cancer of the tongue and jaw, already far advanced, there had been rapid recurrence. Under a month's ray treatment there was some improvement, though suspicion of involvement of the larynx existed. The gentleman returned to his home in South America, expecting to continue the *x*-ray there.

Coley reports three cases of tongue cancer which showed improvement.

Grubbe reports thirteen cases of cancer of the tongue, with good results in seven.

PLATE XII.

FIG. 1.

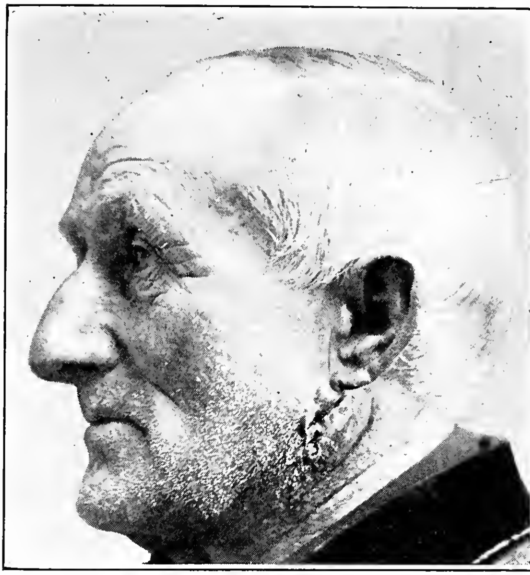
Rapidly Growing Carcinoma.

FIG. 2.

Result after Seven Weeks of X-ray Treatment.

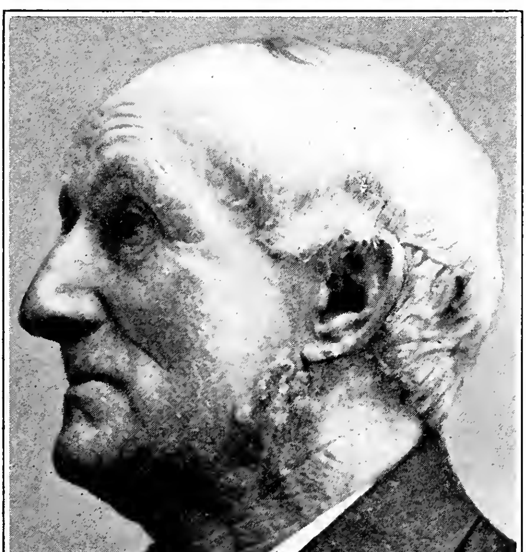
PLATE XIII.

FIG. 1.



Epithelioma Extending from Lower Part of Ear to Angle of Jaw.

FIG. 2.



Good Cicatrix, no Evidence of Cancer.

PLATE XIV.

FIG. 1.

Epithelioma of the Cheek.

FIG. 2.

Result after Seven Weeks of X-ray Treatment.

FIG. 3.

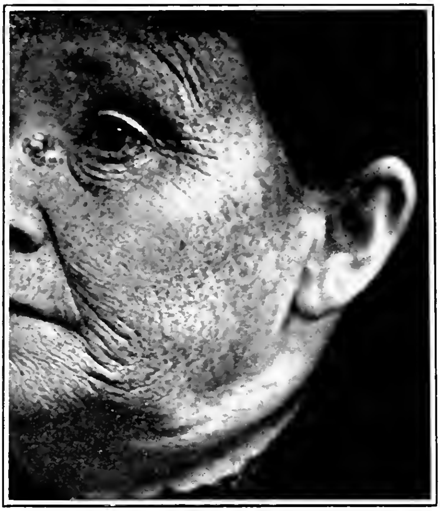
Epithelioma of the Lip.

FIG. 4.

Appearance Six Weeks Later.

PLATE XV.

FIG. 1.



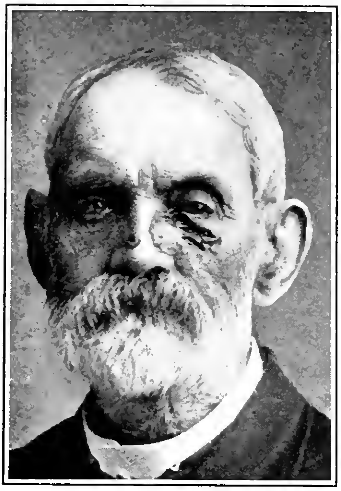
Epithelioma of Nose, near the Eye.

FIG. 2.

Picture Taken Two Months after Treatment.

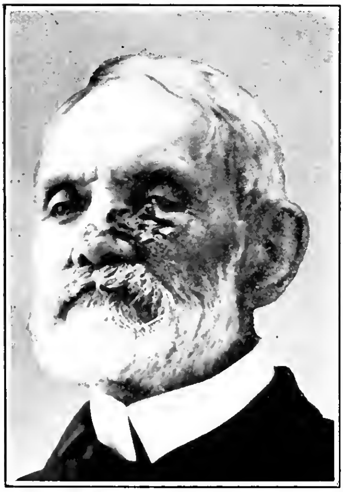
PLATE XVI.

FIG. 1.



Epithelioma Involving Lower Lid and Internal Canthus.

FIG. 2.



Appearance at about Time X-ray Treatment was Begun, February 20, 1904.

FIG. 3.

Photograph Taken April 10, 1904, Fifty Days after First X-ray Exposure.

Dickson has noticed ill effects in extensive breaking down of tissue, and this too without retarding the growth.

Engman[1] reports a case in which a slough was produced. There was no recurrence in nine months.

In a papilloma, not examined microscopically, but thought by some to be malignant, there was prompt disappearance under exclusive radiation.

Beckett reports two cases of epithelioma of the tongue in which the submaxillary glands were removed and the lesions treated with the ray, with very satisfactory results.

In Plates XIV. and XV. are shown cases of epithelioma promptly removed by the x-ray.

In Plate XVI., Fig. 1, is shown an extensive epithelioma involving the internal canthus, lower lid, and side of nose. Fig. 2 shows the appearance of the patient at the time x-ray treatment was begun, and Fig. 3 shows the condition fifty days after the first exposure.

[1] American Dermatological Association, May 12, 1903

CHAPTER IX.

SARCOMA.

A SEEMINGLY most favorable showing for various forms of sarcoma in the earlier days of radiotherapy led physicians to a possibly somewhat exaggerated hope that at last a means had been discovered of successfully combating this most fatal malady. Patients were relieved of rapidly growing tumors, and some appeared to have even made full recovery, when recurrence would put a speedy ending to the patient's struggle for life and to the physician's efforts and hopes. On the other hand, it must be admitted and should, indeed, be claimed and proclaimed with some degree of pride and satisfaction that large and rapidly enlarging sarcomas can be made to disappear in a manner wholly unknown before the introduction of the ray.

Thus, time at least is gained, and there is strong reason to believe that this can be taken advantage of to pursue, along with radiotherapy, such other lines of treatment as offer hope of success. Among these are to be mentioned electrolysis, the employment of toxins, possibly radium and its emanations, and various drugs internally.

The weight of authority to-day would seem to indicate that the ray alone, while capable of causing disappearance of sarcomatous masses and inhibiting increased growth while being employed, has so far shown little power to prevent recurrence.

The known hopelessness of operating for most varieties of sarcoma, and the gloomy outlook for sufferers from this form of cancer, render the ray's possibilities of the utmost importance.

In reviewing the results achieved we must bear constantly in mind that prior to the ray method no permanent benefit could be promised from any means at our command.

Sarcoma of the tissues of the neck may be regarded as one of the gravest pathological conditions known.

So far as the writer is aware there exists to-day no authentic record of primary sarcoma of the tissues of the neck cured by operation.

Reports available, while they make a fairly good showing, considering the gravity and hopelessness of the disease, are still too recent to be of the greatest value. Cases entered to-day among the clinically cured are unfortunately all too likely to be found in the list of dead in a report made three months hence. A number of apparent cures have been reported by Pusey (1), Richmond (1), Boardman (1), Coley (4), Dixon (1 practically cured), Bowen, Kirby,[1] Fiske, Winfield, Evans and Williams, and others, but "cures" which have stood the test of time are rare. Spring[2] has analyzed 74 cases found in literature. Of these 17 are placed among the cured, 5 improved, and in 47 life was prolonged.

Varney[3] gives 13 personal cases, all showing recurrence or death. Coley reported 25 inoperable cases up to January, 1903, without favorable result. Out of 36 patients only 4 had been cured. Pusey[4] reports upon 11 cases. In a round-celled sarcoma of the neck considered inoperable the tumor disappeared. Two were relieved of all pain.

In sarcoma of the kidney Scott saw general improvement and cessation of hemorrhage.

In a supposed sarcoma of the thoracic cavity referred to me by Dr. Morrell, causing great bulging of the chest wall, there was early improvement. The subsequent history I have been unable to learn.

Kienböck[5] reports a very interesting case of sarcoma cured by the rays. It was one involving the mouth, fauces, antrum of Highmore on both sides, protruding into the orbits and pressing upon the optic nerves, producing complete blindness; also large tumor-like masses extending from the nostrils. The tumor was excised a number of times, with prompt recurrence. Thirteen not very intense exposures

[1] Journal of Advanced Therapeutics, 1902, xx.

[2] Northwestern Lancet, July 1, 1903.

[3] Journal of the American Medical Association, June 6, 1903

[4] Ibid., April 12, 1902.

[5] Wiener klin.-therap. Wochenschrift, January 31, 1904.

were given through a course of three months, resulting in a complete disappearance of the tumors in all the affected parts. The patient regained vision sufficiently to be able to get about without any assistance. The diagnosis of sarcoma was made certain by histological examination.

Grossman[1] reports a similar case. A sarcoma having its origin in the nostrils was repeatedly removed without effect. He was referred to Dr. Kaiser for ray treatment on September 15, 1903, and was still under treatment at the time of the report. The patient is practically cured, showing very little remains of the disease.

Dr. George E. Pfahler[2] reports a case of retrobulbar sarcoma which after four months' treatment is apparently cured.

Sarcoma involving the tonsil was seen by S. Allen to shrink and permit of greater ease in eating and talking.

My own experience relates to the fatal case of metastasis mentioned on page 220, and a supposed sarcoma of the kidney in a lady being treated by the ray in a neighboring city, whom I see in consultation from time to time. In the latter case the pain has decreased and there has been general improvement, but no diminution in size so far to be made out. Also a patient referred to me by Dr. John Walker with the clinical diagnosis of sarcoma of the chin, in which I concurred, as did also Dr. Stern. Here there has been gradual though slow improvement, until now the entire mass has disappeared as well as neighboring glandular swellings. (See Plate XVII.)

Lymphosarcoma. Varney[3] reports 6 cases with no recoveries.

According to Coley, primary sarcoma of the lymph nodes yields more readily than other varieties.

In the case of Mr. B., referred to me by Dr. Holland at the suggestion of Dr. Whitney, of Denver, who saw the patient in consultation, pronouncing it a sarcoma, there was a tumor overlying the right inferior maxilla and encroach-

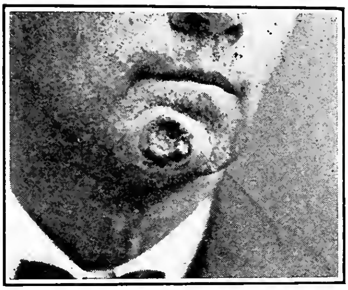
[1] Wiener klin.-therap. Wochenschrift, January 31, 1904.

[2] Pennsylvania Medical Journal, January, 1904.

[3] Journal of the American Medical Association, June 6, 1903.

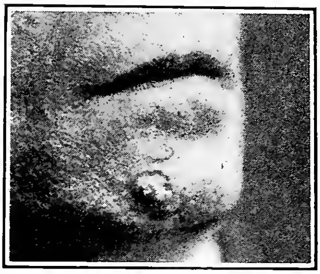
PLATE XVII.

FIG. 1.



Sarcoma of the Chin of Seven Months' Duration.

FIG. 2.



Appearance after Five Months' Treatment.

FIG. 3.

Disappearance of Tumor with Good Cicatrix after Seven Months' Treatment.

PLATE XVIII.

FIG. 1.

Lues Hereditaria. Mistaken for Lupus, and Treated for Years without Results.

FIG. 2.

Appearance after One Month of Treatment.

FIG. 3.

Resulting Scar Tissue Improved by X-ray.

ing upon the fauces, nose, and ear, and even involving the external auditory canal so far as several ear specialists could determine. From the beginning of ray treatment there was decided alleviation of symptoms and decrease of pain so that narcotics could be dispensed with. A plaster cast was taken before the rays were begun, and a second cast taken subsequently showed a decided diminution in size. A lesion within the external auditory canal believed to be of the same malignant nature entirely disappeared, and there was for a time decided improvement in the hearing and of subjective symptoms in this region. The last-mentioned benefits must be, in part at least, attributed to the daily application of the high-frequency current by means of a specially devised ear electrode.

Melanosarcoma. Dr. J. D. Gibson[1] reports a case of melanosarcoma in a man, aged forty-six years, entirely cured. The technique was similar to that usually employed, a plate machine being used.

Marsh, of Troy, speaks of a patient with melanosarcoma, whose body was covered with 3000 metastatic tumors beneath the skin, originating in a "black mole" which had been excised. The blood count showed 18,000. There was a decrease in leukocytes of 2000 after each sitting, but the patient grew gradually worse.

Skinner reports good results in a tumor of the ear which had been operated upon three times.

Exner[2] mentions an inoperable case in Gussenbauer's clinic greatly benefited. There were metastases in the skin, many of which subsided.

Beck reported an advanced case which improved for a time, but ended fatally.

Harper[3] saw three pigmented areas disappear from the sclera which had persisted after operation for melanosarcoma.

Lord,[4] Pratt,[5] and others report cases.

[1] Alabama Medical Journal, November, 1902.
[2] Wiener klin.-therap. Wochenschrift, June 18, 1903.
[3] American X-ray Journal, 1902, iv.
[4] Western Medical Review, August 15, 1902.
[5] American X-ray Journal, October, 1902.

During the past winter I have watched with much interest the improvement in a recurrent melanosarcoma of the palm excised by one of our most distinguished surgeons, and wisely—as I believe—advised to follow out a subsequent course of ray treatment. The gentleman placed himself after a few weeks in the care of my associate, Dr. S. Stern, who gave about fifteen treatments. When first seen the cicatrix was thickened, tender, red, and at one of its extremities there was a round, brownish-red discoloration, indicating strongly a recurrence *in situ*. The scar flattened notably under the ray, the redness and tenderness disappeared, but the mole-like pigment deposit remained. Subsequently two similar deep-seated pigmented lesions appeared in other portions of the palm.

I now advised, while continuing with the ray, to treat each lesion with the electrolytic needle. This was carried out, with the result of entirely removing the original growth and causing the two newer ones also to disappear. The patient being called to Europe promised to have treatment carried out while abroad. At present the history cannot be completed, but that from this combined plan there was decided benefit there can be no doubt.[1]

A sarcoma of the ring finger in a healthy appearing young man, referred to me by Dr. Pusey, of Chicago, in November, 1901, had originated in a congenital, brown, flat mole, which had become irritated by the ring which the patient wore to hide the growth. It had been once excised but had recurred along the line of the cicatrix. When first seen the axillary nodes were already decidedly involved, having begun to enlarge five weeks before. Against my advice, which was to begin ray treatment at once, or at least in combination with renewed operation, he had a simple excision performed and went about for some three months in fancied security. I was asked to see him shortly after this. He was then upon his death-bed, emaciated, suffering excruciating pain from extensive metastatic recurrence in the kidneys, spinal cord, bladder, and probably other organs.

[1] While abroad patient underwent excision of larynx for malignant growth. On his return there was one small new pigment nodule in the palm, which was removed by electrolysis.

Since he had had one or two early irradiations, and because they were again given at the last simply for his peace of mind and with a hope of allaying pains, his case is included in my list.

This case at least teaches the little hope of benefit we can expect from the knife.

It also serves to emphasize the great importance of preventing irritation of these embryonic structures. I have for years taught and practised the advisability of early proper removal of melanotic moles, since patients themselves so often injudiciously attempt to tie off or cauterize them, thus furnishing the very best chance for malignant degeneration.

While I have more than once observed rapidly fatal generalized melanosarcoma from the patient's own inadvertent act, in the hundreds of cases in which I have employed the electrolytic knife-needle, whose use I described a number of years ago, I have never known of injury resulting. It seems only fair to claim that in this prophylactic procedure many sarcomas as well as carcinomas are prevented.

A case of extensive alveolar melanotic sarcoma of the cheek and neck in a man, aged thirty-one years, is reported cured by Dr. Walker,[1] of Evansville, Ind.

The growth was twice excised and examined by Dr. Cline, of the New York Post-graduate School, who confirmed the clinical and microscopic diagnosis of others.

The sittings were extended to as much as thirty minutes, and given daily. No "burn" was produced. At time of report there had been no evidence of disease for several months. The time is, of course, too short for final verdict.

Osteosarcoma. In recurrent osteosarcoma after operation the prolongation of life, decrease in the growth, and improvement which increases after cessation of treatment may at times be claimed.

This statement I feel warranted in making from the results in a case of my own.

Mr. N. S., aged thirty-nine years. Swelling of jaw began over three years before he came to me (August 16, 1902).

[1] American Electrotherapeutic and X-ray Era, September, 1903.

He had been operated upon four times by excellent surgeons, always followed by recurrence. Examination showed sarcoma. He had already been given sixteen ray treatments in hospital. After a few sittings the pain which had been almost unbearable disappeared and for a year there has been little or no return of pain.

A radiodermatitis involved the conjunctiva and mucous surface of the cheek and caused the buccal membrane to resemble luetic leucoplakia. This resulted from applying the rays through the mouth to an extensive ulcerating tumor of the jaw, palate, and pillar of fauces.

The patient was recently seen after a long interval and the improvement still persisted.

In a second case there was no diminution in the tumor of the jaw nor any lasting relief of pain, and the patient disappeared.

In a third patient, still under treatment, there was relief of pain almost from the first, general improvement, diminution in the size of tumor, both within the mouth and externally. The ear was involved; a bleeding mass occupying the auditory canal was held in check by the ray.

Dr. Carl Beck has reported a case of osteosarcoma of the orbit. The patient was a woman, aged forty-two years, and the first signs of cancer of the orbit had been noticed fifteen months before the eye was enucleated, but a very speedy recurrence ensued. When first seen the tumor extended over the whole frontal bone. It was considered good practice to remove part of the tumor and treat the remaining portion by means of the rays. The treatment was commenced tentatively at first, but as the growth did not seem to be inhibited, treatment was pushed more boldly, resulting in great improvement.

In seven osteosarcomata reported by Varney there was a marked diminution in size on careful measurements made each week; there was also great diminution in pain except where great metastasis had taken place or where the tumor was secondary to an involvement of the vertebræ.

In osteosarcoma following trauma with severe pain and paraplegia, in the practice of Murphy, of Chicago, pain disappeared after the third treatment, and paraplegia after twenty-five sittings.

In a case observed by Burdick for three years in which twenty grains of morphine daily were required to allay the suffering, there was decided improvement and no progression after the ray treatment was begun.

In a second patient treated for a year the growth diminished two-thirds. In another the growth remained stationary for a year.

Ali Krogius[1] reports a sarcoma of the skull cured by the ray. The patient was a man, forty years old, presenting a tumor, about the size of a closed fist, attached to the periosteum. The upper part of the tumor appeared to infiltrate the bone itself, with small nodules scattered through the adjoining periosteum. After two months' treatment all the tumors disappeared, but treatment was continued two months longer. There was no recurrence.

Round-celled Sarcoma. A round-celled sarcoma of the neck, cured by the rays when it had recurred after operation, is reported by Blacklock.[2] The patient was a young married woman who noticed what was at first taken to be a simple lymphatic enlargement on the right side of the neck, but which grew so rapidly that after three months' time it was deemed necessary to remove it by operation. Examination proved it to be round-celled sarcoma. The tumor recurred in the site of the cicatrix. Two treatments were given daily of about ten minutes each, at a distance of about six inches from the target. Dermatitis was produced in about twenty days. The pain had ceased after the fourth treatment. In about twenty days more the treatments were resumed, and continued for about three weeks, when the patient was discharged as cured. At the end of four months the patient remains apparently well and suffers no ill consequences and shows no apparent tendency to recurrence.

Kirby[3] reports on an enormous inoperable tumor of the neck which disappeared under treatment. I had an opportunity to examine this patient after he had ceased treatment, and the condition of the scar was all one could wish for.

[1] Läkar. Handb., 1903, No. 8.
[2] Medical Sentinel, January 1903.
[3] Journal of Advanced Therapeutics, February, 1902.

A few months later a fatal ending proved the hopes to have been deceptive.

In a remarkable case of orbital and maxillary sarcoma which I saw several times by the courtesy of Dr. Snow, decided improvement took place for a number of months, and at one time gave the greatest encouragement, so nearly had it disappeared.

Other patients who seemed for a time to be on the road to recovery have been reported by Morton, Skinner, and others.

Coley reports extensive inoperable round-celled sarcoma of the neck, pectoral region, and axilla which disappeared. In three months, however, there was extensive metastasis, apparently located in the mesentery of the colon; under four exposures a week for six weeks the mass decreased one-half and was still improving when the report was made.

In four cases of inoperable round-celled sarcoma reported by the same author, the tumors entirely disappeared. Up to date of report (November 17, 1902) three had remained free from recurrence. By January 23, 1903, there was recurrence in every case.

J. G. Chrysospathes[1] reports a very remarkable case of sarcoma of the abdomen cured by the rays. The patient was a woman, thirty-five years old, who developed a tumor, the size of a child's head, in the right side of the lower part of the abdomen. Laparotomy was performed, and it was found that the tumor was inoperable, as it was adherent not only to the anterior abdominal wall, but also to a large mass of small intestines. It apparently started from the right ovary. A small section was excised, which on examination was found to be a small round-celled sarcoma. A few days after the operation a fecal fistula developed. The pain became very severe, and a marked infiltration and spreading of the tumor along the right round ligament occurred. All this time the fistula was open, and the flat sarcomatous abscesses developed along the scar of the incision increased in size and number. The patient developed a general cachexia. The rays were given with a medium tube, at first

[1] Münchener med. Wochenschrift, 1903, No. 50.

every second or third day for two or three minutes, at a distance of 30 cm. Later the current was gradually increased from two and one-half to four or five ampères, the length of exposures raised to five or ten minutes, and the distance from the tube diminished to 20 to 15 cm. The pain was permanently stopped after the first few exposures. The abscesses along the scar opened spontaneously and healed in a few days. The fistula closed, and the general condition of the patient became very much improved. The tumor persisted in size at first, but after a few weeks it began to diminish very rapidly in volume. The thickening of the ligament gradually lost its hardness, and finally disappeared. An examination, made a few months after treatment, of the abdomen *per vaginam* showed no traces of the disease.

Fibrosarcoma. In a patient treated by Torrey and apparently cured, death resulted from typhoid. Examination of the scar after death showed no trace of recurrence.

Spindle-celled Sarcoma. A spindle-celled sarcoma of the arm is depicted in the third edition of Williams' work and recorded as cured.

One of the pelvis and abdominal wall showed remarkable improvement in a case reported by Skinner. This patient was treated by mixed toxins for a year without any effect.

Rodman has never observed benefit from the toxins in the spindle-celled form; still, in combination with the ray, he thinks it might succeed.

Combined Treatment. While it is still quite too early to deduct trustworthy conclusions, it is interesting to note that those whose experience entitles them to have their views carefully considered feel justified in the belief that toxins and the ray administered together give better results than either alone.

The rays have caused entire disappearance of round-celled sarcoma after the toxins had failed.

In the spindle-celled variety little benefit has come from the toxins, and apparently more from the ray.

Dr. Coley has reported upon thirty-six cases of sarcoma of all forms, about two-thirds, however, being round-celled. His results with the employment of the x-ray alone had not been at all encouraging, only four cases having been temporarily relieved. His continued observations led him to the conclusion that the rays in themselves were of little value, but as an adjuvant to the mixed toxins they possessed a distinct therapeutic use. He cites several cases in which the rays had caused the entire disappearance of the sarcomatous growth, but in every case there had been a distinct and fatal recurrence. The dangers arising from the employment of the combined agents were not great if sufficient care be employed in their exhibition. These are chiefly the establishment of more or less profound toxæmia from absorption of the broken-down neoplasm. A remoter danger consists in the possible formation of metastases.

Sarcomatosus. Sarcoid growths in adults which microscopically resemble granuloma and clinically resemble mycosis fungoides, without marked tendency to infiltration of the surrounding parts—and which condition also resembles carcinomatosus—present the features of a disease which should be benefited by the ray.

One case that probably belongs to this class will be found mentioned in the chapter on Mycosis Fungoides.

CHAPTER X.

SKIN DISEASES.

THE employment of the Roentgen ray in the treatment of diseases of the skin is by no means the result of an accidental discovery, but the consequence of careful reasoning from facts observed.

In 1897 Freund instituted some experiments, believing that if the rays were capable of producing so marked an effect upon the hair and healthy skin, as had been observed, they could be utilized in diseases of the skin.

Freund's success led Schiff to try the ray in lupus.

If we study the action of the ray on a normal skin surface up to the point at which it causes cell degeneration and destruction of tissue, we find that the epidermic structures are the first to be influenced.

After preliminary hyperplasia of the prickle-cell layer, as Pusey[1] has shown, there is increased pigment deposit, and if the ray is pushed there occurs division of nuclei without true mitosis. We have in this an indicator of the effects to be anticipated in skin pathology.

Pushed to a certain degree, degeneration or atrophy of the more highly differentiated skin structures or the appendages is produced. Thus the nail beds, hair papillæ, and glandular structures may be injuriously influenced, while surrounding parts possessing less differentiated tissues have their normal vitality increased. In the corium inflammatory changes with free exudation of leukocytes is noted.

In the bloodvessels the changes are also marked. Cells lining the vessels swell and project into the lumen, and may be swept away in the current when marked proliferation has occurred.

Thus the study of the skin gives a clue to the changes to be looked for in disease processes, and indicates rather a wide field of probable utility.

[1] American Dermatological Association, May 12–14, 1903.

Destruction of tissue of low resistance and simultaneous stimulation of normal cells appears to be the key to successful therapy, especially in such new-growths as epithelioma, papilloma, lupus, and granulomata in general.

Caution. As a general rule, it is ill-advised to apply the ray to trivial affections readily relieved by better-known measures.

When we consider the decided influence exerted upon the normal skin, an influence which is seen at times, as Scholtz first pointed out, upon the surface of exit as well as upon the surface where the ray first impinges, one need not be surprised at therapeutic effects hoped for and realized, and occasional bad effects.

There seems no question that the glands which are included in the more highly differentiated structures of the skin are found experimentally to undergo destructive changes. An atrophy is produced which has a curative result upon increase in growth and increase in function of these organs, and hence must prove beneficial in these enlarged and overactive elements of the skin's anatomy.

Six years have elapsed since these early observations, and during this period an extensive experience has been gained by dermatologists the world over.

I shall endeavor to give the conclusions of various writers, along with my own, for the various diseases rather than to give extended clinical histories of personal cases.

Scholtz, basing his belief upon an experience covering 200 cases, concludes that in a variety of affections the method is of value.

In 425 cases of my own the results have been such as to lead me to regard Roentgen's discovery as of decided importance in the therapy of skin diseases.

In arriving at a just estimation of the influence to be exerted upon dermotherapy of the future, we must study our statistics with the utmost regard to diagnosis. Some reports that have come under notice treat of rodent ulcer and lupus as though they were identical conditions and synonymous terms. This grave error has even occurred in the address of the president of a Roentgen ray society.

In the experience of many with whom I have conversed, as well as in my own, many reports of cases supposed to be lupus have proved to be rodent ulcer and *vice versa.* Lupus-like lesions of lues have also been subjected to the ray under the same error of diagnosis.

Such a case is illustrated in Plate XVIII, Figs. 1 to 3. In Fig. 1 is shown the condition as it had existed for several years, being treated as a lupus. In Fig. 2 is shown the result after one month of vigorous antisyphilitic treatment. In Fig. 3 are shown the cicatrices which were greatly improved by the *x*-ray.

In the treatment of many skin affections so much can be done by adjuvant measures that the physician should not feel that he must rely wholly upon the unaided ray. The same changes of medication for the different stages is as much called for here as when the ray is not used if we are to expect prompt and best results.

Acne. ACNE VULGARIS. In the treatment of acne the essential point seems to be the atrophic action of the rays upon the glands which, while it is not so marked perhaps upon the sebaceous and sudoriferous glands as upon the hair follicles and papillæ, is sufficiently great to render marked service. As in other conditions of the skin, the application of the rays should be supplemented with various other measures which are recognized as of value by the dermatologist. Expression of the comedones and general cleansing measures are indicated.

In treating patients in accordance with this plan I can say that the improvement has frequently been more prompt in showing itself than in following older methods alone and the time required to effect a cure has been shortened.

The ray is of especial service in the inveterate pustular form with deep-seated, suppurating lesions, dermal abscesses, and intracutaneous infiltration.

My cases include those with comedones predominating; the sebaceous; the dry, scaly, papular, pustular, inflammatory red lesions about the mouth and chin in women; the necrotic form, resembling acne varioliformis; the scrofulous or cachectic form of the trunk and back of the neck, etc.

The sluggish, indolent forms are often the most markedly influenced.

In Plate XIX. is shown a very aggravated case which was rapidly and remarkably benefited by the ray, large abscess-like lesions disappearing and large pustules desiccating and crusting without any other internal or external medication.

Dr. R. R. Campbell[1] reports 15 cases treated by exposure to the ray alone, and he justly assumes, therefore, that the uniformly good results he obtained were entirely due to the latter.

The patients were all exposed at a distance of from 10 to 15 cm. to a medium low tube, for ten minutes each time. The exposures were from eight to thirty in number and extended over periods of from one to three months.

In August, 1901, Dr. Pusey was led, by observing the effect of the ray on acne incidentally present in a patient whom he was treating for sycosis, to extend the method to intractable cases. In 11 cases treated up to March, 1902, decided value was shown for the method.

Zeisler[2] reports 34 cases, including all degrees of severity, many of the most rebellious nature. Some of these were cured in from four to six weeks.

Compared with their obstinacy and the difficulty of treating these cases, including incision, curettage, etc., the ray gives uniformly excellent results, and Zeisler regrets that this wonderful discovery had not been made twenty-five years ago. He also states that the belief long held by him as to the constitutional causes of acne has become considerably modified by the results of irradiation.

In the chronic form Varney believes that the ray far surpasses any other measure, especially when pits and scars have remained after old suppurating lesions.

Ullmann exposed the back fifty times in half-hour sittings in very severe acne and was rewarded with a good result.

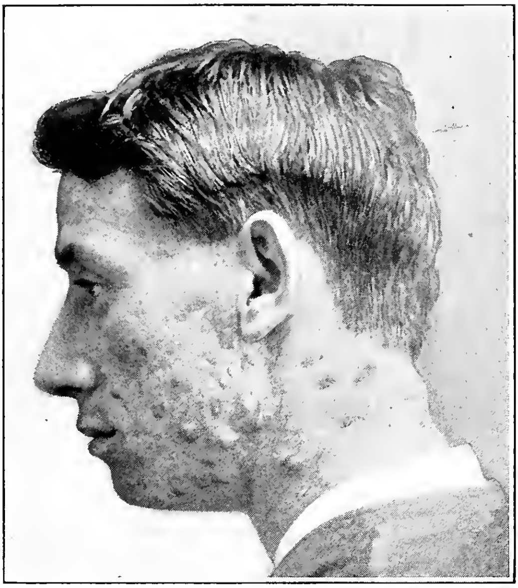
I have had excellent effects in two instances of inveterate acne of the back, one in a phthisical subject who seemed to derive considerable benefit generally as well as locally. He has recently written me that the previous cough has almost disappeared.

[1] Journal of the American Medical Association, August 9, 1902.

[2] Ibid., February 21, 1903.

PLATE XIX.

FIG. 1.



Aggravated Acne, Keloidal Scars, and Abscesses.

FIG. 2.

Resulting Scars Improved by X-ray after Active Lesions had Ceased.

The patient was treated by two tubes simultaneously, one posteriorly opposite the thorax, the other for the face.

Until now I have seen no undesirable redness produced in treating acne and have had almost uniformly good results in about thirty-eight cases.

Technique. The tube is at the usual distance of 20 cm., but the exposure can be somewhat longer than in psoriasis, for instance. The sittings vary with the amount of effect produced. All parts not to be affected should be carefully protected with screens.

Gautier, who was one of the first to treat acne, advises sittings of five to ten minutes with the tube 30 cm. and with a current of six ampères and eighteen to twenty volts. It is probably possible to push treatment to the production of atrophy of the glands and follicles; and unless it is continued until a large number of these organs become atrophic, slight recurrence must be looked for. While we believe that most acnes can be relieved by external measures alone, those who hold the opposite view can carry out any plan of internal medication desired at the same time, and in those instances in which there is undoubtedly an internal cause the *x*-ray alone could not be expected to produce permanent beneficial results unless such a plan were pursued.

After two years' trial of the method, I would be loth to treat obstinate acne without its aid, as in it we have at least a powerful adjunct to other measures.

Acne rosacea often shows marked and rapid improvement. I always employ the electrolytic needle coincidently to destroy the enlarged vessels. Several very obstinate cases have been benefited beyond what I could expect from other means alone, especially the sebaceous form.

Acne Varioliformis. Although this condition is almost always relieved very promptly by white precipitate ointment, in patients treated by the ray, the well-known tendency to recur seemed to be removed, or at least decreased.

Alopecia. Applied in a mild form and with sufficient care as to time, distance, etc., a stimulating effect upon hair growth can be obtained. This fact is not to be overlooked in attempts to remove superfluous hairs. If it is discovered that the beard operated upon is growing stronger instead of falling, one has but to increase the dosage in order to obtain the desired effects.

I have observed, in the regrowth of hair after inadvertent epilation of the beard in treating epithelioma and other diseases, that when the hair grew in again it was at times thicker and stronger than previously, and in one instance of carcinoma of the forehead it came in darker.

The increased growth was especially noticeable in a subject of lip cancer, who lost one side of the moustache under raying. This side became subsequently so much thicker than the opposite that the patient thinned it out with scissors.

In the treatment by the ray of psoriasis and seborrhœa of the scalp when associated with baldness, I have observed some benefit to the hair.

In studying the condition of the tissue, in alopecia artificially produced in guinea-pigs, Oudin, Barthélèmy and Darier[1] found that the least differentiated skin structures have their vitality increased by the ray, while the glands, hairs, and nails (the more differentiated structures) undergo atrophy and other retrogressive metamorphoses. The atrophic changes in the follicles have a decided bearing upon the destruction of hair.

It seems rather paradoxical that the ray should cause falling of the hair and cause renewed growth of the same appendage—that the hair can be stimulated to renewed vigor we have already mentioned.

With our improved and gradually improving methods of measuring dosage, we may be able to secure the stimulating effect without the preceding loss of hair. At present it is ill-advised to treat the scalp at a short distance and in long sittings.

Holzknecht found no noticeable effect in an alopecia pityroides treated.

Alopecia Areata. My personal experience has been limited to three cases which have not shown results at all remarkable. Plaques of baldness thus treated, compared with others upon the same patient treated by applications

[1] Monatschrift f. prakt. Dermat., 1897, Bd. xxv. p. 1897.

of pure deliquesced carbolic acid at intervals of three weeks, as well as a comparison of the results in individuals treated by local measures with those treated exclusively by the ray, has so far shown nothing in favor of the latter.

The method of treating alopecia areata by the rays, which is due to Kienbock, consists of radiating the whole scalp during four sittings of about ten minutes each. A general alopecia of about four weeks' duration results. A small fringe of hair generally persists around the area of the original spot. It is noted that the border of hair around the patches is less in the case of the newer than of the older spots. At the end of about four weeks the hair begins to grow in the areas which were at first bald and gradually regrows over the whole scalp.

He reports a man, aged twenty-six years, who had an extensive alopecia for three years. He gave six sittings at a distance of 20 cm. and fifteen-minute exposures; the lanugo dropped out and in about two months was replaced with strong, dark, normal hair. That part of the head not exposed to the ray remained as before treatment.

Freund advises the use of the ray in all cases, and expects much quicker results than by the aid of medication, but remarks that it should not be regarded as a specific. While we have already a very efficient method for those cases which are capable of recovery, still we have in the *x*-ray probably a quicker method, but one attended with several disadvantages.

For the severe cases of generalized alopecia of long standing there is no more hope to be held out for the ray than for any other method.

As illustrating the opposite side of the question, cases which had resisted almost all of the older methods of treatment were subjected by Heidingsfeld[1] to control experiments by the *x*-ray. Some of the patches were untreated. One large patch was subjected to five sittings, after the method of Kienbock, and the rest treated once weekly with 50 per cent. trikresol in alcohol. After an interval of two months the trikresol patches were covered with a luxuriant

[1] Cincinnati Lancet-Clinic, September 20, 1902.

growth of lanugo hair, and the others remained unchanged. After six months all the patches were covered with hair, with the exception of the x-ray patch, which, in spite of trikresol applications, remained absolutely unchanged.

Holzknecht[1] relates the successful application in a case in which at the end of three weeks the patches were red, while normal areas from which the hair had fallen remained white. At the end of two months hair was growing upon the diseased area, while neighboring portions of the scalp were still bald, and at the end of four months all the parts were freely covered with hair.

He demonstrated a patient in whom five sittings of ten minutes each, at a distance of 20 cm., produced the same good results. He reports the same success in two other instances.

It is not necessary to bring about epilation in these cases, since we can use the ray until it produces only its stimulating effect on the hair papillæ and follicles.

Blastomycosis. Varney[2] reports a case of "cutaneous blastomycosis" (Plate XX.) lasting over a period of four years which he curetted and used the x-ray every other day in addition to some internal medication. In three weeks the parts were completely healed, and three months later there was absolutely no sign of recurrence.

F. H. Montgomery describes a case of blastomycetic dermatitis which he cured with the x-rays after it had proven refractory to other forms of treatment.

In a second case the borders of the patches which had not improved under iodide of potassium disappeared under the ray in from twelve to sixteen exposures. In Pusey's two cases there was marked and rapid improvement. Although medication by the iodides has been carried out in these cases, the improvement is greater than these experienced observers could attribute to the drug alone, which, as is well known, has a decided influence on the affection.

Cicatrix. There remains no question that the ray exerts a unique influence in flattening raised scar tissue.

[1] Wiener klin. Rundschau, October 19, 1901.

[2] Detroit Medical Journal, June, 1903.

PLATE XX.

FIG. 1.

Hand before Treatment. Note Characteristic Lesions on Finger and Nodules on Wrist. (Dr. Varney's Case.)

FIG. 2.

Hand after Three Weeks' Treatment.

In Plate II. is shown a patient after the ray had removed not only a widely disseminated recurrent cancer of the chest, but had also obliterated the hypertrophic reddened scar of operation.

Varney has treated a number of patients with disfiguring scars from variola. In those treated early, when a gradual erythema was produced and epithelial cells rapidly filled the discolored pits, mild irradiation for a period of three weeks was followed by desquamation, after which traces of the pits were difficult to discover. I have seen some benefit in the pits left by acne, syphilis, operation, wounds, burns, lupus, and scrofuloderma.

In Plate XVIII. is shown disfiguring cicatrices due to lues hereditaria which were improved by the ray in conjunction with electrolysis.

In one case where hypertrophied scar tissue was formed after an operation for tuberculous glands of the neck, Harris[1] was successful in removing it after three months' intermittent treatment.

In cicatrix of glandular origin in a case of lupus there was decided flattening of the scar.

THE X-RAY SCAR. The scar that follows treatment by means of the *x*-ray has been referred to already. The nature of the cicatrix is more like that of normal skin than that produced by any other method of removing diseased tissue. The nature of the scar following the removal of epithelioma of the face by means of the ray is one of the strongest recommendations of this form of treatment.

The scar very nearly resembles normal skin. It is elastic, pliable, soft, and of approximately the same color as the surrounding skin. It is seldom as white as the usual scar following the removal of tissue by means of the knife or caustics, and does not have the same amount of pigment found in the site of the scar caused by the ultraviolet ray, although this latter is not a constant quantity, and soon disappears in most instances.

The scar from the *x*-ray is seldom or never found hypertrophied, and generally just fills the space left by the loss

[1] Medical Annual, 1902.

of the pathological tissue, and does not present the hard, firm feel of a foreign body that is often the characteristic of scar tissue. There is no marked tendency on the part of this scar tissue to contract, thus differing from other scars.

There is no clearly defined theory to account for the difference between the *x*-ray and other cicatrices, but it has been suggested that the cause is in some way connected with the well-known stimulating effect of the rays when administered in small doses. The exact explanation of the phenomenon by the above theory is not at all clear, and leaves some room for doubt. If the effect of the ray continues until it is able to cause breaking down of diseased tissue, it is likely that it will exceed mild stimulation of the healthy tissue in the vicinity, as indicated by the occurrence of burns.

Clavus. Zeisler reports the case of a young man who for the past two years had his life made miserable by the presence of numerous soft corns on the soles. The affection was symmetrical and consisted of upward of sixty soft corns distributed over the plantar surfaces of all the toes and the adjacent regions of the sole. All treatments, including excision, keratolytic ointments, special pads, etc., had been tried in vain. Twelve daily exposures were given with a strong light, at a distance of 10 cm., for ten minutes each. No visible reaction resulted, but the treatments had to be discontinued. Three weeks later, the patient was reported absolutely and perfectly free from all his corns and has remained so.

Eczema. Chronic, persistent, and recurrent types are best subjected to the method. Individual plaques which other plans have influenced but little, patches with infiltration and thickened epiderm, tylosis of the soles and palms, psoriatic-like areas, often give way to irradiation when obstinate and refractory to other plans.

In 31 cases of my own 2 showed remarkably prompt cures; 1 was benefited much by a single application. With few exceptions all received benefit. A comparison was often instituted between opposite sides of the body, or with similar patches otherwise treated. As compared with high-frequency currents the ray seems to hold a decided advantage. One very obstinate recurrent eczema of the hands in a trained nurse, treated over a long period by other measures, never did so well as under the ray.

The itching grows very much less almost as soon as the treatment is commenced, while the moisture rapidly gives place to dryness.

The treatment is usually not prolonged, four to six weeks generally sufficing. It may often be combined with other adjuvant measures. Dusting-powders and the ordinary salves and pastes should be used as occasion demands. Treatment should be given with a rather low tube, about 0.008 penetration. The exposures should be pushed until the redness has in a large measure disappeared, and then discontinued, allowing the cumulative action of the rays an opportunity to assert itself. If the healing does not progress to a cure, the raying may be continued at intervals of one week or oftener.

All forms are more or less benefited, the benefit being largely at first the alleviation of symptoms. The relief experienced is often prompt and marked. The technique of exposure is practically the same as for psoriasis and similar affections.

Caution. Some care should be observed in treating moist surfaces to obviate too severe reaction, and about the face to prevent the falling out of eyelids and eyelashes. While the adjuvant treatment is of benefit in the later stages it must be remembered that metal-containing ointments may impede the efficient passage of the ray.

Varney says that mild irradiation produces stimulating reaction and reduction of infiltration. He reports five cases out of seven cured.

In the mycotic form it also often acts well.

In the so-called eczema marginatum, striking results are occasionally to be noted, and I have seen several patients promptly benefited.

Eczema Seborrhoicum. In a very obstinate instance of this affection of the psoriatic type, involving the scalp and chest in a young lady and in which the ordinary methods of treatment had not succeeded to our mutual satisfaction, the *x*-ray was added to other measures, when in a comparatively short time a cure was effected. In a number of instances I have seen prompt results.

Reports from many other sources are encouraging.

Favus of the non-hairy surface is so readily cured without the ray that it seems superfluous to employ it here. Favus of the scalp is so persistent and difficult to eradicate that the ray should be used whenever possible to cause epilation, even if it does no further good.

In a young woman I have witnessed a cure of a limited area without causing any marked falling of hair.

In a generalized favus of the scalp in a little girl sent by me to Dr. Morton's electric department at the Post-graduate School, I have watched a gradual improvement. In conversation with gentlemen from various parts of the world, at the Madrid Congress, I learned that a number, including Jamieson, of Edinburgh, had seen decidedly beneficial results in this disease.

According to Norman Walker, the *x*-ray method of treating favus is unapproached by any other form of treatment. He reports several cures.

On the other hand, cases of favus treated and carefully studied by Scholtz did not yield satisfactory results, and he concludes that only in mild cases is there any excuse for the use of the method. He proved that the rays do not kill the parasite, but only cause the hair to fall and that the parasite continues active when the hair grows again.

This he has witnessed after repeated epilation. Energetic additional treatment, with weak carbolic, pyrogallic, or chrysarobin ointment, is absolutely necessary. Even the relapses are not infrequent. Schiff and Freund advise repeated raying for four or five weeks while the hair is growing.

Socoloff[1] has had good effects in four out of six cases of favus and herpes tonsurans.

Technique. It is absolutely necessary in extensive involvement, especially in children, to epilate the entire scalp and not only the affected parts. If we were only to epilate the infected parts, we would most likely have relapse in

[1] Bolintschriai Gazetta Botkina, June 23, 1902.

other parts of the scalp where the fungus lies hidden in the follicles and where it would gradually develop. A long distance from the tube has been advised (25 to 30 cm.) so as to include a large surface. The hair should be cut at the beginning of treatment, but not subsequently. The scalp may be divided into areas and each be rayed in turn. Hairs begin to fall in about three weeks, and in a few weeks more the scalp is perfectly smooth. A small, reddened, moist surface remains where the scutula were, but these heal very rapidly. The general redness disappears in about ten days. The hairs begin to return in about six to eight weeks. At times there is a slight recurrence which a few exposures will remedy.

Caution. We must be very careful how we use rays in recurrence, as we might produce a permanent alopecia. To prevent recurrence at the end of reaction Freund uses the following salve:

℞—Carbolic acid (glycerin solution),	2.5
Lanolin,	50.0—M.

Sig.—Apply night and morning.

Freund does not attribute the beneficial results of the rays to any bactericidal effect, but merely to the extensive epilation. The remarkably satisfactory results are testified to by Schiff and Freund, Ziemssen, I. Neumann, Albers-Schönberg, Hahn, Grouven, Lion, Norman Walker, Spiegler, Gastou, Nicolau, Boczar, and Bukofsky.[1]

FAVUS OF THE NAILS. In favus of the nails I have had little result from the treatment of two cases. In a third there has been decided improvement, attributable in part at least to the ray.

Since the ray has been shown to cause accidental shedding of the nails, it naturally suggests itself to utilize the method for this purpose. Strangely enough, when we strive to secure this effect, as for shedding of the hair, we do not always succeed in the same manner as when we are not desiring it.

Hyperidrosis. Pusey[2] remarks that, while the action of the rays upon the glandular structures is less than upon

[1] Freund, Grundriss der Gesammten Radiotherapie. Wien, 1903.

[2] Journal of the American Medical Association, September 28, 1901.

any other element of the skin, there seems to be good theoretical ground for believing that the rays may be applied in hyperidrosis. I tried the method in this affection before I had seen any reports in literature, without startling results. In fact, the patient being cured of another complaint ceased treatment, the hyperidrosis showing at the time little benefit.

Since then Stelwagon has discovered accidentally that it had a decided effect in lessening the amount of secretion.

Pusey refers to a verbal report of excellent results in axillary sweating.

Engman[1] reports reduction of axillary perspiration by 50 per cent. to 75 per cent. after about eighty exposures.

It is noteworthy that in Schmid's report of dermatitis atrophicans following long exposure of the hand the function of the sweat glands was not impaired.

Hypertrichosis. The first scientific epilation was carried out by Freund and Schiff. A hairy, pigmented nævus occupying the entire back was rayed daily for two hours. At the end of twelve days the hairs began to fall. A "burn" taught the wisdom of short but frequent sittings, and they subsequently employed an intensity represented by 2 ampères and 12 volts as a maximum.

The influence of the ray in this condition is not entirely satisfactory. There still exists a diversity of opinion as to the advisability of employing the ray for cosmetic epilation. Some believe it should never be so used, and a number have abandoned it after a trial, because of danger, tediousness, or lack of results. In his latest writings Pusey says the method is less satisfactory than he had anticipated.

In my own hands it has not been eminently satisfactory, and I have refused to begin a course unless the patient was willing to assume the risk of dermatitis, etc. Only one of my sixteen cases has persisted to a satisfactory finish, so far as I am aware. Several are under my treatment now by the older, slower, but satisfactory method of electrolysis. That permanent removal of the hair with the ray can be accomplished is beyond question.

[1] Journal of the American Medical Association, September 28, 1901

The alopecia brought about is due to the destruction of the minute vessels of the follicle. This is a slow and very gradual process, as can be seen from the fact that recurrence will always take place, occasionally even three or four times. Only persistent, repeated treatment over a long period of time will bring about the desired result.

This method finds its greatest field of utility in extensive hirsuties, where the hair covers large areas, or is of such a fine, delicate texture, that electrolysis is out of the question.

Freedom from relapse is from a few weeks to a few months, depending very much upon the method of treatment pursued. Patients treated with relatively intense rays, up to the degree of a mild reaction, will remain free from recurrence for a longer period than those receiving short and infrequent exposures. At the beginning the patient should understand that to get satisfactory results the treatment must extend over a considerable time, and that they must persist and not lose courage when they see the hairs return. The intervals between the recurrences gradually lengthen, the growth becoming less each time, and the number of exposures necessary to remove them decreases, until the hairs remain away permanently.

Caution. We must use all the precautions previously mentioned, and not forget that the treatment is mainly for cosmetic effect, and that to replace the slightly disfiguring growth with an unsightly scar is obviously not the object aimed at. It is advisable to resort to those means alone that will exclude the possibility of any marked reaction.

Technique. A mask may be applied as referred to in the chapter on protective measures, or, preferably, the patient sits or lies before a stationary screen. If the growth is chiefly on the chin and neck, the head should be thrown backward and turned so as to permit the rays to strike the parts at a right angle.

The patient sits at a distance of about 20 cm. from the tube during exposures of about five minutes, with a current not higher than 2½ ampères. This should be repeated every second or third day until the hairs begin to fall, which is generally in six to eight weeks. According to the procedure of Gastou, Vieira and Nicolau, falling occurs between the eighth and twentieth sittings. Some claim that currents should never exceed 2 ampères and a maximum tension of $11\frac{1}{2}$ volts. The spark length should be not less than six inches, the tube being at eight or ten inches from the skin. Hard tubes should be preferred, to obviate intense reaction. Gastou and Vieira favor short exposures at a considerable distance. Bissérié says the time for renewed applications is at ten days' interval. It is advisable not to wait for recurrence, but to use the rays as a routine treatment, a few exposures every few weeks for at least a year or more, or, as Schiff says, one or two every two months, when a permanent cure may be expected. There is usually a slight brownish pigmentation of the skin which gradually disappears. There does not seem to be much difference so far as the length of treatment is concerned, whether the hairs are dark and coarse or a fine, delicate, lanugo growth. If anything, the dark hair yields the more readily. It is said the hair may become snow-white before it falls, and at times the renewed growth is stunted or bleached. I have noticed a whitening of the hairs before the fall, coincidently with a faint browning of the skin, as though a migration of pigment had occurred. Just about the hair, when loosened, is a whitish, powder-like change in the epiderm. The hair can then be lifted from its bed without pain.

Scholtz resorts to a more radical procedure. He begins with daily exposures of fifteen minutes, at a distance of 30 cm., or ten minutes at 25 cm., for three or four days, then every second day, finally every third day, continually diminishing the time of exposure to five minutes or even three minutes; or he uses soft tubes at a distance of 20 cm. from five to eight minutes, and rarely requires over four to five sittings. Oudin also favors soft tubes at close range for short sittings. He saw one of his cases six months after the last treatment with regrowth visible. The hair generally begins to fall at the end of the second week or beginning of the third week, a slight dermatitis showing. He believes that with repeated intermittent raying the hair can be permanently removed. Sjögren holds the same opinion.

Freund advises not to begin raying until the hairs are long enough to be distinctly felt and during treatment not to permit their being pulled. He sits the patient at a distance of 15 cm., but does not mention the time of his exposures. In twenty to twenty-five sittings the hairs begin to fall. He does not wait for recurrence, but as prophylactic treatment uses the rays every four to six weeks. This treatment is kept up from twelve to eighteen months, when he expects a definite result.

Zeisler reports eleven cases in which normal exposures at intervals of from one to two weeks resulted in pigmentation or temporary erythema and loss of hair. Afterward he repeats his sittings at an interval of about two months. He reports several subjects who remained free from hair for over a year.

Lancashire begins with frequent short sittings changed into less frequent, extending over a long period of time.

Among the injurious effects accidentally produced in attempts to destroy hair upon the face we may mention atrophy of the skin, which has been observed by Ehrmann.

Decided burning followed by disfiguring scars have been seen by Crocker.

As to methods of exactitude in dosage it has been determined that three tints upon the chromoradiometer are sufficient in young people, and four for older subjects. The equivalent of five to seven tints will produce erosions.

Béclère had not at the time verified the value of Holzknecht's meter, and gives these results merely as they came to him.

So as to avoid all possibility of missing the first symptoms of reaction as the result of the rays, we must never permit patients under treatment for sycosis, favus, trichophytosis, alopecia areata, hypertrichosis, etc., to shave or cut the hair during treatment. If the hair is very short we should not begin treatment until it reaches a certain length. Gastou, Vieira and Nicolau use hard tubes at a distance of 15 to 30 cm. for ten minutes every second day. The hair with this method begins to fall out in six to eleven sittings. No reaction was observed in any of the cases. They strive to keep to a certain definite strength of ray by employing the same make of tube, with spark of 15 cm., with a current of 5 ampères and distance rays correspond to No. 6 of the radiochromometer, a tension of 25 volts, at 25 to 30 cm.

The rationale of the ray's action in producing fall of hair is not definitely settled. It has been attributed to a partial destructive or inhibitory action upon the blood supply of the follicle.

In favor of this view we have the fact that young hairs, whose vitality we can assume is greater, resist more the ray's epilating power.

Another theory is that some anatomical change short of destruction occurs in the papillæ, and that for a season the normal activity is suspended to be subsequently restored to partial or full vigor.

That the normal vigor can be increased by the ray when given in mild dose is undoubted. The depilatory ray is stronger, and that it is capable of permanent destruction, if persisted in, seems also certain.

If applied at intervals, irrespective of evidence of new-growth appearing, it is claimed the capillary bloodvessels may be kept in a state of paresis, preventing reappearance of hair.

Keloid. The absolute futility of excision for almost all keloid gives to the new method a very great importance, in view of a number of reputed cures, and a much larger number of cases decidedly improved and still improving when the reports were made. In my own cases there has been improvement, but until now no cure. In three cases being treated at the Skin and Cancer Hospital the tumors are disappearing after some thirty exposures.

In a report by Pusey[1] the patient presented two keloids which had recurred after removal. The condition was very obstinate to the rays, and only after eighty sittings and the production of a severe dermatitis did improvement occur. After the dermatitis, which was a deep one, had healed, cure resulted.

In one case after three surgical operations had failed irradiation resulted in a cure.[2]

[1] Medical Fortnightly, March 15, 1903.

[2] Australasian Medical Gazette, April, 1901.

In an extensive keloid of the buttock, Crocker made fourteen exposures of fifteen minutes each, 3 ampères of strength with the tube at three inches' distance. When the inflammatory action had subsided the growth was only a quarter of its original size. Harris reports a complete cure in employing a soft tube with 6 ampères.

Caution. The danger of this ampèrage is justly pointed out by Crocker. Electrolysis, which we have found of decided benefit in some cases, may be coincidently employed as well as thiosinamine injections, which give occasional good results.

Coley reports an extensive keloidal condition of the arm following a burn which did not improve after many treatments with the ray.

In keloidal acne with numerous hypertrophic scars occupying the site of former acne abscesses, there was some improvement, but the young man ceased attendance. In another case of my own the benefit was very marked.

Keratosis Palmaris et Plantaris. This most obstinate condition, which is usually congenital and often hereditary, is most difficult of eradication by any method previously employed. In three inveterate cases treated by Zeisler the results were extremely satisfactory.

In one case the normal condition was restored to the palm of the hand after only five strong exposures.

There is a precancerous keratosis of various regions, including the lips, which may be beneficially influenced by the ray, and it is interesting to note that a very similar condition may result from exposure to the ray, being followed in some instances by epithelioma, as mentioned elsewhere.

Stelwagon saw cure in one and improvement in several other cases.

In my own experience I find that we have in the ray a method of reducing the deformity, lessening the underlying papillary elongation, dilatation of bloodvessels, elongation of the interpapillary processes, and thickening of the stratum corneum and possible hypertrophy of sweat coils.

Skinner reports on a case designated as "ichthyosis." One hand treated with the ray improved much more than the other treated with green soap.

In Fig. 58 the palms of a young lady are shown which had been so thickened from earliest childhood as to amount to a deformity and disfigurement.

I treated also her mother, while two other children in the family are similarly affected. There was subjective improvement from the first.

Fig. 58.

Keratodermia palmaris hereditaria.

I am indebted to Dr. Morton for the privilege of using this plate, made for me by Dr. Brandt, the patient having been sent by me to his department for treatment at the Post-graduate School.

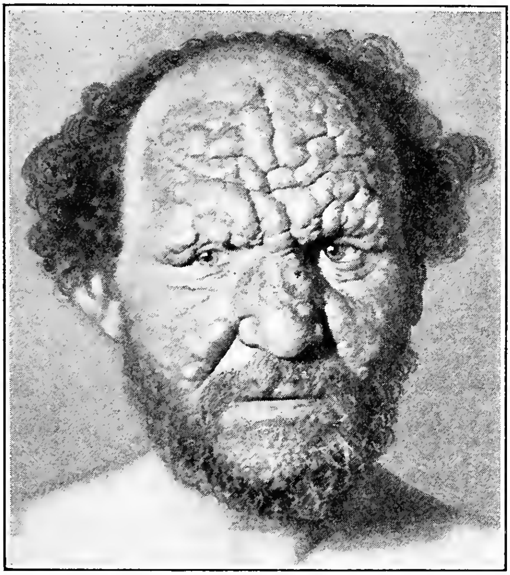
Keratosis Senilis. Eleven cases were successfully treated at the Massachusetts General Hospital.[1] I have observed good results in about an equal number.

[1] Bowen's report.

Lepra. In tubercular leprosy, Sequeira[1] has obtained a flattening of the lesions.

Scholtz examined skin from a case of lepra and came to the conclusion that the hyperæmia and the reactive inflammation which were concentrated in the tubercle were the cause of healing, and that the bactericidal action of the rays was unworthy of consideration. In two trials he had no therapeutic results. Others report negatively. In one case

FIG. 59.



Lepra improved under *x*-ray.

treated by us the patient (shown in Fig. 59) claimed to feel better, and that the nodules over the brows and forehead had flattened.

The subjective improvement was accompanied by little objective evidence, but some nodules had softened and flattened. The patient disappeared before sufficient time for judgment had elapsed.

Lichen Planus. Lichen planus hypertrophicus, which had resisted even curettage, was seen by Zeisler to disappear

[1] British Medical Journal, September 28, 1901.

in an almost marvellous way, after four strong exposures given at intervals of five days, the skin being left in an almost normal condition. In four other cases he reports that the large thickened patches yielded in as few as forty-six exposures of ten to fifteen minutes' duration. He found that under treatment the papules decreased in size, becoming scaly, while surrounding pigmentation is apt to increase temporarily. The pruritus is relieved oftentimes in a very striking and gratifying manner, as we have noted in several instances of our own.

Scholtz finds that there is marked improvement after very few exposures and strongly advises the use of rays in every case. After a very few exposures the skin becomes smoother. He reports three cases with favorable results.

In several cases of my own the results have been fair. Our experience does not justify us as yet to express a decided opinion as to recurrence.

Gilchrist, Bulkley, and others report favorably in this affection.

Lupus. In lupus vulgaris the ray has one of its most important uses and presents one of the most satisfactory modes of treatment. It was in this affection that the method came into prominence and achieved one of its greatest successes, so that it came to be regarded almost as a specific. Even extensive involvement of tissue may be overcome in a few months of energetic raying. The nature of the pathological tissue making up the lupus nodule led investigators to believe that because of the low grade of vitality it presented it would be readily attacked by the evident reducing action of the ray. Compared with many foreign countries, we have little lupus in the United States, and a much smaller proportion of inveterate, disfiguring cases. This is due in part, no doubt, to earlier treatment being instituted in this country, at which stage cure is not so difficult.

Kümmel is reported to have cured lupus as early as 1897.

The first case reported as cured in this country was by Jones, of San Francisco, in 1899; the second being recorded by Knox, in 1900. Beck reports a cure which has endured

PLATE XXI.

FIG. 1.

Lupus of Ala Nasi.

FIG. 2.

Firm Cicatrix after Short Course of X-raying.

for four years. Many others have since been reported, and the treatment has become recognized as of unquestionable value.

The particular benefits of this method are rapidity, shortness of each sitting, the small expense as compared with the Finsen method, and good cosmetic effect as compared with the older methods.

In Plate XXI. is shown a small patch of ulcerating lupus of the nose cured after twelve exposures, without adjuvant measures.

While the ray itself will often prove sufficient without other measures, when ulceration is caused by the ray, or originally exists, it may be necessary to use salves, pastes, etc., as the conditions indicate. Curetting and cauterization may have to be resorted to in many cases, but in the main the amount of supplemental treatment is considerably less than in the Finsen method.

It is by the dermatological specialist pre-eminently that these cases should be treated, so far as possible, not only because of the difficulties of diagnosis, but because of the necessity in many cases of combining other methods in order to hasten or to complete the cure. Among these adjuvants may be mentioned electrolysis, the thermocautery, curettage, the application of pyrogallic and other ointments.

In Plate XVIII., Fig. 1, is shown a condition which illustrates an error in diagnosis. The patient came to me with a supposed lupus, having been treated for this disease during many years. My diagnosis was hereditary lues, and under mercurial and iodide treatment the condition was in one month's time as shown in Fig. 2, Plate XVIII.

Jamieson, among other observers, believes in combining scraping and cauterization.

A great advantage of the ray in lupus is that, especially in children, the method being painless and free from blood, the children submit quietly and cause no loss of time by ill behavior.

Scholtz says that in lupus of the nose rays should be applied from both sides, and also from above and below. That the rays penetrate the nose affecting the opposite side from that rayed I have been convinced by observations in my own practice. The ray treatment has the immense advantage over previous methods that a cure can be effected in a large percentage of cases. The method is of especial value when the deeper structures of the nose and mucous membranes of the mouth and other parts are involved, making ordinary surgical methods unavailable. Here, too, the excellent cosmetic effects, painlessness and the avoidance of anæsthetics, are features not to be too lightly passed over; the disadvantage consists in the length of time and difficulties attending the application.

Fig. 60.

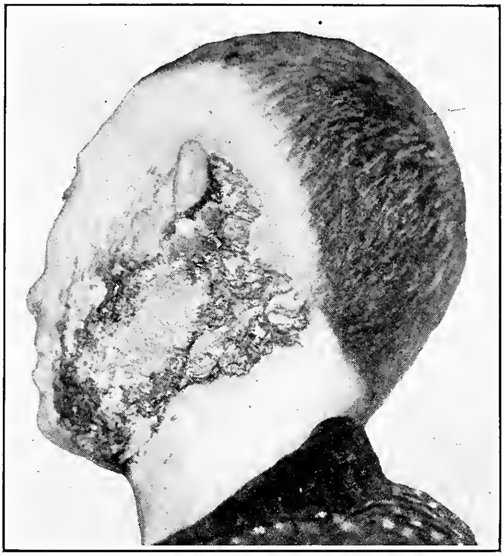
Lupus of many years' standing. The ulcer was healed by the ray.

In Fig. 60 is shown a patient, referred to me by Dr. Fox, who treated one side of the nose with his dental burr method, while I applied the ray to the other. It was evident from the healing of the ulcer and diminished infiltration that the ray had exercised a marked effect. Naturally the ray could not be fully excluded from the other side, which Dr. Fox thought improved faster.

In Plate XXII., Fig. 1, an extensive lupus of thirty-five years' duration was transformed in three treatments into an eczema-like state. When this healed, after several weeks there was no evidence of lupous nodules in the reddened cicatrix, as shown in Fig. 2, Plate XXII.

PLATE XXII.

FIG. 1.



Life-long Lupus, showing Reaction from Few Exposures and Typical Loss of Hair.

FIG. 2.

Appearance after Reaction had Subsided, with Disappearance of all Lupous Nodules.

Histological Changes. Scholtz found in a number of lupous foci, excised at various intervals after exposure, that the cells were swollen, and between the plasma cells there was a large number of leukocytes, especially polynuclear. Unusually large giant cells with one hundred to two hundred nuclei he believed were the result of the ray's action. The giant cells finally degenerated at the onset of the inflammatory reaction just as did the other cells.

Technique must of necessity vary with the age, extent, duration, and changes resulting from preceding treatment. If uncomplicated by sclerosis and scarring, less intensity of raying is required. In mild, recent, and superficial cases, and in children, our aim is to produce only a slight reddening and œdema, but no necrosis. It takes longer to secure results, but they have the advantage of being without scar-formation. The majority of patients coming under ray therapy the world over to-day belong to the class presenting deep infiltration, destructive ulceration, and cicatricial tissue, resulting from former attempts at cure. In this class much more energetic raying is necessary.

Reaction is not to be avoided in these cases, and in some instances even superficial burning is of benefit, by establishing molecular disintegration of the nodules and setting up a reactive inflammation which is to substitute healthy tissues for the lupous infiltration. The location of the patch, extent, and time the patient can remain under treatment are elements which influence our decision whether such marked reaction is to be produced.

Daily exposures may be made, beginning with ten minutes, at a distance of about 20 cm., reduced daily by two minutes until reaction begins, when the interval can be lengthened until superficial necrosis sets in. Treatment may then be suspended until the surface heals. If any lupous nodules remain, a few more exposures are given. That a definite cure has been reached can be argued from the appearance of the scar and by the negative results of a tuberculin test.

This is practically the method followed by Scholtz in securing his excellent results.

Oudin recommends that a semihard tube be used with 10 cm. spark, at 20 cm. from the skin; 16 volts, 4 ampères, and fifteen interruptions per second. The first sitting is of one minute's duration, increased half a minute each time.

While dehæmatization is unnecessary, Dickson and others have thought better results were obtained by the use of adrenalin chloride. The exposures are given at nine inches from the anode. The excitation current is generally about 200 watts, and the anode is allowed to become of a dull-red heat. A tube is selected having a resistance as nearly as possible equal to four or five inches in air, and having a penetrability of about $\frac{8}{1000}$ of our radiometer, differences in these measurements being compensated for by altering the distance from the patient, the value of the exciting current, and the length of exposure; in the normal case the exposure being five minutes.

Schiff formerly believed that it was necessary to set up an energetic and inflammatory reaction in order to secure the best therapeutic results. He now believes,[1] however, that a hyperæmia is all that it is necessary to produce. He advised $3\frac{1}{2}$ ampères, $12\frac{1}{2}$ volts, 10 cm. distance, and fifteen minutes' exposures.

LUPUS HYPERTROPHICUS. Pusey reports the cure of a woman who presented hypertrophic patches on the lip and under the chin. These consisted of closely set groups of waxy, glistening, almost translucent tubercles, which at a distance looked like zoster. They had persisted for about seven years. One patch had been cut out, but had recurred in the scar. Antisyphilitic treatment had no effect. Considerable erythema was produced at the end of two months, which was accompanied with shrinking of the tubercles.

The dermatitis was confined sharply to the diseased area. The disease was apparently cured, with no scarring.

Statistics. Varney reports 12 cases, 10 of which have been discharged clinically cured and kept under observation for from six months to two and one-half years. One recurrence in this time.

Rodman and Pfahler[2] collected 75 cases, of which 65 were put down as cured.

I have found records of 106 reported cures.

[1] Journal de Physiotherapie, 1903, No. 1.

[2] American Surgical Association, May 13, 1903.

Lupus Erythematosus. This disease, which is quite common in America, has shown a disposition to yield to the ray more readily than to any other method with the possible exception of the high frequency currents. Of the two forms in which it generally occurs, the sebaceous and the erythematous, the former shows the greatest reaction under the influence of raying, about 90 per cent. being cured in from eighteen to thirty-five sittings. The erythematous form does not give such prompt or such certain results, and treatment must be largely combined with other measures.

Curettage of the soft tissue, applications of caustic solutions, and emollient salves are necessary, and the electrolytic needle will be found of invaluable aid in destroying the vitality of new tissue.

It has been observed that after the reaction has subsided the disease is greatly improved. When the disease is confined to a definite limited area, rendering possible complete screening of the healthy parts, we may proceed with the treatment in spite of prodromal symptoms of dermatitis. On the other hand, when the diseased areas are of irregular form and widely distributed, it is almost or quite impossible to avoid exposing some of the surrounding surface. Here it is advisable to use every possible precaution to guard against dermatitis, as from the patient's standpoint an acute inflammatory, exceedingly painful, disfiguring, and troublesome burn might appear more formidable than the previous condition. Means of obviating dermatitis are to be well considered, as its occurrence frequently determines the patient to discontinue treatment, in spite of all assurances that the condition is ephemeral.

Out of 16 cases treated by me 2 have been entirely cured, 2 seemingly cured had recurrence, and 12 were very much benefited. Recurrence was noted in one patient who had discontinued treatment before the lesions had quite disappeared and is now again under treatment. Two remained too short a time to be considered. The results are generally satisfactory, though there are cases which progress very slowly and a few in which the rays seem not to have any effect whatever.

Technique. The same general rules are observed as in other skin diseases. The first treatments are from two to five minutes, depending upon the amount of pigment in the skin, the extent of the lesion, age, etc.

Scholtz claims that after energetic treatment, producing a superficial necrosis, the temporary cosmetic results were very satisfactory, but that even in these cases there was a local recurrence in a very few months. With less energetic treatment extending over a period of months, there was an apparent cure.

Woods[1] reports a cure after five exposures of ten minutes each.

Startin relates a typical involvement of the face in a middle-aged woman cicatrized after six applications.

At times a lesion will disappear quite promptly. I have observed total disappearance of a single plaque on a girl's cheek after a few vigorous applications of the ray, but after six months there was a recurrence involving almost the same area.

Morris finds that the cases that are most likely to be benefited are those that resemble the vulgaris type, and this, I think, I have several times verified. In many of the cases treated by me curettage was made to the active advancing border. This, I believe, materially hastens cure.

Rodman and Pfahler found that final results compared favorably with those of other methods.

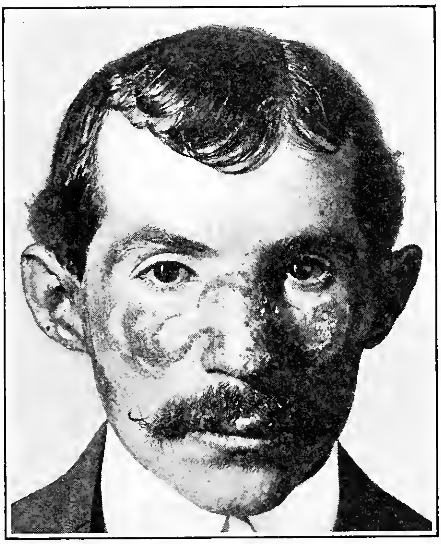
The case of Mr. B., aged forty-two years, is of unusual interest from the fact that the lesions occur in various situations, including the lower lip and involving the vermilion border, extending upon the mucous membrane within the mouth; the disease also implicates the ciliary margin of the right lower eyelid.

The patient came to me in February, 1902, with the history that the first patch had appeared upon the lower lip after a pimple had been cut in this situation by the barber. *x*-ray treatment was begun in March, with exposures of five and afterward ten minutes. After about a month's treatment the condition of all areas was very much

[1] American Journal of the Medical Sciences, September, 1901.

improved, some patches appearing cured. The patient disappeared and returned four months later, having had some severe intercurrent illness. The skin surface of the lip and patches on the cheeks had remained apparently cured. After a few treatments the patient again disappeared for another four months. At this time the lower eyelid was found affected, there being slight extension upon the conjunctival surface. Two-thirds of the lashes had fallen. The vermilion border of the lip was of a brick-red color

FIG. 61.



Typical bat-wing form of lupus erythematosus.

and decided evidence of the affection could be traced well within the mouth. After a short course of raying several months again elapsed, and in June the lower lip and a patch upon the side of the nose and cheek alone appeared active. The Piffard modification of the Goerl lamp was then used in connection with the x-ray, and from this time on the improvement was more rapid, and the plaque involving the lip and several others reached a condition of apparent cure.

The typical bat-wing form (see Fig. 61) may prove very obstinate, though in one case there was complete disappearance of lesions after about fifteen rayings of medium intensity. About four months later an erythema, disappearing under pressure, occupied the original site, but showed no pronounced tendency to assume the usual aspect of an infiltrated, scaly patch.

In one case a cure was effected after a single raying, but as an extensive curettage had preceded it the latter deserves most if not the whole credit.

Fig. 62.

Fig. 63.

Lupus pernio. Feet and hands were also affected.

I think it a very important point, to which I directed attention several years ago, that the lupus erythematosus tissue was soft and could at times be curetted just like a lichen planus, and that if a small, sharp curette were used to bore in beneath the edge and undermine the patch it was not too painful; whereas scraping down upon a patch from without inward was too severe for the patient to bear without an anæsthetic.

In Fig. 62 is shown a young girl who for many years had presented the rather rare form described by Hutchinson as lupus pernio.

Under the ray there was rapid and marked improvement. Each separate plaque on the cheek became at one time suddenly transformed into a bulla, which on healing left only a trace of the disease. The hands and feet were affected and became aggravated and very painful in damp and cold weather.

In another case there had been a long course of ray treatment in Boston, with reported slight benefit.

The right cheek was curetted in one sitting, to the left was applied the actinic ray, to the lip aromatic sulphuric acid. Under this plan there was decided improvement.

Schiff applies a ray of intense light ($3\frac{1}{2}$ ampères current, tension of $12\frac{3}{4}$ volts, and distance of 10 centimetres) with ten- to fifteen-minute sittings. A severe dermatitis is regularly produced, this "Roentgen erosion" having an essential significance in the healing. The erosion is treated by the Bardeleben bismuth burn-bandage.

A considerable number of cures are recorded in literature.

Mycosis Fungoides. While the nature of the individual lesions in mycosis fungoides would offer apparently the very best opportunity for ray benefit, the generalization of these lesions would render efficient application a difficult though by no means impossible task.

Dr. Steiner[1] presented a case at the Dermatological Society of London on March 11, 1903, which was apparently cured. A current of 60 volts, with electrolytic breaks and 10 ampères, was employed. Improvement was noted as early as the fourth day, with a marked flattening of a large tumor. The lesions which were present when the patient was presented have since disappeared, the regions occupied by them appearing perfectly normal except for a deep pigmentation.

Scholtz says energetic treatment produces a superficial necrosis; the lesions healed apparently with permanence, but new ones continually appear on other portions of the body, so that there is really not very much to be gained. He[2] had

[1] Dermatological Society of Great Britain, July 16, 1902. [2] Loc. cit.

two cases in which small tumors disappeared entirely when superficial necrosis was produced.

Jamieson[1] reported notable diminution in the tumors in one case which he considered cured. In one instance he succeeded in greatly alleviating the pruritus by a few irradiations.

Pathological Changes. In studying the histopathology of the disease before and after raying in a patient who had shown signs of the disease for six years, Jamieson and Huie[2] find that the greatest changes in apparently cured areas were in the upper third of the corium, a granulomatous tissue taking the place of the normal. Dilated bloodvessels were conspicuous. The disintegration of the corium begins by a swelling and proliferation of connective-tissue corpuscles.

The impression is made that the disease is a phenomenon of cell reversion, the connective-tissue corpuscles having reverted to an embryonic condition.

It is suggested that perhaps the *x*-ray, by acting on the vasomotor nerves, restores the constitution of the corpuscles and enables them to resume their hereditary specialization. It may also have the power of causing reproduction of elastic fibres. After two months of ray treatment, skin within an inch of the first specimen showed improvement by (1) disappearance of granuloma and infiltration; (2) disappearance of œdema and hyperæmia; (3) restoration of normal corium tissue, both collagen and elastic fibres.

Personal Cases. In the patient (Fig. 64) still under treatment there has been marked improvement after twelve sittings.

My associate, Dr. Stern, reports on three cases referred to him for treatment by Dr. Lustgarten. The results were very gratifying in all. The most satisfactory result was achieved in the case of Mr. K. (see Fig. 65), who, when he first began treatment, had been suffering from the disease for over four years. He had large tumor-like masses scattered over the entire body, including the face and extremities. The itching was very intense, causing loss of sleep

[1] British Journal of Dermatology, January, 1903. [2] Ibid., April, 1904.

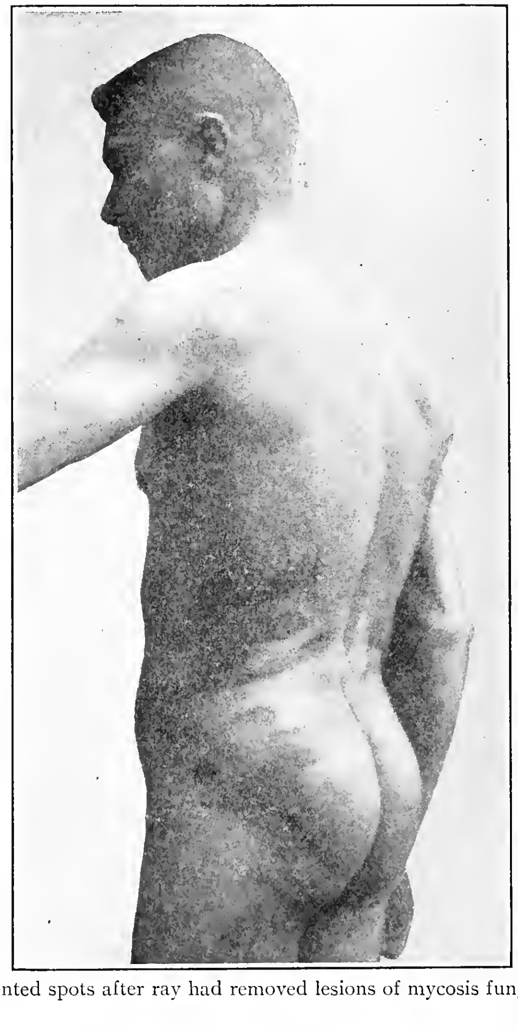
and appetite, and bringing about a condition of general cachexia. He had received over a hundred hypodermic

FIG. 64.

Mycosis fungoides. Prefungoidal stage.

injections, amounting to more than 40 grains of pure arsenic, without any apparent result. A medium tube was used at a distance of about six inches, with exposures of ten minutes' duration. The itching of the exposed parts stopped almost after the first treatment, and the tumors began to visibly

Fig. 65.



Pigmented spots after ray had removed lesions of mycosis fungoides.

flatten and practically melt away, as it were, under the ray. After a number of exposures a dermatitis would be produced, followed by a shedding of the epidermis, with a complete disappearance of all signs of the tumor. In this way a dermatitis was produced successively on almost every part of the body with a complete disappearance of all signs of the disease. The subjective symptoms all improved rapidly. Two months after treatment he had gained twenty-five pounds in weight and felt perfectly well in every respect. It was found that one twenty-minute exposure at about six inches to a good medium tube would invariably produce a dermatitis of the exposed area, which would result in the cure of the particular lesion exposed. In exposing the face to the rays a conjunctivitis of the left eye was produced which disappeared rapidly.

Alopecia of the back of the head developed which persisted for about three months. He was given in all about sixty exposures, covering a total amount of time of over fifteen hours, at a distance of between six and twelve inches. There were a number of recurrences, but none in regions where a dermatitis had been produced at any time. These yielded very readily to further treatment.

The second patient is Mr. B., who likewise has been afflicted for a number of years. The history is very similar to that of Mr. K. There was rapid improvement and alleviation of all symptoms under the ray. He is still under treatment.

The third case was of a much more aggravated form. Here the disease had lasted over ten years, and was more in the nature of a general sarcomatosis. Large suppurating tumors covered the entire body, freely discharging a considerable amount of pus having a very foul odor. These tumors softened, broke down, and then gradually flattened under treatment. While there was considerable improvement, this one did not do so well as the other patients.

He was referred for further treatment by Dr. Lustgarten to the Montefiore Home. At the last report, while he was considerably improved, there was not much hope for complete recovery.

Dr. Albert E. Carrier[1] reports an interesting case of mycosis fungoides of twelve years' standing (Plate XXIII.),

[1] Journal of Cutaneous Diseases, February, 1904.

cured by the ray. Distributed over the body there were over three thousand tumors, varying in size from a pinhead to an orange. At the end of about three months' treatment the lesions had all disappeared.

Mr. C. W., aged thirty-one years, was presented at the New York Dermatological Society in March, 1904, and twice previously, at which times the features of the disease were not at all distinctive. The patient was referred to me by Dr. Sherwell, of Brooklyn. The appearances as seen in Fig. 64 are those of an eruption covering the entire body from the neck to the region of the knees. They consist of rounded, erythematous lesions of various shades of red. Some of the darker, port-wine-colored spots are considerably elevated above the *niveau*, but there are no signs of mycotic change or tumor formation. The disease began three years ago upon the lower abdomen and has never entirely disappeared, although some spots have grown lighter. Treatment was begun at once, with a low tube at ten inches from the skin and applied for ten minutes as the patient slowly revolves, so that an entire circuit of the trunk is made. Three such exposures at different levels are given, so that the entire time of the sitting is one-half hour. After the third sitting the tube was changed to one of high vacuum placed at six inches. After five sittings the results have been: greatly diminished itching, decrease in depth of color, decrease in infiltration and increase of desquamation of the plaques.

The first case in which I had an opportunity to employ the ray was the first, I believe, to be recorded in literature. Treatment was given to allay the itching and diminish the dermatitis in the prefungoidal stage. This was in a measure accomplished, but the patient entered an institution, and, I believe, no further rays were administered. I saw him subsequently when tumors had appeared on various parts. The disease is so strikingly like sarcoma at times, and the clinical appearances are so like lepra at others, that the ray would, *a priori*, be expected to do good, in both lepra and mycosis, and if proven beneficial in one should be likely to be in the other. In Fig. 66 the resemblance to the nodular form of leprosy is well illustrated,

PLATE XXIII.

FIG. 1.

Mycosis Fungoides before X-ray Treatment.

FIG. 2.

Present Appearance.

FIG. 3.

Large Fungoid Tumor before X-ray Treatment.

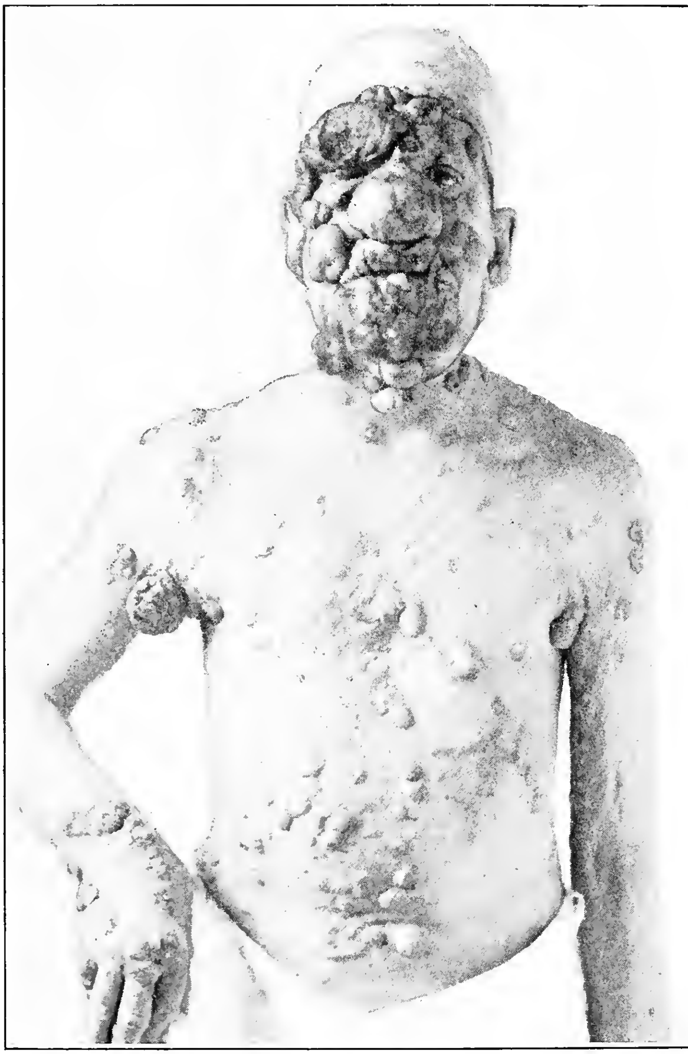
FIG. 4.

Present Appearance

Case of Dr. Albert E. Carrier.

and, indeed, the patient was for a long time mistaken for a leper. I am indebted for the privilege of studying the

FIG. 66.



The nodose or tuberose form of mycosis fungoides.

case as well as for the photograph to my friend Dr. G. K. Dickinson, of Jersey City.

Pusey has treated one patient with very great improvement in the tumors rayed; the patient, however, ceased treatment.

Brocq[1] has reported a patient improved in a remarkable manner. A full report will be made later.

Molluscum Contagiosum. In recent cases, when the lesions are not of long standing, it is generally sufficient to remove them mechanically, as with the curette. When the disease has involved a large extent of surface, however, and the tendency to recurrence and autoinfection of new parts is strongly manifest, the rays then offer, perhaps, one of the most satisfactory means of combating the condition. In some extreme cases in which the lesions have progressed, the ray is at least a painless and satisfactory method of treatment.

I have employed it as an aid in both the disseminated form and single large growth with apparent benefit, since both patients made prompt recovery. I saw the lady, who had presented the small growth over almost the entire body, four months afterward and there had been no return.

Nævus. NÆVUS FLAMMEUS. In port-wine mark the ray has been reported by some to have given better results than other methods of treatment.

The known effect upon rather deeply situated bloodvessels leads to the belief that nævi could be influenced for good. In a case in point, Jutassy carried the treatment to the point of blister production, the results proving the method efficacious and lasting. I have had decided improvement in one case. The ray was given for the removal of superfluous hair, and the nævus being upon the cheek came in for a share of the effects. Subsequently individual dilated vessels and separate red points were attacked with the electrolytic needle and the actinic-ray lamp was also used, each further decreasing the disfigurement.

NÆVUS PIGMENTOSUS ET PILOSUS. Possibly in the whole realm of dermatology prophylaxis finds no more definite and satisfactory field than in the prevention of both carcinoma and sarcoma by the early and proper removal of

[1] Annales de Dermat. et de Syph., February, 1904.

melanotic growths or pigmented moles. It is established beyond all question that malignancy follows certain forms of irritation of certain of these growths, especially at certain periods of life. While it is more particularly late in life that these changes occur, occasionally they may take place quite early. Many of these tumors formerly considered sarcoma have been shown in recent years to be carcinoma. While many of these nævi can probably be best removed by electrolysis, the larger ones and especially those containing much hair can be destroyed with the ray.

One of the first successful attempts at radiotherapy was carried out on an extensive hairy mole. Small pigmented and hair-bearing nævi are probably best and quickest destroyed by electrolysis, but the larger ones can be most successfully rayed.

Nævus Vasculosus. Dickson reports a vascular nævus gradually disappearing under the rays.

Taylor reports a nævus of the breast five and a half inches in diameter which showed notable improvement. A high tube was used at six to eight inches daily, then every second day. A personal case still attending is improving.

Paget's Disease. In this precancerous malignant dermatitis about the nipple one would expect that the ray would prove most effective. In one case still in the eczematoid stage Stelwagon found, however, that no effect was produced.

Pusey reports a successful case treated in 1901–1902.

In Paget's disease of the nipple occurring in a negro woman who refused operation, Dr. E. R. Meek[1] succeeded after four weeks' raying in entirely eradicating the diseased area. Two weeks later microscopic examination showed the skin and subcutaneous tissues to be normal.

In a woman presented at the New York Dermatological Society, April 26, 1904, by Dr. Fordyce, a lesion of the buttock which presented all the clinical and microscopic appearances of Paget's disease had been quickly cured.

Paronychia. The ray has such a well-known predilection, as it were, for affecting the nail bed and surrounding parts,

[1] Boston Medical and Surgical Journal, June 18, 1903.

as well as the nail itself, that one could almost argue in advance that certain nail affections would be benefited.

Specific and mycotic, favic, and trichophytic affections have been subjected to the treatment, but hitherto with but little success. We have recorded elsewhere a slight effect observed in favus of the nails. I have shown paronychia in a subject of secondary lues whose finger-tips were seemingly greatly improved by raying after they had grown steadily worse under local and general use of mercurials. The toes not rayed continued unimproved coincidently with improvement in the fingers.

Pityriasis Rosea. In three instances I have witnessed apparently more rapid disappearance of widely disseminated lesions than is usually observed under our ordinary methods of treatment.

This disease, as is well known, often disappears within a few weeks, so that the relative advantage of the ray must be carefully considered.

Prurigo. W. Scholtz[1] speaks of prurigo as one of the conditions which has been improved by the action of the rays.

In a case showing no improvement there was rapid recovery under ordinary methods, such as the production of sweating, etc.

Pruritus. In view of its well-known action on pain, the ray has been used in obstinate skin diseases with intense itching as a marked symptom. Fair success has accompanied this form of treatment in the majority of my own cases. In one there was no benefit, the patient even complaining that the exposure aggravated the condition. In the pruritus of cancer, especially of the liver and gall-bladder attended with slight jaundice, little benefit has come from the method. In that of lichen and mycosis this is marked.

In one of Zeisler's cases pruritus genitalis was much benefited after three mild exposures.

In the treatment of eczema it is noticeable that the itching usually disappears promptly on the application of the rays.

Pruritus Ani. In itching about the anal orifice and buttocks, the ray often acts in a very prompt manner, often

[1] Archiv f. Dermatologie u. Syphilis, pp. 87, 241, 421, January, February and March, 1902.

after other treatment has failed to give relief. Naturally when the condition depends on systemic disorder, internal or appropriate measures must be employed.

In several cases we have had alleviation.

Dr. Pennington[1] reports eleven cases of pruritis ani which improved under ray treatment after having been ineffectually treated by a great variety of other methods. The patients received no internal or other local medication.

PRURITUS VULVÆ. Scholtz finds ray treatment very satisfactory.

Sjögren and Sederholm report several patients treated with remarkable success.

We have succeeded in a measure even when diabetes was the cause. As a rule, the strength of ray should not be great for the localized form and often even for generalized pruritic dermatoses.

Psoriasis. In generalized inveterate outbreaks the ray will prove of marked benefit, when many other remedies have failed. In the case illustrated in Fig. 67 the condition had persisted for many years in spite of all of the accepted remedies applied with the utmost persistence. After the patient had a limited number of exposures the area to which the ray had been confined was completely cleared, and the entire outbreak has been subsequently caused to disappear.

In one case the treatment was confined to a single hand for the purpose of making comparative observations. The result was that the hand treated with radiation is cured, while the other which received only medicinal treatment has not improved. (Inveterate case referred by Dr. Fox.)

In these cases it is important that the ray be confined to only a small area at a time and that careful attention be given to possible burn. The importance of this is emphasized by the fact that these patients have to be exposed for long periods to the ray, and it is almost impossible to avoid some dermatitis. We do not regard this as in itself serious, and in the cases that have exhibited this phenomenon, as in the second case, the benefit has been more marked and rapid. The point to bear in mind, though, is that if these

[1] New York Medical Journal, February 20, 1904.

patients are to be subjected to a dermatitis, it is essential that the latter be confined to a small area.

The treatment may be advantageously combined with such internal and local measures as are likely to assist the action of the ray. I have found removal of the scales to hasten the cure.

Fig. 67.

Psoriasis. Area to which ray was first applied free from lesions.

Zeisler holds that the results in psoriasis are not to be considered permanent; a patch may be cleared in three applications, but in four weeks' time it will have returned.

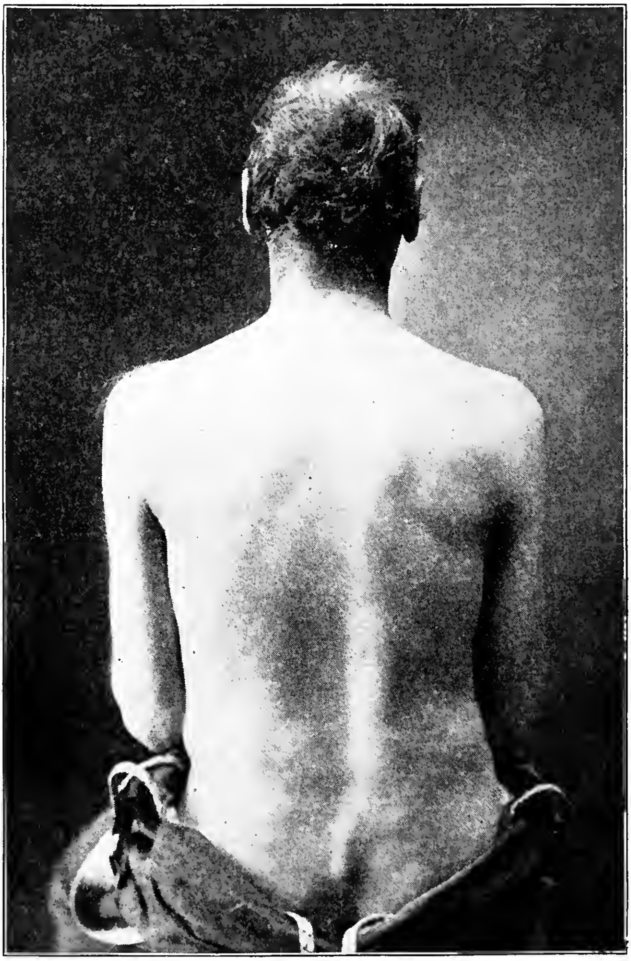
The first symptom of improvement is the lessening of the redness and the appearance of brownish pigmentation mainly along the margin of the plaques. The scales become loose and permit of removal without leaving the characteristic bleeding surface. The pigmentation increases, the

FIG. 68.

Psoriasis before treatment. Dr. Ferris' case.

scales drop off, leaving a smooth surface behind. After this stage is reached it is advisable to keep up a mild after-treatment with chrysarobin for a few days. The pigmentation lasts for some time even in the surrounding parts, but it gradually decreases. There is occasionally recurrence,

Fig. 69.



Psoriasis lesions removed by the ray.

but this yields readily to renewed raying. Scholtz suggests prophylactic raying in subjects showing marked tendency to relapse, to make sure the last vestige of disease is destroyed. On the scalp the ray's effects are confined to the affected areas by proper shielding. Upon the general surface the larger the area operated upon the better, providing the patient is not placed at too great a distance from the tube.

Besides the 16 cases which I have observed myself, in which there was always benefit and at times complete removal of lesions; one with very extensive and persistent plaques having cleared up nicely, favorable reports have been given by Williams, Hahn, Startin, while Hyde, Montgomery, and Ormsby report 32 cases treated with satisfactory results.[1] In moderately thickened patches the scales very often disappear after two or three sittings.

Ferris[2] reports an interesting case, of which Fig. 69 is an illustration, in which lesions on the chest disappeared after rays were applied to the back.

The acute cases, according to Williams, where the color is bright, are more quickly benefited than those covered with scales. He finds relapse frequent. F. H. Montgomery thinks they are postponed longer than after other methods.

There is often associated with psoriasis a painful chronic arthropathy which Brocq, Adrian, and others have studied. The skin lesions are usually universal, and at times there is found a reflex trophoneurosis as a possible cause. The arthralgia can often be relieved by *x*-ray which at the same time removes the skin-efflorescences, but when great deformity and destruction of joints occur little hope can be held out. Bowen reports from the Massachusetts General Hospital six cures out of eight trials.

To illustrate about what results we may expect, I cannot do better than quote from a letter just received from Dr. Bowen: "You may remember the case of a Mr. K., whom you kindly sent to me last summer—a very chronic psoriasis, especially of the hands. You had nearly cured him when he left and we finished it up in a few treatments, so that he was perfectly cleared. He then went home to Scotland

[1] Journal of the American Medical Association, January 3, 1903.

[2] American Electrotherapeutic and X-ray Era, May, 1903, to which journal we are indebted for loan of illustrations.

for the summer, and toward the end of that time his hands were as bad as ever. We have now succeeded in getting them well again after, I think, fifteen exposures. This seems very satisfactory, as apparently nothing else would touch the case, and we cannot expect, I suppose, that this new treatment should prevent recurrences."

Technique. The tube is placed at a distance of 40 to 50 cm.; in case the apparatus is not powerful a closer exposure is necessary. Exposures of three to five minutes may be given at 20 cm. on alternate days. As a rule, improvement is very soon manifest without any dermatitis; however, here as in other cases a small amount of redness may hasten the disappearance of the patches. A decided burn dermatitis in the case of the hand already mentioned was followed by a very marked and rapid improvement. Recurrences are overcome more readily than the original outbreak. Scholtz[1] claims that at a distance of 40 cm., with exposures of about ten minutes, five or six sittings generally are sufficient to effect removal of the lesions. In small lesions he makes the exposure at 10 to 15 cm., and exercises great care that the rays always strike the surface at a right angle.

As a rule, one area must be treated after another by dividing up the body into definite regions and giving daily exposures so that the whole surface becomes gradually exposed and the patient is kept under constant observation.

Psorospermosis. In Darier's disease there have been few observations. In a case treated at the New York Skin and Cancer Hospital the foot-soles were so involved in a woman that walking was well-nigh impossible. After fourteen exposures there was so great improvement that the patient remained away for some time, but subsequently returned for further treatment.

Rosacea. Here the results are highly satisfactory, as a rule. Electrolysis, knife puncture, and scaling applications can be coincidently carried out, shortening the period of treatment.

Scleroderma. Varney reports a case of scleroderma in a young man in whom marked improvement occurred. If

[1] Loc. cit.

large areas were irradiated so great malaise was produced, the patient would be confined to bed.

Scrofuloderma. This being usually in reality a tuberculous affection, one would look for no less a result than in lupus or tuberculosis vera cutis. In several instances I have observed enlarged and suppurating nodes to diminish under the ray.

In a boy with lupus and scrofulous swellings, who was referred by my associate, Dr. Mayer, to the electric and *x*-ray department of the Post-graduate Hospital, a cure was effected.

The same result was obtained in a little girl I treated, who presented the same combination of lupus and enlarged glands.

At the Massachusetts General Hospital, according to Bowen's report, 3 out of 6 cases were cured.

Zeisler reports tuberculous ulcerations healed after five weeks.

Bagge[1] saw a very extensive tuberculous ulceration of the chest and infra-axillary region heal over after it had existed as an open sore for seventeen years.

Seborrhœa Oleosa. This condition, as it affects the face, nose, etc., has been treated with benefit by a number of dermatologists. The secretion becomes less and the functional activity of the sebaceous glands diminishes, while there is a question of their shrinking or becoming atrophic, just as is noted in the case of comedones, acne, etc.

Hypertrophic sebaceous glands, patulousness of their ducts, and hypersecretion are all influenced for good.

Sycosis. The treatment of this condition by means of the rays was first suggested by Schiff and Freund, and since then numerous foreign observers, including Albers, Spiegler, Scholtz, and Gastou, have confirmed their results, reporting cures in very obstinate cases. In my own experience extending to 23 cases, almost all of long standing, the results have been for the most part prompt and excellent, and in a few almost astonishing. In this country there have been many cases reported cured, and the method has earned an

[1] Fortschrit. a. d. Geb. d. Roentgenstrahlen, 1899, vol. iii.

important place in the regular therapeutics of this disease, being superior to mechanical epilation and the use of mercurial, carbolic, and other applications. Among those whose success has been marked are Gilchrist, Hyde, Varney, Pusey, and others.

The time of the treatment depends upon the case, but may be roughly stated at from two weeks to two months in the average severe case. Other methods may be used in conjunction with the ray which has a particular value in obstinate and long-standing cases, especially of the coccogenic form with follicular abscesses and those in which deep-seated indurated masses exist.

Sycosis in common with folliculitis barbæ, ringworm, favus, and other diseases involving the hair follicle is benefited proportionately to our ability to cause prompt falling of the hair.

There seems, however, to be an influence exerted, aside from the epilation and any bactericidal effect which the ray may have. The latter is considered by most observers to be slight.

In many instances before the hairs loosen, pustules, papules, indurated nodules, and deeply infiltrated masses flatten and soften, while follicular abscesses disappear. Both the coccogenic and the non-parasitic forms are acted upon rather promptly, and, though at times after a re-growth of hair scattered new lesions may appear, the recurrence gives way to a very few rayings.

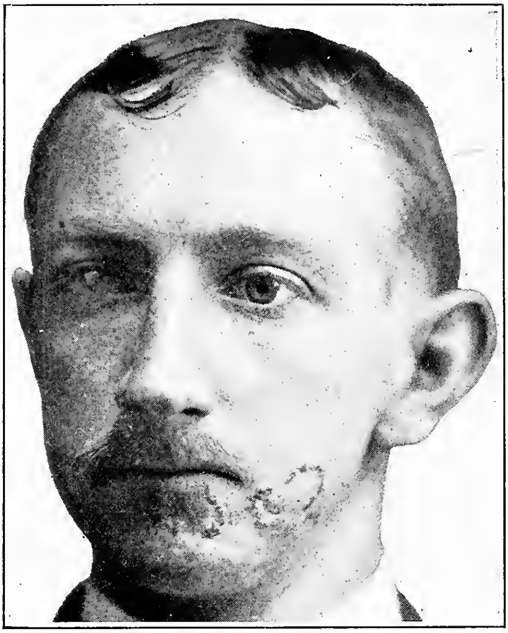
Scholtz found that only in mild cases were permanent results obtained, unless repeated rayings were carried out after seeming cure, and relapses thus prevented. Such a course surely seems most rational and advisable.

That we must not mistake some intercurrent affection for a return of the original process is well illustrated in Plate XXIV. This patient having been smoothly epilated upon one side and over the chin and neck, with disappearance of an obstinate sycosis, returned before the hair had begun to grow, stating that the disease was coming back.

The rings shown in Fig. 1, Plate XXIV., constituted in reality what appeared to be the ringed form of impetigo contagiosa, one ring extending well over the vermilion border

PLATE XXIV.

FIG. 1.



Ringworm-like Impetigo following Sycosis Cured by X-ray.

FIG. 2.

After Three Irradiations.

of the lip. These lesions were entirely removed by three applications of the ray, and in Fig. 2, Plate XXIV., is shown the condition ten days later.

Among my successful cases was one presenting upon the right cheek a patch of lupoid sycosis of many years' standing. The centre of the patch was occupied by a cicatrix due to the suppurative inflammation and previous severe treatment.

Fig. 70.

Sycosis of beard and region of temple.

In spite of the latter the disease had persisted and spread, there being scattered patches of folliculitis not alone in the bearded region, but in the brows and hair margin as well.

The man had been treated by me several times during the past five years, but there was always a renewed outbreak. In September, 1902, I gave three exposures, but did not see him again until February, 1903. His attendance was very irregular, treatment being carried out on March 7th, May 29th, and June 20th. This last coil-exposure was of eight

FIG. 71.

Sycosis of neck

FIG. 72.

Sycosis of pubic region.

minutes, at six inches, quality of ray 8, of radiometer 2½ ampères, 5-inch spark. This was followed in two days by a dermatitis lasting for two weeks. All the lesions within

PLATE XXV.

FIG. 1.

Obstinate Sycosis of Beard.

FIG. 2.

Permanent Cure after Four Weeks' Treatment.

the area of dermatitis had wholly disappeared on subsidence of the redness and the cicatrix had likewise vanished. The other lesions gradually disappeared.

A somewhat similar case is shown in Fig. 70, which was rapidly cured.

Plate XXV., Fig. 2, illustrates a very favorable result in an obstinate and deep-seated sycosis of eight months' standing, which had received very persistent treatment in various capitals of Europe, including Antwerp and Brussels. On arriving at New York the condition was more aggravated than ever, according to the patient's statement. Ray treatment was begun on September 15, 1903, and continued for one month. The figure is from a photograph taken about two weeks after the beginning of treatment.

FIG. 73.

Obstinate sycosis.

The hair of the beard is now growing again, and the pigmentation caused upon the face has wholly subsided. Where previously there were deep-seated nodules beneath the skin, the tissues are now perfectly soft and free from evidence of inflammation.

In Figs. 71 and 72 are shown, in the same patient, a very long-lasting sycosis of the face, neck, and pubic region which rapidly improved under ray treatment, applied vigorously to the various regions.

Another case of chronic, persistent sycosis referred to us by Drs. Kudlich and Arlitz, of Hoboken, is shown in Fig. 73. There was rapid improvement and he was almost well when he ceased treatment.

In Plate XXVI., Fig. 1, is shown a persistent sycosis which disappeared after a dermatitis was produced. The after-picture (Fig. 2) was taken about six weeks later.

Technique. Exposures should be short and frequent, even daily, until reaction in the lesions or a general skin reaction is produced, with fall of hair; or ten-minute exposures given at longer intervals until the total dose of absorbed ray accomplishes the work required.

The length of exposure and dose of ray is regulated also by the depth of involvement of tissues, duration, etc.

As a rule, a decided reaction is required in true sycosis to destroy or remove the tricophyton ectothrix or to render the soil unfavorable for the further growth of hyphomycetes. In sycosis due to infection with common pyogenic organisms less vigorous raying may suffice, though here the hair should as a rule be made to fall. I have usually employed a rather high tube, and the most effective sittings have been between five and ten minutes.

Gastou, Vieira, and Nicolau caused epilation with eleven ten-minute sittings, and complete cure after the thirteenth daily dose of 25 to 30 volts, 5 to 6 ampères, 15 cm. distance, No. 6 of the radiochromometer scale. After fifty-three days the hair had grown again.

Freund finds that with a hard tube four to six, eight- to ten-minute sittings at 15 cm. suffice.

In 17 cases, 5 were completely cured in one course; 5 others had one recurrence, 3 cases two, and 1 case three. At times after mild exposures the lesions appeared aggravated, requiring cessation of ray and soothing applications until the inflammation subsided.

In trichophytosis ectothrix of the beard and neck, in a patient of Gastou and Nicolau, the hairs began to fall after the second sitting, and after the fifth the face was well.

In another case after eight exposures the patient showed no recurrence six weeks later.

Trichophytosis Capitis. In ringworm of the scalp, the reports of different radiotherapists vary greatly in the matter of results. It may be stated, however, as generally accepted at the present time, that the ray is a valuable agent in the cure of this condition, that there is improvement in

PLATE XXVI.

FIG. 1.

Sycosis of Long Standing.

FIG. 2.

After Six Treatments.

most of the cases, and when adjuvant treatment is coincidently given the results are excellent.

The experiments of Scholtz indicate that the rays do not destroy the fungus, which is liable to reappear with the return of the hair.

The interesting observation has been made by Holzknecht that after producing shedding of the skin in ringworm, the fungus was still to be discovered in the exfoliated shreds, from which it could be cultivated, indicating that the beneficial action had been other than bactericidal.

The defluvium capillorum is to be explained as the result of inflammation of the matrix cells.

Freund, who deserves the credit of suggesting the ray in ringworm, has had good results, as have also a number of others, including his associate Schiff, Sokolow, Kienböck, Török, Grouven and Lion, Oudin, Barthélemy, and more recently Sabouraud, whose experience extends to over one hundred cases. The technique, as well as the modus operandi and indications, are in the main the same as given under favus.

Sabouraud[1] propounds the following therapeutic formula: To cure a plaque of tinea tonsurans, it must be exposed at a distance of 15 cm. from the centre of the tube (Villard), having a constant resistance corresponding to a half-centimetre spark of the Spintermetre (Béclère) and to the fourth division of the radiochromometre (Benoist) until the electric source has furnished a sum total of x-rays corresponding to $4\frac{1}{2}$ or 5 units H of the Holzknecht scale.

This will produce epilation without accident. The parasitic rays—*i. e.*, all those which are not direct—are shut off by a suitable screen arrangement.

A slight erythema appears about the seventh day and disappears four days later. Beginning with the fifteenth day the hairs fall spontaneously, and epilation is complete in a few days.

The rays do not kill the parasites. Hence, continued antiseptic treatment is necessary. This the author accomplished by means of tincture of iodine diluted with five

[1] Revue pratique des mal. cut., syph. et vener., February 1, 1904

times its volume of alcohol. Seven weeks later the hair begins to grow.

He finds that the time of treatment has been reduced by the ray from an average of eighteen months to three months, and has recently expressed his opinion privately that this new method will go far toward ridding Paris of this great scourge.

Zechmeister reports a case which was radically cured in twenty-one sittings at a distance of 25 to 15 cm., with an exposure of five to fifteen minutes.

Gastou produced total alopecia in nine sittings. In three weeks the hair began growing and in two months growth was complete. Bacteriological examination three and a half months later was negative. He employs 20 to 30 volts, 3 to 6 ampères, 15 cm. ten minutes.

In another cure no parasites could be found three months later. In a case showing microsporon and staphylococcus the hair began to fall after seven sittings and was complete after ten, the skin appearing smooth, thin, stretched, and as though slightly atrophic, although there had been no inflammation. Tactile sensibility test showed slight hypæsthesia to pain.

In eczema marginatum or trichophytosis cruris, as well as in pustular folliculitis of the pubic region, as shown in Fig. 72, the ray may render excellent service. In one case after the eighth sitting, under the same technical conditions of administration as given for ringworm, there was slight dermatitis and fall of hair.

Other measures may be advantageously added. Here, as in sycosis and other parasitic diseases, Russell finds benefit and acceleration of the rays' action by the simultaneous use of oxygen applied as a spray from a cylinder or by the static breeze. If a pustular eruption of superficial nature supervene after depilation a sulphur ointment or lotion will usually effect its prompt removal.

Tuberculosis Cutis. Various forms of skin tuberculosis aside from lupus have been improved and cured by the method. We have already mentioned the subject under Scrofuloderma. I have advised the ray in tuberculous ulceration about the anus in association with fistula in subjects of pulmonary or other systemic tuberculosis. Even the fistulous tract might be beneficially influenced.

Tuberculosis Verrucosa Cutis. Dr. R. R. Campbell reports a cure in this condition. He could secure no result until a burn was produced, after which the lesion disappeared promptly. At the Massachusetts Hospital a verrucous tuberculosis of the buttock was reported cured.

Ulcers. Chronic ulcers which have resisted all other forms of treatment have repeatedly been cured with the aid of the rays without much difficulty.

Sjögren and Sederholm report four cases of ulcerations in which seventeen to thirty-five sittings of ten minutes' duration were sufficient to bring about a cure.

Colleville treated varicose ulcers with good result.

Taylor[1] succeeded in causing an ulcer to heal while at the same time scar tissue which threatened to produce deformity at the elbow-joint became soft and flexible. Knowing as we do the superior quality of the scar tissue following the ray treatment, this method should receive a trial in all such ulcerations as are known to produce contracting, disfiguring, and maiming cicatrices.

Verrucæ. Perthes[2] reports 18 cases of warts of the hand in which he used the ray, in 16 of which they completely disappeared.

Scholtz claims that on the head a few exposures to the rays even before it will affect the hair follicles, will remove warts, leaving a perfectly smooth surface.

Sjögren and Sederholm report a similar experience. Dry, horny warts on the hands are very little affected by the rays, despite fairly energetic treatment. We have applied the ray in several instances of flat senile warts on the backs of the hands with little benefit. In multiple warts of the face it has at times shown beneficial results, and is employed in a routine way as a prophylactic or after-treatment subsequent to curettage. Under these circumstances recurrence seems to be infrequent. In hard and soft warts Varney reports uniformly good results.

[1] British Medical Journal, September 28, 1901.

[2] Klinisch. therap. Wochenschrift, June 14, 1903.

In a patient sent me by Dr. John Walker there were about forty warts upon one hand, some being confluent and forming a painful tumor which prevented work. The large, original mother-wart was deeply ulcerated at the base. Under vigorous raying, assisted by some scooping out of the growths, especially after the ray had blighted them as it were, a rather prompt cure resulted.

Xeroderma Pigmentosum. This disease is striking in its resemblance to the plain variety of multiple epitheliomata. In fact, it is supposed by many that the condition is identical with this or with the medullary form of carcinoma, with firm stroma and compressed cell-mass. The firm fibrous stroma offers great resistance to the action of the rays, and frequently it does not yield at all, so that in treating this condition it is generally better practice to transform the lesion into an open ulcer by means of curettage, or, better, caustic paste, and when the surface is quite open to apply the rays until the particular lesion is entirely cured. This method of treatment, however, does not seem to prevent the recurrence of the lesion in the margin of the old scars, nor the development of entirely new lesions in other localities.

The development of new lesions is of not infrequent occurrence; still at the same time it can scarcely be said that the treatment has any action in causing this effect. I have, however, observed rapid and extensive tumor formation in a case under ray treatment, but I do not know what technique was being employed. It seems to be the best practice to apply the rays at a rather long distance over a long period after all lesions have apparently disappeared, and thus, as far as possible, prevent recurrence.

Xeroderma pigmentosum is frequently associated with multiple cancer of the skin, and what is not so common, but still a recognized, concomitant, epitheliomatous degeneration of the globe and tissues of the orbital cavity. The signs of xeroderma in the case here reported, which was the first in literature to receive ray treatment, have existed several years. There is one brother of eight years who has had lentiginous discolorations upon the face since birth. Two sisters are free from signs. The left eye has been affected for three years, and the right for one year. Examination of the tissues by Dr. Lustgarten showed the growths to be epitheliomatous. The patient was referred to me by Dr. Briganti, and the treatment was begun on May 18, 1902. Exposures ranging from five to eight minutes were continued with few interruptions until March, 1903. The lesions had then practically all disappeared from the face (Fig. 75), and the lesion in the right eye no longer gave any trouble and was perceptible only as a minute point of thickening at the corneal margin when viewed with a magnifying glass. The left globe was enucleated during the summer of 1902, the rays being resumed as soon as the stump healed. The growths resembled flat epitheliomata of the skin, and were for the most part superficially situated.

The subject was a boy, aged fifteen years, in whom the lesions had begun in early childhood. For three years there had been a lesion of the left globe, and for two years there had been no vision in this eye. Perception of x-ray light-effect was possible, but there was no perception of daylight.

After six weeks' treatment the malignant growth involving the globe had been decreased one-third.

The following report upon the condition of the eye was kindly furnished me in February, 1903, by Dr. P. Briganti:

"I first examined the boy on December 26, 1901. His eye and skin had been treated in an institution in Brooklyn, and I could not make a proper diagnosis then, as the anatomical appearance of the lesions was greatly changed.

"The left eye presented lagophthalmus from cicatricial contraction of the lower lid, which was very deformed, especially at the outer canthus. The eyeball showed signs of recent surgical treatment (actual cauterization), the destruction affecting about half of the cornea in a diagonal direction with the maximum of loss of substance toward the outer canthus. For about 3 mm. from the line of the limbus the sclera was bare of conjunctiva all around the affected cornea; the edges of the conjunctiva were slightly infiltrated and pale, while the rest of it down to the caruncula showed some rather thick bloodvessels, sharply contrasting with the scanty capillary formation. There was some mucopurulent secretion.

"The day after the first examination I performed a plastica of the lid, taking the flap of skin from the forehead. As soon as the eyeball was no more exposed to the external agents, the mucopurulent secretion subsided entirely. A week later the conjunctival infiltration appeared to be decreasing, and in the mean while the cornea itself showed some thickening at its lower portion, which slowly and steadily progressed. Then there was no more doubt in my mind that I had to deal with a malignant growth (epithelioma) of the limbus, which diagnosis I was not ready

FIG. 74.

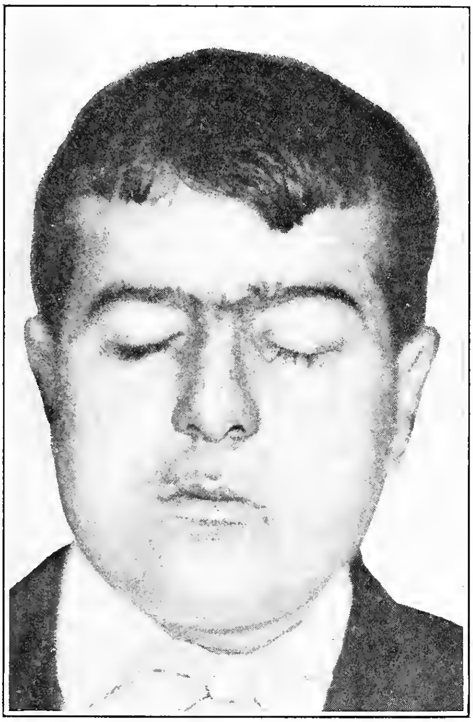
Xeroderma pigmentosum, with epitheliomatous degeneration.

to make before, especially when taking into consideration the age of the patient (fourteen years).

"The boy was then sent to skin specialists and the diagnosis of xeroderma pigmentosum (Kaposi) was confirmed. He was kept under constant observation all the while, when, about March, 1902, the right eye began to show a focus of infiltration about the limbus at a point corresponding to the inner canthus. On May 5, 1902, an excision of the conjunctiva surrounding that focus was performed and the specimen microscopically examined showed to be formed principally of epithelial tissue without appearance of malignancy; however, some irritation was noticeable.

"Some months after, the cornea of the left eye being entirely involved in the infiltration, which extended also to the bulbar conjunctiva, I deemed a new surgical intervention to be necessary. So on July 20, 1902, I exenterated the left orbit, removing all the bulbar and also some of the

Fig. 75.



Xeroderma pigmentosum after ray had removed a number of cancer lesions.

palpebral conjunctiva; then transplanted a large piece of skin from the arm, stitched it to what upper and lower palpebral conjunctiva had been left in place so to make possible the wearing of an artificial eye, which the patient now comfortably does. No repetition of the growth has been seen so far. The content of the orbit was duly examined in the pathological department of the New York Eye and Ear Infirmary, and the diagnosis of epithelioma of the limbus microscopically confirmed.

"The right eye begins to show signs of ever-increasing infiltration at the place where excision of the conjunctiva was made in May, 1902; the corresponding section of the limbus and cornea are involved in the process, while a marked irritation surrounds the infiltrated part down to the caruncula.

"My opinion is that this represents the repetition of the same process that took place in the left eye, and, very likely, unless the *x*-ray treatment proves to be successful, it will end with the ultimate destruction of the eye. I am not in favor of any surgical treatment at present, fearing that it would simply precipitate the unfavorable course."

Under persistent exposures to the ray the remaining eye has improved during the past six months, the growth having increased prior to this *pari passu* with the development of bulbous nodes beneath the eyes (Fig. 74).

At the present time the face is fairly smooth, though evidences of epithelioma continue to crop out.

A case of xeroderma pigmentosum cured by the rays was reported by Dr. A. Jamieson. The patient was a little girl who, at the age of twelve months, began to develop freckles and later telangiectases and whitish spots on the face. The hands and wrists also were affected. The nose was the site of an epitheliomatous growth, which was surrounded with warty lesions. After thirty-four treatments of five minutes each to the face, and of thirteen minutes to the right hand, a dermatitis developed which, when cured, left no trace of the disease discernible.

The writer comments on the fact that the nose, which was the seat of the treatment, was whiter than the rest of the face after the treatment, and thought that this marked a difference between the *x*-ray and the forms of chemical ray treatment which have a tendency to cause deeper pigmentation.

Zoster. In herpes zoster it is very difficult to estimate the analgesic effect of the ray because of the very erratic nature of the pain in this affection. We must remember that in youthful subjects pain is apt to be slight and readily relieved, while in those of advanced years it may persist for months or years after the skin lesions are healed. The latter therefore present the more convincing test cases. At times a severe pain will cease after a single exposure. Various observers have reported favorable results.

The hyperstatic current with glass electrode gives much relief as an added measure.

Other dermatological conditions in which benefit or cure have been reported include dermatitis staphylogenes, pemphigus foliaceus, of which Scholtz records decided amelioration of temporary nature, dermatitis papilaris capillitii (Fox).

In *actinomycosis* Bevan has reported good results from combined *x*-ray and potassium iodide internally.

Dermatitis. Various forms of skin inflammation and irritation, including the itching dermatitis left after vigorous treatment for scabies; vesicular dermatitis of unknown nature resembling that of poison ivy, and dermatitis venenata itself may all be benefited by the ray—the element of pruritus I have seen repeatedly disappear.

Elephantiasis. Sorel and Soret have had some gratifying results. In the early stages Snow[1] says the ray may be of use. Mascat[2] reports one recovery.

Rumph has observed good effects in *erysipelas*, the disease being "scattered," whatever that may mean.

Various forms of *follicular inflammation* and hyperactivity of glands are benefited. Elsewhere we mention glandular changes associated with acne rosacea, etc.

In folliculitis abscedens, barbæ, decalvans, and pilaris the method would certainly be indicated, and in several of my own cases it has acted well in these affections.

Eleven cases of folliculitis of the beard were cured, according to a report by Bowen.[3]

In several instances I have seen *boils* disappear, it seemed to me, more promptly than when the ray was not used.

Reports by others tend to confirm a certain influence

[1] Journal of Advanced Therapeutics, November, 1903.

[2] London Lancet, 1898, vol. i. p. 544.

[3] Statistics from the Massachusetts General Hospital, American Dermatological Association, May, 1903.

here, as we would be led to expect from the results in suppurative folliculitis and similar conditions.

Impetigo contagiosa is so readily curable with ammoniated mercurial ointment that the ray seems scarcely necessary. In two cases I believe I have seen benefit.

Xanthelasma. The ray should act well in generalized and local xanthoma. In two patients of my own with plaques upon the lids the ray has done excellent work.

In xanthoma diabeticum treated by Dr. Stern there was very great improvement.

Dermatitis herpetiformis, papillomatous or warty syphilides, yaws, and similar conditions should at least be benefited by the method.

Pemphigus, pityriasis rubra, morphœa, and other severe affections should receive a trial, as well as acrodermatitis and all other inveterate forms of so-called eczema.

My observation has now extended to 425 patients, presenting various cutaneous affections, in nearly all of which benefit has been derived.

CHAPTER XI.

RADIOTHERAPY IN OPHTHALMOLOGY AND OTOLARYNGOLOGY.

EFFECT UPON THE EYE AND EYE DISEASES.

As a rule, in giving exposures in the region of the eye, even if the globe is not protected, the ray has little effect upon the vision or function and produces no subjective or objective change. Exceptions have, however, been reported.

Hallopeau and Gadaud, after giving a long exposure, found that the patient experienced a disagreeable impression of bright light.

Burdick reports that a Dr. Marsh observed great improvement in his own case of myopia. After experimenting with the rays, and losing his eyebrows, his eyesight improved so that glasses previously worn were dispensed with.

Among others, Scholtz believes that the ray has no effect upon the retina or optic nerve whatever.

The lashes can often be epilated successfully in various diseases, and "wild lashes" can be made to fall. While the brows and lashes have been shed in a great number of those treated by me, conjunctivitis necessitating interruption of treatment has been observed but twice.

Blepharitis. Having observed two instances of cure of eyelid disease in patients being treated for concomitant skin affection of the face, we tried it in a marked case of blepharitis. There was decided benefit and the patient remained away from March until May, when treatment was resumed. Result, disappearance of all evidence of the disease.

Conjunctivitis. In vernal conjunctivitis Starr and Bennett,[1] of Buffalo, and Smith, of Warren, Ohio, have obtained

[1] Journal of the American Medical Association, July 25, 1903, p. 251.

great benefit from exposure of the conjunctiva to the action of the ray.

It has also been found that in the conjunctivitis of measles and in the granular lids there is rapid improvement.

Tuberculosis of the Conjunctiva. Stephenson[1] reports a cure of tuberculosis of the palpebral conjunctiva in a girl aged four years. Tubercle bacilli were present in the sections of granulation tissue. Ten-minute exposures were given six to ten inches from the tube. Enlarged submaxillary glands increased in size, however, and were removed.

There was no visible cicatrization left on the conjunctiva, and the writer regards the cure as complete.

Diseases of the Cornea. Williams reports two cases of corneal involvement, one presenting a flat leukoma in the lower half of the cornea. Exposures were given once a week for three months, then twice a week for two months, after which time the scar was smaller, smoother, and less dense, and vision was improved.

Dennett[2] reports having observed that ulcers of the cornea are stimulated to rapid healing.

Epithelioma of the Margin of the Lid. This condition offers one of the best fields of usefulness for the use of the ray, since both the delicate nature of the organ involved and the surrounding anatomical structure render operative measures extremely unsatisfactory and dangerous to the integrity of the organ, while the malignancy of the disease when it attacks these tissues renders it rapidly destructive. The ray, on account of its selective action upon cancerous tissue, attacks the diseased parts and discriminates with a nicety which cannot be approached by the hand of the operator. Protection should be afforded as far as possible by the ordinary form of shield, but it is improbable that the healthy parts will be affected during the time that a tumor of ordinary dimensions is under treatment. A shield for protecting the globe will be found mentioned under the chapter for shields.

[1] British Medical Journal, June 6, 1903.

[2] Medical Record, February 13, 1904.

A case is reported as cured by Taylor. The conjunctiva of the everted lower lid and inner canthus became covered with a smooth layer of opaque, horny epithelium.

Sweet[1] has had good results in three cases.

In a case related by Wild the treatment was followed by panophthalmitis, necessitating the removal of the globe. This is among the marked exceptions, as the ray rarely affects the eye.

Pfahler[2] reports a case involving both eyelids and the inner canthus, which was vastly improved after thirty-four exposures.

In three cases of our own the lid and inner canthus region was involved, including the case of xeroderma pigmentosum, and all have so far done well. (See under Epithelioma.)

Glioma. Harper[3] reports a case treated which has recurred after operation upon the retina.

Hordeolum. In several cases of stye in our practice we have found a rapid disappearance which may be attributed to the ray.

Lupus Erythematosus of the Lid Margin. In a patient whom I had treated for lupus erythematosus of the mucous surface of the lip, extending well within the mouth, as well as for scattered areas over the face, there developed a patch along the margin of the right lid dipping over upon the conjunctival surface. By persisting with the ray, localized carefully, the plaque disappeared.

Sarcoma of Orbit. Mosely reports one case as cured.

Pratt describes one case of melanosarcoma discharged as cured after nine and one-half months' treatment.

Lord speaks of some success in the treatment of these lesions.

Snow saw a tumor of the orbit rapidly vanish.

Harper observed disappearance of melanosarcomatous pigment areas from the sclera.

Also see under the chapter on Sarcoma.

Trachoma. Trachoma is an affection which is rarely cured in less than one or two years by the most approved

[1] American Journal of Medicine, December 13, 1902.

[2] American X-ray Journal, October, 1901.

[3] Ibid., 1900, iv.

methods. Surgical measures have hitherto given probably the best results.

Sydney Stephenson[1] and David Walsh, after having varied results in various forms of eye disease, applied a combination of *x*-ray and high-frequency current in four cases, in all of which marked improvement followed. Typical hypertrophic severe trachoma was present in four male children from two to twelve years of age; the cornea was involved in three. The exposures of ten to fifteen minutes were given at eight inches from the anode; an average strength of 5 ampères and 20 to 25 volts was used. Every case showed definite improvement from the first exposure; there was a cure in two and considerable improvement in the other two, treatments being continued.

The first effect was to render the granular body redder and more prominent; in the second stage rapid absorption of the granulations presumably took place. In control experiments the eyes treated recovered, while the eyes untreated remained in *statuo quo*.

The analogy which has latterly been recognized to exist between trachoma and adenoids offers a suggestion as to the possible future inoperative treatment of this form of new-growth in the posterior nares.

Mayo[2] also treats trachoma by means of the rays. A moderately soft tube is placed about nine inches from the patient, the exposures being of about two or three minutes' duration. The lids are everted and the lower one is pushed up so as to cover the cornea. Four to six daily exposures, the number depending upon the condition of the case, are given. Where there is extensive infection and when the case is not severe, a lesser number of treatments will suffice. After this first course, the treatments are continued on alternate days for some time; the results have been almost uniformly very good.

Among other eye conditions treated may be mentioned optic atrophy, of which Pusey has treated one case.

[1] Medical Press and Circular, February 18, 1903.

[2] Lancet, London, February 28, 1903

NOSE.

The nasal mucous membrane, when affected by any of the diseases which are amenable to treatment by either of the phototherapeutic methods, is generally reached with difficulty by means of the Finsen light. The x-rays, on account of their penetrating power and of their peculiar property of causing reaction at the point of exit as well as at the point of entrance, will be found more readily applicable in these cases.

In **lupus of the nostril** Ducastel uses a speculum to throw the rays into the nostril. This may produce intense headache or syncope unless sittings are very short.

Hypertrophic Rhinitis. This condition is frequently found in the practice of dermatologists where it accompanies and complicates sycosis. In the experience of the authors it has been found frequently benefited by the application of the rays to this primary condition.

In **lepra** where the bacilli are found in the secretions the Finsen light, due to its bactericidal properties, is more apt to destroy their vitality.

Ozæna. Adolphe Casassa[1] has seen such a remarkable benefit in these cases from radiotherapy that he thinks this ought to be the first method of choice in the treatment of this offensive and troublesome disease. Prof. Dionisio, in reporting on six cases treated by this method, found that there was a rapid diminution in the secretion and crusts, with the prompt disappearance of the characteristic odor, even in the cases which have proved rebellious to other treatment. Recent reports bring the number of cases improved up to twenty.

Rhinoscleroma, from its similarity to carcinoma, might be influenced.

EAR.

Growths within the meatus or auditory canal can be treated through specula with external parts shielded in the usual manner. A speculum is mentioned by Williams,

[1] Revue internationale de thérapie physique, October 1, 1903.

one blade of which is of aluminium and the other of silver; the silver blade is to be placed opposite the parts to be protected.

LARYNX.

There are two methods of applying the ray to the larynx: one is through the tissues of the neck and the other by way of the mouth. The former is preferable, due to the fact that it is much more comfortable to the patient and the ray does not have to penetrate any more intervening tissues than when applied through the mouth.

The lesions mostly affecting the larynx are cancer, tuberculosis, syphilis, and lupus. Data relating to cancer and tuberculosis will be found under their respective chapters; syphilis is better treated by other means, while lupus is probably preferably treated by the ray than by the Finsen method, though perhaps more patients have been treated by the latter. T. C. Evans reports improvement from the ray in laryngeal lupus.

MOUTH.

For treating growths within the aural cavity various forms of specula can be employed, either of glass painted on the inside with white lead, as suggested by Williams, or with the head in a suitable position, the surrounding parts protected with a shield, the ray can be directed without the use of a speculum toward the roof or base of the tongue, floor of the mouth, cheeks, or lips, in all of which situations we have had occasion to treat malignant growths or leukokeratosis, which is so often a precursor of malignancy. The mucous membrane is peculiarly susceptible to the influence of the ray and dermatitis is apt to occur at the skin junction.

Gibson reports melanosarcoma of the mouth cured.

I have seen benefit in osteosarcoma and syphilis.

Macintyre[1] had a complete cure in a case of lupus of the mouth and lips.

Beckett describes a case of epithelioma inside of the lower jaw in which the enlarged glands were removed by

[1] Glasgow Medical Journal, November, 1902

operation and the lesion treated with the ray, resulting in a complete cure. In a case of ranula incised and subsequently treated by ray, there was no recurrence after several months, although previously the cyst has always refilled after operation.

TONGUE.

In the treatment of chronic, obstinate, and generally refractory conditions of the tongue the ray is of especial advantage, confining as it does its action to the limit of the diseased area, and not involving, as an operation usually does, large portions of unaffected tissue. The advantage of this is particularly apparent in the case of cancer of the tongue.

Some conditions which have long been regarded as extremely chronic, difficult, and unsatisfactory to treat, as, for instance, leukoplakia, are somewhat beneficially influenced by the rays. Papillomata have proven particularly susceptible to this form of treatment.

The ease with which the rays may be directed to any part of the oral cavity by the use of the "Allen" shield with a short projecting tube offers great advantages.

A short tube, the diameter of which is small enough to allow its being grasped between the teeth, is used. The end of the tube which is taken in the mouth should be insulated by means of a rubber tube which slips over it; this can be sterilized for the use of each patient. A guard such as is used on the top of a bicycle to protect the handle-bar from being scratched may be used; or rubber tape as used by electricians for insulation purposes may be applied each time; this has the advantage that it is always clean, but the disadvantage of a disagreeable odor.

The patient should be seated comfortably in a chair, the head being immobilized by means of a photographic head-rest. If the lesion is situated at the back of the tongue or upon the palate, or the sides of the mouth, the tube of the shield may be grasped between the incisor teeth and the bore of the tube directed at the point to be treated. If, on the other hand, the lesion is situated upon the tongue, where it can be conveniently attacked by having the tongue protruded, the mouth may be kept open by the use of gags, of cork or rubber, forced between the molars.

Papilloma. A case of papilloma of the tongue rapidly and successfully caused to disappear by means of the *x*-rays alone was that of I. B., a Russian, aged thirty-six years, who had a large papillomatous tumor (Fig. 76) which had begun as a small papule and had been steadily growing for about three months. History was absolutely negative. For two weeks it had begun to give some pain; tumor was of about the size of a small marble, slightly flattened upon the top, and exhibiting no inflammatory symptoms.

FIG. 76.

Flat, non-malignant papilloma of tongue.

Treatment was begun December 9th. The ray was given for three minutes with a tube of five-inch resistance placed at a distance of five inches from the patient, and excited by a coil. The anode was kept at a dull-red heat.

December 11th, condition was not changed; ray three minutes, tube six-inch resistance, eight inches from patient.

December 13th, tumor flatter and smaller, ray five minutes, tube five-inch resistance and five inches from patient.

At about this time small, white areas began to appear around the margin of the tumor.

December 20th, patient conscious of great relief, and diminution in size of tumor. General health better than at any time since appearance of growth. Ray five minutes, tube six-inch resistance and six inches from patient.

December 23d, tumor had decreased to about one-half original size. In appearance perfectly clean, and no pain or signs of any alteration. Ray five minutes; tube of six-inch resistance, at six inches from patient.

December 27th, growth very much smaller, flat, and smooth; marked irregular shrinkage around border; ray six minutes, resistance of tube eight inches, and six inches from patient.

December 30th, tumor resembles a small, white disk with slightly reddened spot in centre. There has been no pain for one week; ray five minutes; tube five and one-half inches' resistance and six inches from patient.

January 2d, tumor consists of tiny, slightly reddened papule, soft and painless; ray five minutes; tube five and one-half inches' resistance, six inches from patient.

January 6th, condition of tongue apparently perfect, no sign of tumor or site thereof; patient not rayed, but discharged, with instruction to return on the first appearance of any recurrent symptom.

Up to the present writing the patient has exhibited no sign of recurrence. No pathological examination was made in this case owing to objections on the part of the patient, but clinically it presented all the signs of a papilloma.

We have treated a number of patients with papillitis of the tongue with beneficial results.

In one particular case which was accompanied by hemorrhages from the papillæ this symptom promptly disappeared.

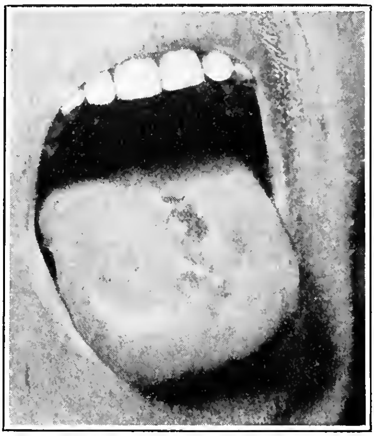
Leukoplakia with Warty Overgrowth. Mr. C. S., aged fifty-two years, presented an extensive postluetic leukoplakia with thickened plaques, and a tumor of almond size covered with filiform spiculæ which can be made to stand erect.

Energetically prolonged antiluetic treatment produced no effect upon the lesion, and the usual local applications had little or no effect upon the leukoplakia. The wart-like tumor had begun ten years ago, and after six or seven years the peculiar filaments began to grow from the surface.

The history and clinical appearances are against the diagnosis of cancer, which is known to be so prone a sequence to leukoplakia. The tumor was removed under cocaine first in September of 1901. A new lesion formed nearer the tip, of much smaller dimension, being only the size of a lentil, but very firmly embedded in the tissues. This was removed in June, 1903, by curettage under cocaine and the *x*-ray applied to complete cure and as a prophylactic.

In several other cases of leukoplakia, implicating the buccal membrane, the roof of the mouth as well as the tongue, which we have treated by the ray, but little improve-

Fig. 77.



Leukoplakia after healing of obstinate ulcers and improvement in white areas.

ment has been noted excepting in those in which there was a previous history of lues, and in which antiluetic remedies were coincidently employed.

In several instances it has seemed to aid materially, and when we remember how little effect is usually produced by antiluetic measures, even in those patients who give abundant evidence of the previous existence of the disease, we are in a position to appreciate the benefit and to credit the new method with a portion of it.

In the case of Mr. F. J., aged sixty years, whose tongue began to give trouble ten years ago, and who has always been a great smoker, there are no symptoms or history of lues; no family history of cancer.

The appearances were those of an extensive though not thick leukoplakia, the color being of a dull gray with islands of ulceration and deposits of yellowish, false membrane.

Treatment was begun by *x*-ray on October 24, 1902, and continued for one year with many long intervals, when the condition was that shown in Fig. 77.

An antiluetic course, including both hydrargyrum and kalium iodidum, separately and combined, was given over a considerable period. The mercurial alone produced marked irritation, and it could not be said that the iodide aided materially. The patient's belief, as well as my own, is that the ray accomplished the beneficial results.

In lues of the tongue presenting infiltrations and ulcerations, which for a time were thought might be cancerous, referred to me by Dr. R. T. Morris, a course of *x*-rays in association with other measures seemingly hastened prompt recovery.

CHAPTER XII.

GENERAL DISEASES AMENABLE TO RADIOTHERAPY.

THE field of radiotherapy is extending its bounds day by day. We will attempt in the succeeding pages to indicate those conditions in which it has been and is being used. This data is so scattered, fragmentary, and oftentimes unreliable that an attempt has been made to collect that which seems of importance and interest and arrange it in an alphabetical order, and with a view to the anatomical regions involved.

Abscess of Antrum. Gibson mentions several patients who were relieved by ray treatment.

Caries Sicca. In dry caries of the shoulder-joint Willard secured ankylosis after two months' raying; while, as is well known, there is usually about two years' disability before ankylosis occurs.

Chronic Inflammations. Gibson reports that chronic inflammations treated by him were beneficially affected by the ray.

Chronic Recurrent Appendicitis. The rays have been applied in several instances of recurrent appendicitis, with the result of alleviating the pain and other symptoms.

Dr. M. F. Wheatland, of Providence, R. I., has reported a case in an elderly man in which the symptoms were greatly relieved.

Elephantiasis. According to Snow[1] the ray may be of benefit in early cases.

The benefits of this method are most striking in those hitherto incurable affections which physicians are most poorly armed to combat. Among these may be included hypertrophic elephantiasis. The great improvement if not complete cure in these cases offers a strong demonstration of the utility of this method.

[1] Journal of Advanced Therapeutics, November, 1902.

Epilepsy. Dr. J. H. Branth, at the Post-graduate Hospital, has treated a patient subject to epileptic attacks with what he regards as very satisfactory results. The treatment has been kept up for some months, and he finds that the attacks are much less frequent and considerably milder in degree. The tube was kept about two feet above and behind the head, and exposures were given three times a week.

In the treatment of this ailment a great deal will depend upon the cause of the attacks, and the ray may be of some use in cases due to cellular changes in the brain tissue, but can scarcely be expected to be of much value in traumatic cases due to pressure or if due to causes originating outside of the brain.

Fibroid of Uterus. Gibson found the hemorrhage was controlled by exposing these patients to the ray.

Goitre. A case of goitre cured by means of the ray has been reported by N. G. Blacklock,[1] in which the treatment consisted of only six exposures and the subsequent care of a burn that lasted for six weeks.

Campbell saw a goitre almost wholly disappear in a patient who was coincidently treated for acne.

Spring reports three cases that were progressing well under the ray.

Glandular Enlargements. In the treatment of enlarged glands the ray ought to prove an ideal method wherever it will cause the disappearance of the swelling and inflammation, because by this method there is the removal of the tumor without any dissolution of continuity of the skin. In this way all risk of infection is obviated, and the result is obtained with a total absence of scarring. In a few cases the skin is caused to slough and the softened contents of the gland are eliminated through this channel, but even in these cases the scar which marks the site of the opening is less marked than in the great majority of operative cases.

Dr. F. C. Bishop has had good results in the treatment of tuberculous nodes of the neck.

It has been supposed by some that the rays have the power of driving microbes and extraneous substances into

[1] Medical Sentinel, January, 1903.

the tissues, thus causing dermatitis. On the supposition that this is true, and that the rays will also drive medicaments into the tissues, A. Wiener uses a cream made with celluloid as a base, and containing creosote. This he applies to the surface of the skin at the site of tuberculous nodules, and then exposes to the rays. It is assumed that the latter drive the creosote into the tissues and produce a cure, while the celluloid prevents carrying into the tissues foreign bodies that may be in the air or on the surface of the tube. It is said that experiments have shown that medicaments are actually carried into the body.

Gleet. Noble M. Eberhart[1] reports nine cases of gleet treated with very good results, after from three to nine exposures. He uses a low tube; the patient lies upon the back with the thighs separated, and the rays are applied to the perineum through a lead screen.

Hodgkin's Disease. In pseudoleukæmia there has not been any brilliant results from therapy prior to the introduction of the *x*-rays. In fact it has been commonly supposed that there was little to be anticipated in these cases. Injections of arsenic and the internal administration of such medicaments as thyroid extract have embodied all that constituted the essential treatment of these conditions, and the results have been very unpromising of this serious though fortunately rare condition.

Pusey[2] reports three cases—one was in a child and one in an old man—which were greatly improved by exposures to the rays, the first being practically cured.

The glands have almost entirely disappeared after about three months' treatment, and those few that remain are very small and soft. A remarkable fact was the improvement in the general condition of these patients from the time that the treatment was begun, and the fact that the blood showed an astonishing increase in the hæmoglobin. The action of the rays was very prompt in manifesting itself, and lessening in the size and hardness of the glands was noticed almost from the first.

[1] American Electrotherapeutic and X-ray Era, February, 1903.

[2] The Roentgen Rays in Therapy and Diagnosis, Philadelphia, 1903.

Williams reports surprisingly rapid improvement at first, but at the end of six months in his most favorable of three cases the glands had enlarged again, although treatment had been continued.

His first patient died nine months after treatment was begun, although decided improvement had occurred and the author believes that life was probably prolonged. In all of his cases the improvement at first is so remarkable as to be almost marvelous, but unfortunately up to the present time many do not remain well. In literature we have found twelve cases reported, including two of our own. Childs (Denver) one case, Stover one case, Coley one case with remarkable improvement, Senn one case. Hett in one instance found improvement with disappearance of the enlarged glands, but not lasting; it was followed by recurrence. At the skin and cancer hospital a case has received forty treatments; there is improvement, but not complete disappearance. In the personal cases the time under treatment was too short to draw conclusions, but no great improvement was noted.

Dr. Nicholas Senn[1] reports a case of splenomedullary leukæmia cured by the rays. The spleen, lower end of the sternum, and the epiphyseal extremities of the long bones were exposed daily from ten to twenty minutes.

Three weeks after treatment was begun, a marked diminution in the size of the spleen was noted with a corresponding improvement in the blood. Two months later the only abnormality found in the blood was a slight anæmia.

Dr. Edw. B. Finch, of this city, has kindly furnished me the notes of an interesting recovery under the ray, which I had also the privilege of observing. The young man, who had been afflicted for two years, presented a soft, projecting mass over the manubrium sterni, with discharging sinus.

The diagnosis had first lain between lymphosarcoma of the thymus or anterior mediastinal nodes. A portion of the tumor behind the sternum was curetted. A guinea-pig inoculated died in sixteen days. Cause unknown.

[1] New York Medical Record, August 22, 1903.

The glands now enlarged in the neck, axillæ, and groins, and the spleen was enlarged, with evidence of disease of the whole lymphatic system.

Blood examination excluded tuberculosis, syphilis, and leukæmia, while the increase of polymorphonuclears pointed to sarcoma.

Exposures were made for ten minutes each, to from four to nine separate areas.

After fifty-six exposures I saw the patient apparently in good health. He had gained fourteen pounds, and all symptoms had disappeared.

Four months later there was recurrence of the presternal tumor, and twenty-one additional treatments were given with seemingly good results.

Quinine had been administered coincidently with the ray treatment, and Dr. Finch believes the good results were enhanced by the fluorescence supposed to be produced in the blood.

A boy, aged seven years, was referred to us in October, 1903, by Dr. Bradshaw, in whom the disease had existed for over a year with very marked involvement of the lymph nodes on both sides of the neck, chest, and axillæ, accompanied by a pronounced anæmia. The appearances are shown in Fig. 78. No improvement after a few exposures.

Pusey has treated two cases of leukæmia with no lasting effect. In one patient, who died in an apparently septic attack, disappearance of the tumors was attributed to the treatment, which, however, the patient did not persist in.

Indolent Ulcers and Wounds. The ray shares with blue light the property of stimulating the healing of long-standing ulcerative processes. The dose in these cases should be small to produce a stimulating effect. The tube should be rather low, having about 0.008 penetrating power, as shown by our radiometer, and the length of exposure should be about three minutes.

The treatments should be given not more often than three times per week, and the patient must be carefully watched for evidences of absorption of deleterious products.

At the first evidence of healing the treatment should be discontinued.

Leukæmia. Pusey treated two cases with no lasting effect.

Lipoma. In a diffuse flat lipoma of the neck and shoulder in a lady I have seen appreciable decrease in size. Treatment is being continued.

Fig. 78.

Lymphadenoma. A case of lymphadenoma[1] was treated with marked success at the University of Colorado Hospital, and the results have led the observers to take further steps in the same direction.

Myxœdema. In one case reported by Bishop the swelling was greatly diminished.

Neuralgia. Bondurant has reported a cure by one exposure of an intense intercostal neuralgia.

[1] G. H. Stover, Denver Medical Times, August, 1902.

Grünmach finds some beneficial results in neuralgia of different locations.

Rumpf reports good results from the ray.

In 28 cases treated by Stembo[1] 21 were cured.

To be effective the rayed part should give to the finger of the operator gently passed over it a pricking sensation. From three to ten sittings were required, with exposures lasting from three to ten minutes.

In many painful conditions of a neuralgic character we have witnessed relief following *x*-ray exposures.

In severe trigeminal neuralgia, fourteen exposures gave complete relief (Gocht).[2]

Neuritis. In brachial neuritis cure was hastened in one case, according to Snow.

Paraplegia. Murphy reports three cases due to tuberculosis of the spine, in which two were relieved promptly, two applications stopping the pain, and after twenty-three sittings the patients were able to go about on crutches. The prognosis in these patients is considered good.

Rheumatism. Articular rheumatism with a marked swelling in a young girl was improved and the pain dispelled in two exposures, according to Sokolow.[3]

Stenbeck[4] reports 52 cases with improvement in 40 to 80 per cent.

The pain is usually promptly relieved.

An instance of chronic articular rheumatism of seven years' duration, relieved of pain for five months without other treatment, is reported by Taylor.

Dr. R. H. Boggs[5] finds that iodine painted on the surfaces to be treated is of advantage in this disease. He thinks that the *x*-rays will force the iodine into the tissues.

Splenic Anæmia. Dr. Pulley[6] reports two cases treated by the ray: in one he gave seventeen exposures followed by diminution in the size of the spleen and improvement in

[1] Therapie der Gegenwart, 1900.
[2] Fortschrit. an der Geb. der Roentgenstrahlen, 1897, vol. i.
[3] Ibid., 1898, vol. ii. p. 209.
[4] Ibid., p. 227.
[5] Medical Record, October 10, 1903.
[6] Lenox Medical Society Report, 1903.

all other symptoms; the second case, which was accompanied by vomiting of blood, was also improved.

Sinuses and Fistulæ. Berry Hart reports two cases of old sinuses of the abdominal wall treated by the ray, healed after all other methods had failed.

Spring and Hart report good results in callous sinuses.

Deep fistulæ may be made to close by the ray, due to an increase in the amount of connective tissue produced closing the sinus.

Murphy (J. B.) reports some remarkable results in intestinal fistulæ.

Tabes. Dr. J. W. Daniel[1] makes a preliminary report upon two cases treated, but does not give technique. The patients relate their own history and both indicate very material improvement. The writer states that so far as he has observed this seems to have benefited these patients more than any other method. In one case the disease had lasted over eight years.

Edwards, of Nashville, reports one patient treated with what he considers good results; there was a return of the knee-jerk and a diminution of the ataxic symptoms.

Tic Douloureux. Snow reports a case of eight years' standing which had been cured and remained well for five months at the time of report.

Tuberculosis. In the treatment of tuberculosis of bones, joints, and even the lungs, it is widely claimed that the rays have accomplished some astonishing effects. Some reports of cures in tuberculous peritonitis and tuberculosis of the bowels have been published. In tuberculosis more than in any other condition are we justified in stating that cure has resulted when the symptoms have entirely disappeared, as the recurrence of tuberculous symptoms generally is an indication of a reinfection, and not of a recurrence of the disease in the sense that this term is generally understood.

Some experiments were undertaken by Lortet and Genoud to test the effect of the ray upon inoculated animals. On April 23d eight guinea-pigs were inoculated in the fold of the right groin with bouillon that had been infected with a

[1] Medical Age, June 10, 1903.

guinea-pig's tuberculous spleen. Two days later three of the animals were stretched out on a board and the inoculated region was exposed to the influence of the Roentgen rays. This was done daily for about an hour for fifty-three days. On June 9th the five check animals were observed to have spontaneous abscesses, and their inguinal glands of the affected side were softened. On the other hand, the three that were under treatment with the Roentgen rays had no abscesses and their inguinal glands were firm and sharply defined. Nine days later the five check animals showed abundant suppuration in the inguinal fold or on the thigh, and they had manifestly grown thin. The three that were under treatment were in good condition and had gained in weight; their inguinal glands were small, having gradually shrunk, and showed no tendency to suppuration.

The Roentgen rays, therefore, are held to have prevented the acute development of tuberculosis in this instance. The authors suggested their therapeutic employment in tuberculous disease of the thoracic and abdominal organs, especially in children.

Diagnosis. Notwithstanding all that has been said about the diagnosis of tuberculosis pulmonalis, the earliest case on record is undoubtedly that of Wasserman, of Vienna, who showed at the Medical Club, in January, 1897, a case which he had diagnosticated by means of the Roentgen rays.

The right lung was involved, and no symptoms could be elicited by percussion or auscultation. With the rays the left side of the chest appeared clear and healthy, while the right side exhibited diffuse shadows, which represented points of infiltration. In one place a very clear area was brought out by the light, when applied either in front or behind the right lung, which to all appearances indicated a cavern. All other methods of testing proved beyond a doubt the diagnosis of phthisis.

Childs[1] reports a case in which both apices were affected —the left down to the second rib. Seventy-six exposures were given, consolidation persisting on the left side, but expectoration had ceased.

[1] Medical News, January 24, 1903.

Burdick, of Chicago, found, in the early days of skiagraphy, when many exposures were required, that phthisis patients were beneficially influenced in the process of picture-making. In one case the patient was so much benefited that he asked for renewed applications.

After six weeks' treatment he was apparently completely cured.

He subsequently reported 42 cases of tuberculosis treated with the ray. They are divided as follows: hemorrhagic tuberculosis, 4; fibroid, 8; acute abdominal, 4; chronic, 13; mixed, 7; and joint affections, 6.

He reports 70 per cent. of symptomatic cures. In fibroid phthisis consolidated areas yielded slowly to the ray's influence.

Dr. Boido[1] reports 14 cases, all Mexicans, with 11 seeming cures. The climate of Arizona, perhaps, contributed considerably to these cures. In reporting these cases, he says that "the x-ray in this climate has apparently cured 11 out of 14 cases of tuberculosis."

Soiland, of California, speaks of the beneficial effect of the x-rays in tuberculosis of the lungs; in 1899 Dr. H. P. Pratt, of Chicago, treated 3 cases of lung tuberculosis, 1 of them being improved and 2 apparently cured. A short time since there were being treated at the Royal Infirmary, Edinburgh, 5 cases of pulmonary tuberculosis and 5 of laryngeal tuberculosis; of the pulmonary cases, 1 has been cured, 2 were improving at the time of the report, 1 was not changed, and 1, which was an advanced case, was growing worse.

Exposures of one hour's duration at a distance of eight feet from the tube are employed by Gaunt, who believes with Edison that the rays thus administered may exert a stimulating action upon healthy cell tissues and thus prove beneficial.

In treating a patient with acne of the back and chest, who at the same time suffered from lung tuberculosis, we have made use of two tubes at once: one applied at the back and the other in front. The two tubes may be excited

[1] American X-ray Era, February, 1903.

by the same machine; that is, if they are not of too high resistance and the machine is sufficiently powerful; or they may be excited by two separate machines or coils.

The advantages gained by this are economy of time and of current.

Rudis-Jicinsky reports 20 cases, 16 of which were much improved.

Krauss discharged 2 patients as cured.

Boggs treated 6 patients, 5 of which showed decided improvement and in 1 there was an apparent cure. The treatments were given for six months with exposures on every second day.

Tuberculous Peritonitis. Ausset and Bédard gave in a case daily exposures of thirty minutes each, and after fifty exposures the ascites which had been present disappeared, as well as the hard, tuberculous masses. A second equally favorable case was reported by them, according to Freund, two years later.

Tuberculous Sinuses. Old glandular sinuses about the neck, in active cervical adenitis or subsequent to it, are susceptible to marked improvement and probable cure. Suppurating glands and discharging sinuses are often promptly dried up by the ray.

Childs and Briggs report cases improved to a point of apparent cure.

Murphy reports a case in which laminectomy had been performed one year previous, leaving a discharging sinus; twenty-one applications of the ray closed this up entirely.

Tuberculous Cervical Adenitis. Here improvement is often marked and rapid, and because of the beneficial effects on scars and scar-producing affections, the method should be tried at least in advanced as well as in recent cases. In tuberculous glands of the neck Rodman, Pfahler, and others have obtained excellent results. These observers report ten instances with favorable outcome in all.

Five instances of tuberculous glandular enlargement, in patients with a distinct tuberculous history, are reported by Varney; 3 were inoperable by reason of extent of involvement, and in 2 there had been recurrence after operation; in 1 case two discharging sinuses closed, the disfiguring scars of five different operations were completely removed. In another case a discharging gland with a disfiguring scar healed in six days, and six months later no sign of recurrence was observed.

In an operable case ten days' treatment completely reduced the glands. Hope Fowler has treated 6 cases of tuberculous glands of the neck. Of these, 2 are reported as cured and the other 4 as improved.

Bishop reports favorable results in cases treated by him.

Tuberculosis of Joints. Ridlon feels that *x*-ray treatment will amount to little, although cases not benefited by ordinary mechanical methods he has found to improve in varying degrees—marked irritation of the skin must precede benefit in even superficial joints. Hip-joint and spine tuberculosis have not been benefited.

Permanent results cannot be expected until ankylosis has occurred, if bone is widely implicated.

As early as 1899 Leigh[1] reported elbow-joint tuberculosis, in which operation was advised, cured by six exposures.

Tuberculous synovitis may be promptly relieved according to Burdick.

In tuberculosis of the knee-joint and other complications, of four years' duration, irradiations over a period of five months resulted in a clinical cure.

In a tuberculosis following injury to bones of the hand, four discharging sinuses healed, pain and tenderness disappeared, and fairly good motion was restored.

Murphy, of Chicago, reports similar good results in tuberculous granuloma or Pott's disease. In two cases of tuberculosis of the knee-joint involving the synovial membrane he also reports very satisfactory results.

Ludloff[2] shows that in *x*-ray pictures the diseased parts of bones are more transparent, and draws attention to the fact that generally in the vicinity of bone protuberances one will find the tuberculous foci.

Synovial tuberculosis can be differentiated from hydrops by finding foci in heads of bones.

[1] American X-ray Journal, 1899, vol. iv.

[2] Wiener klin.-therap. Wochenschrift, Wien, June 14, 1903.

Bone Tuberculosis. Tuberculosis of the head of the tibia cured by exposures to the rays is reported by M. R. Toland. The patient was a young woman who had suffered for seventeen years, and who was examined by the rays for the purpose of making a diagnosis. The exposures produced so beneficial an effect that the patient remarked it without having an idea that the rays possessed any therapeutic property. The hint thus given was acted upon and the exposures continued with the therapeutic effect in view. In five months all of the symptoms had so abated that the patient was declared cured.

The relief from pain in a case of hip-joint disease is reported by Zeisler.

Tuberculous foci in bone presents thickened walls. In tuberculous joints the outlines are diffuse unless cheesy foci are present, when the area of each can be seen.

Tuberculosis of the Spine. Murphy reports three cases, with most gratifying results.

The compression leading to paraplegia is due to a granuloma within the cord, which granuloma is destroyed by the ray.

Tuberculosis of the Larynx. This condition has been treated quite extensively by the ray, but the observations reported up to the present date do not justify any definite conclusions.

Ravillet[1] reports beneficial results in one case treated by him.

At the Edinburgh Royal Infirmary 4 trials resulted in 1 cure, 1 recovery of voice, and 2 unchanged at date of report.

PROPHYLAXIS.

It is too early to formulate definite conclusions upon the exact value of Roentgenism as a preventive of disease. I have employed it quite largely with the view that the rays might attack elements hidden from our normal senses. Thus I have used it after the removal of pigmented moles, nævi, growths which we know tend toward malignancy when

[1] Revue de la tuberculose, April, 1897.

persistently irritated; papillomata upon mucous membranes, various lesions of the tongue, including leukokeratoses, fissures, growths still benign, etc.

It may be found that one of the most useful powers of the ray is to prevent recurrence after operation for cancer in its various forms.

CHAPTER XIII.

X-RAY BURN.

THE curious phenomenon known as x-ray burn seems to have escaped public notice for some time after it had been discovered. The first case on record appears to be that of O. Leppin,[1] an engineer, reported on July 9, 1896, only seven months after the discovery of the ray. The lesion in

FIG. 79.

Dermatitis caused by x-ray. Case of Dr. Gilchrist.

question was on the left hand and was described as a peculiar dermatitis-like sunburn: red, swollen, and with a vesicular eruption on the middle and third fingers.

Three months previous to this, or only four months after the discovery of the rays, a case of alopecia was reported by Professor Daniel,[2] of Vanderbilt University.

[1] Deutsche med. Wochenschrift, 1896, No. 28.

[2] Medical Record, April 25, 1896.

In February, 1897, T. C. Gilchrist[1] made a complete collection of the cases upon record and gave particulars in tabulated form of duration, distribution, character of lesions, subjective symptoms, etc. He concluded from the cases studied that the skin of the trunk was most seriously affected. In the same communication he reports a case presenting some interesting features (Fig. 79), the most noticeable of which was an enlargement of the bones, a distinct osteoplastic periostitis being shown to exist. The powerful piercing quality of the rays was here demonstrated for the first time. Efforts were made to show the presence of foreign bodies in the skin without avail, and chemical analysis failed to disclose the presence of platinum. The existence of injuries in the deeper tissues is used as an argument in discrediting the theory advanced by Tesla[2] that the injury is caused by the formation of ozone in the skin, and the absence of platinum upon chemical analysis is used to disprove that of Thompson.[3] Since then numerous cases have been reported and various theories have been advanced to account for its causation. For a short period there was a reaction in public opinion; it was generally believed that burning by the ray was inevitable, and that the consequences were very serious and frequently fatal to the member involved. Certain it is that in a number of cases great injury has resulted, and in some even carcinoma has followed a more or less serious burn. Johnson and Merrill[4] have reported two cases of precancerous keratosis following *x*-ray burn, in one of which amputation of the hand seemed a likely sequel to the injury.

We have had a similar case in our own experience which we report more fully under deleterious effects. In this case a manufacturer of *x*-ray tubes developed a carcinoma of both hands as the result of the action of the rays. A Hamburg tubemaker is likewise reported to have lost an arm from the same cause.[5]

[1] Bulletin of Johns Hopkins Hospital, vol. viii., No. 71.

[2] Nikola Tesla. Abstract in Public Opinion, vol. xxi., No. 4.

[3] E. Thompson, Boston Medical and Surgical Journal, December 10, 1896, vol. cxxxv., No. 24.

[4] Philadelphia Medical Journal, December, 1900.

[5] Münch. med. Wochensch., 1903, No. 24, p. 1048.

Causes. It is now known that while the x-ray burn is a dangerous and likely accompaniment of exposures to the ray, it is possible, in a great measure, to lessen the frequency of its occurrence if not altogether prevent it.

It would appear from the mass of evidence extant that the most frequent causative factor is idiosyncrasy of the patient. Different individuals and different individual integuments are influenced by the x-ray in varying degrees. Some persons are promptly and energetically affected, both in their general system and superficially, while others seem almost unaffected by the action of the ray. In some skins it seems almost impossible to produce any reaction, and upon certain pathological processes the effect of the ray appears to be very slight. This idiosyncrasy varies in about the same proportion as sunburn, and probably varies in the same subject. But any person may be burned, though it will require a longer exposure under exactly similar circumstances to produce a burn in some than in others.

It is said that blondes react much more readily than brunettes, and those whose condition is somewhat impaired by long illness are more susceptible than those in good general health.

Old persons are subject to the effect in proportion as their resistance generally has lessened.

Jutassy, Benedikt, and Kienböck observed that children and emaciated people are much more susceptible to the effect of the rays than others.

Hahn and Albers-Schönberg[1] claim the reverse as regards children.

It has been stated that because of less cell resistance those tissues that are near the bone are more liable to burn than those having fat under them.

This is contrary to our experience. We have found that parts of the body containing a great deal of fatty tissue are much more susceptible to burns than other parts.

Dermatitis is easier produced on the body than on the face, and burns on the body are more difficult to cure than

[1] Münchener med. Wochenschrift, 9–11, 1901.

on the extremities. The great susceptibility of diabetics is mentioned by Comstock.[1]

The second factor is the character and vacuum of the tube itself. It appears that the burn effect is in exact proportion to the amount of rays absorbed by the skin, and with a low-vacuum tube, from which the rays are absorbed readily, the amount of burn will be greatest. Brown has observed that high-vacuum tubes burn rapidly, while low tubes do so only after a longer interval. It is a recognized fact that, other conditions being equal, a tube will cause burn in proportion as its vacuum is lowered. In this connection it is well to state that the amount of effect of the ray is in all probability exactly proportional to the amount absorbed by the body in question, whether it be a photographic plate or the vital human tissues. Draper pointed out the fact, which Eder fully demonstrated about fifty years ago, that only the rays of the spectrum that were absorbed by a body had any chemical action upon it; also the observed fact that the rays from a low tube are much more readily absorbed than those from a high tube, and that the former cause burn more frequently; and, further, that the whole tendency of modern physics to regard the ray as a form of light vibration led to the natural conclusion that absorption and effect are natural complements.

Mosley claims to have found that the high-vacuum tubes are more apt to cause dermatitis.

In this connection it may be mentioned that Johnson and Merrill, in a report on the technique of the treatment, pointed out that "for two equally soft tubes operated on the same current, one may produce a burn in three minutes, the other in thirty minutes." One of the authors[2] later showed that there is a condition of tubes in which burn was more readily produced, and that this is independent of the condition of the tube with regard to its vacuum.

It has been pointed out by us[3] that some tubes, irrespective of their degree of vacuum, develop a tendency to burn,

[1] Southern California Practitioner, October, 1903.

[2] Bull. de l'associat. obstet. de Paris, 1901, vol. i.

[3] Medical Record, New York, November 15, 1902.

which renders them for a time unsafe to use without strict oversight.

Barthélemy substantiates our position in regard to this "burning state of the tubes." He says that such accidents may happen when least expected, without our being able to foresee and in most cases without our being able to say why the burning occurs in one case and not in another.

He believes that the tube is a more important factor than all the other conditions connected with the subject. In a test made upon twelve patients without regard to age, pigment of the skin, moisture of surface or other state, with absolutely the identical electric conditions, he succeeded in producing exactly similar trophic changes in all the cases.

That the burn is not due to bombardment or brush discharges emanating from the tube is proven by the fact that these may be entirely cut off and still the burn may occur. We find the identical burn produced with the Becquerel rays, where there are no electric discharges present.

It has recently been determined that a high potential exists within the container of radium.

A third factor is proximity, and it has been observed that patients placed near the tube are, *cæteris paribus*, more frequently burned than those who are placed at some distance. This fact is capable of logical solution, as the circumstance of the rays emanating from a theoretically single point in straight lines toward every direction will render evident that their intensity at any plane is inversely proportional to the square of the distance from the tube, or rather the point of bombardment.

Fourthly, it has been claimed by some observers that coil-excited tubes are more prone to burn than when excited by a static machine. The truth of this contention was for a long time not accepted, as it was not clear that any difference existed in the current passing through the tube. A difference, however, was shown by Franklin,[1] who pointed out that in the case of a static machine, when a tube has

[1] Medical Record, October 25, 1902, vol. lxii., No. 17.

a given resistance, the difference in potential will continue to increase until sufficient to penetrate the tube, and that the voltage of each successive discharge through the tube will be constant, and in consequence of the constant resistance, the amount of current will be constant at each discharge. The number of discharges will depend upon the rapidity with which the difference of potential is created in the machine. In the case of a coil, however, the voltage in the secondary will be absolutely constant for any given current in the primary, and where the resistance of a tube is low the amount of current which passes under the constant voltage will be relatively large, whereas when the resistance is high the amount of the current will correspondingly decrease. The number of discharges is wholly dependent upon the interruption rate in the primary.

There are various other causes that seem to have some influence upon the production of burns, such as dryness of the skin, anæmia and hyperæmia, and, perhaps, the condition of the atmosphere as regards humidity and temperature and the temperature of the tube and the anode. It has also been said that the hands of operators are more apt to burn in winter.

Degrees of Burn. Kienböck divides the degrees of *x*-ray burns into four grades. The first is that of erythema with a peculiar characteristic, dry, puckered-up, so-called *x*-ray skin; the second, œdema; the third, blistering and exfoliation; the fourth, necrosis and ulceration.

He was the first to determine that the longer the latent period, that is, the period elapsing between the exposure and the burn, the less the reaction. So a burn of first and second grade will develop after a latent period of two to three weeks, of the third grade in from one to two weeks, and the fourth grade in a few days. A rapidly developing form of dermatitis has frequently been observed as coming on within twenty-four hours after a given exposure. Desquamation and cicatrization are complete in about three weeks.

Holzknecht[1] found in twenty-two cases that patients

[1] Archiv für Dermat. und Syph., July, 1903.

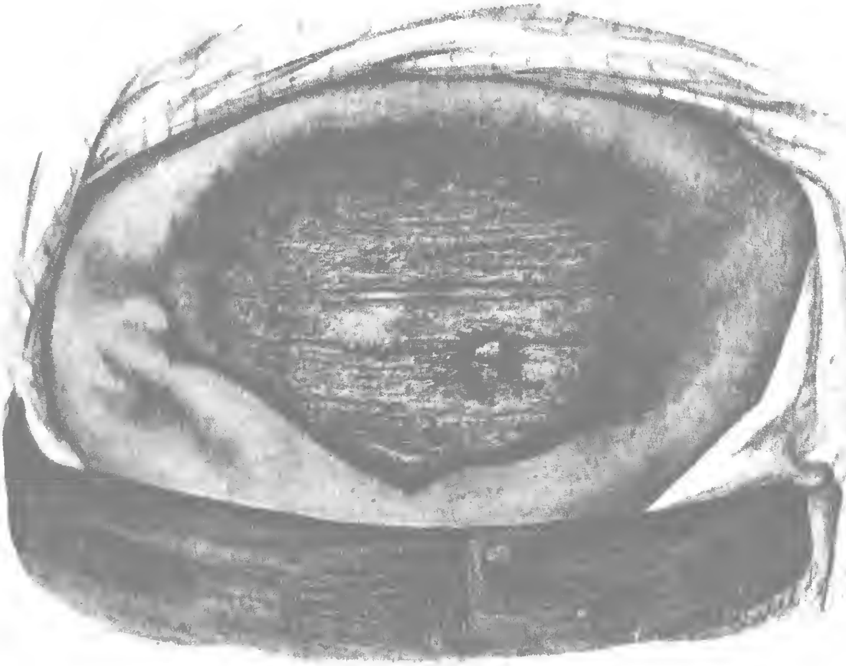
treated with old, discolored tubes developed an erythema in a few hours after exposure; this, he thinks, has nothing to do with the x-rays, but is due to other, probably violet, rays. He concludes that this reaction, which may appear as early as an hour after exposure and generally disappears in a few days, may influence the course of a subsequently developed burn by aggravating it in the superficial tissues.

Symptoms. x-ray burn *per se* begins usually with a slight, prickling sensation. This may occur at any time from within a few hours after exposure to several weeks, but most cases appear in from two days to two weeks. The tingling is followed by a redness and swelling. The erythema produced is not that we observe as the result of internal or external medication, but resembles very closely that brought about by the action of the sun's rays. It may be diffuse or only appear in spots.

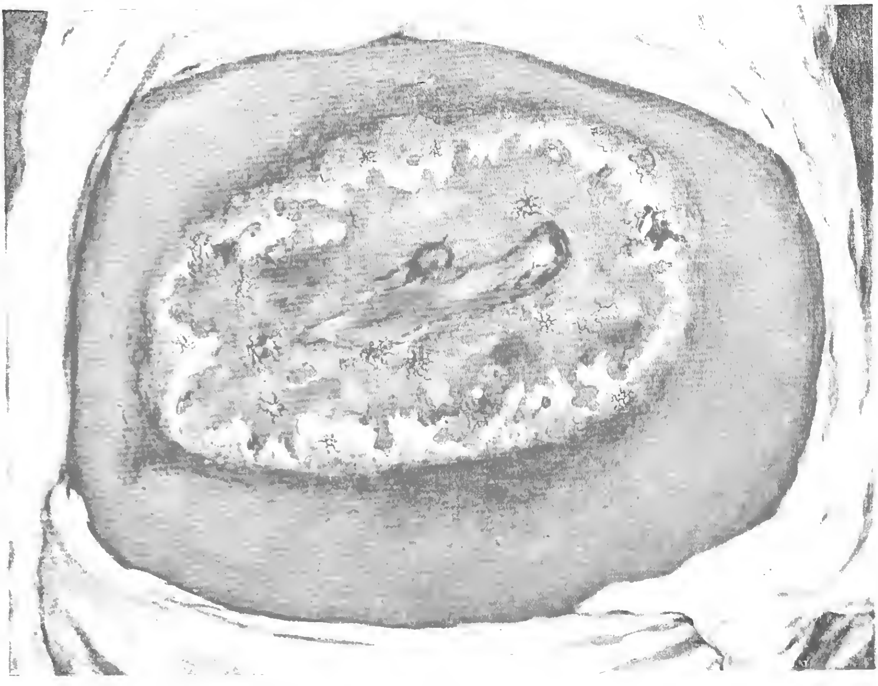
Very often the first symptoms of reaction will be subjective symptoms, such as itching, burning, or stretching of parts, observed mostly at night. Occasionally, especially in nervous patients, we observe a pruritus often accompanied with urticaria, to appear on the part exposed to the rays. This is a signal to postpone further treatment.

With the onset of the burn there may be constitutional symptoms of chilliness, fever, and a slight coryza. Pains in the bones and muscles are not uncommon, and the whole case may, in a measure, resemble influenza. There may be a severe headache, due to the toxins absorbed. These symptoms accompanying the burn have been noted mostly in cases that have afterward developed into rather severe attacks. It is, however, impossible to say at any time before the full development of the case what the exact severity of it is likely to be. It is probably impossible to modify the severity of the case at any time during the course, but it is possible to greatly relieve the symptoms that have developed after they have made themselves manifest.

In a time varying from five to about thirty days, the affected part may become covered with small vesicles, and these coalescing may form quite large bullæ. The vesicles may then break down and the epidermis peel off, leaving a



[illegible] Burn (Second Degree) [illegible]
[illegible]



X-ray Burn (Fourth Degree) showing Telangiectatic Areas.

very sensitive, denuded surface. This denuded surface has a bright-pink color, but may be darker and reddish. The inflammation rarely extends beyond the area of denudation, and the edge of the patch is, as a rule, smooth and unindented. The lesion is on a level with the skin and is neither depressed nor raised. Besides intense itching, great pain may be a constant symptom of the condition at this time. At other times the burn is accompanied by little or no pain or other inconvenience.

In serious cases deep ulceration may set in which requires months to heal.

In Plate XXVII. is shown an ulceration still not wholly healed eighteen months after its onset.

A copious serous discharge is an almost constant feature, rendering some forms of medication, such as by powders, an impossibility. Healing takes place slowly and the new epiderm grows gradually from the edges. It extends inward toward the centre in irregular points and peninsulas. This is the almost invariable rule. Patches of epidermis may, however, start as islands at different points over the area of the burn. In addition to the extension of epithelium from the borders of the lesions, numerous small, for the most part rounded, areas of epithelium spring up at points over the surface of the border of the burn and show a marked tendency to coalesce. (See Plate XXVII.)

A pronounced erythema with tendency to vesiculation and exfoliation, after an exposure of one hour, is reported by Crocker.[1]

The burn thus formed is peculiarly painful, and is in this respect much more severe than the ordinary forms of burn; it is also very refractory to treatment, and the measures which are generally used in common burns are decidedly less effective.

It has been held by many that the effect of the ray is evident only after a prolonged, latent interval, and that at the time of the exposures no effect is noted. While it is undoubtedly true that in the majority of instances the effects are late in their manifestation, there are cases on record

[1] British Medical Journal, January 2, 1897.

where the effects are noted at the time of the exposure or very shortly afterward.[1] It is claimed by a number of reliable authorities that these immediate effects are not due to the *x*-rays, but are caused by other emanations from the tube. In the general run of cases, as has been said, nothing is at first noticed, but subsequently the patient complains of a severe tingling or even burning of the skin, and later, if every precaution is not taken, or very often in spite of it, the burn develops. In these cases it is impossible to say exactly how long a time has elapsed from the exposure which initiated the burn to the appearance of the subjective symptoms, because, the patient being constantly treated, any one of the séances might be responsible, and it is manifestly unfair to blame it upon the last treatment. In our experience we have seen the erythema appear the day after the first raying, no sensation being noted. The earlier writers on the subject invariably stated that only long or repeated exposures would produce deleterious results, but we now know that there are some people so sensitive to the action of the ray that they may scarcely be exposed at all without danger. It is absolutely impossible to tell beforehand as to a patient's susceptibility to burn, but we may get some slight clue by asking patients whether they freckle or burn more readily under exposure to the sun's rays.

Bar-Boulle[2] reports a case of severe burn followed by ulceration appearing two months after exposure. All attempts of cure were ineffectual until the ulcer was subjected to the action of sun rays passed through red glass. There was gradual sloughing and finally cleaning of base of ulcer. Fifty days after there was marked healing which was hastened by the application of silver. They thought that perhaps sunlight had some effect on the general health and indirectly increased vitality of the patient, but in view of their success the red light could be used in similar cases. Something of the histological appearance of advanced burns is given in the section on Histology.

[1] H. Radcliffe Crocker, British Medical Journal, January 2, 1897.

[2] Bull. de l'associat. obstet. de Paris, 1901, vol. i.

A primary though severe erythema is described by Kibbe,[1] His description is as follows: "The stratum corneum was apparently unchanged; the stratum lucidum not clearly visible, excepting over small areas where the underlying disturbance was seen to be slight. The outer layers of cells composing the rete mucosum presented the most striking alterations, particularly in their nuclei, taking the stain, both with hæmatoxylin and lithium carmine, very feebly. The nuclei showed in addition a peculiar granular change, which was at first indicated in those retaining a more normal reaction to the stain by the formation of a fine nucleolus which could be seen here and there in the process of division. Near the stratum granulosum the bodies of the cells were apparently becoming converted into keratohyalin as a first step to the increase in bulk, as it were, of the stratum granulosum, by a development in their interior of coarse granules, staining deeply with hæmatoxylin and also carmine. With the former they appeared like blotches of India ink, in some places giving the impression that the cells had been charred by heat. This was particularly the case around the hair follicles. The chorium exhibited the mild changes seen in a case of dermatitis. Capillary dilatation with collections of round cells scattered through its structures, particularly around the hair follicles. No extravasation of blood was noted."

It is the opinion of many observers, fully concurred in by the writer, that when a burn results in a superficial effect the pathological process may be immensely benefited; a mild burn usually hastens the progress of cure in epithelioma, and no especial effort should be made to avoid it in many instances. At the first sign, however, of approaching dermatitis, such as a reddening, or a prickling sensation in the skin, all exposures should cease if one desires to avoid deeper effects. As soon as the burn effects are apparently cured, treatment may be resumed with care.

In very serious conditions, such as malignant growths, where a burn would be of slight comparative importance, it is well to allow a little more latitude and risk some burning

[1] A. B. Kibbe, New York Medical Journal, January 16, 1897.

rather than discontinue treatment, but when the condition is comparatively insignificant a burn would in all probability prove more serious than the primary condition. One should employ the utmost tact, skill, and caution to avoid it.

In general, we should remember that low tubes are more prone to cause burn than high ones; that some tubes develop a tendency to burn regardless of their vacuum or other known causes; that the nearer the tube, the greater the danger of burn; that the stronger the current, the more likelihood of damage, and that idiosyncrasy in the patient is a potent factor.

The burn effects may continue to increase in severity after the rays are discontinued, as instanced in a case of our own. After three exposures about one-half of an extensive lupous area showed a severe burn-formation, when, almost at the termination of the healing process, the rest of the diseased area became suddenly transformed into what corresponded to a well-marked burn. This, on healing, left the surface almost entirely free from evidence of the lupus, and three months later no nodules were to be seen.

Beck[1] describes the appearance of an *x*-ray burn by dividing the process into three stages. In the first stage the cutis is hyperæmic, congested, and accompanied by a rise of temperature. Exfoliation in small scales, itching, and fluvium capillorum are concomitant symptoms. The glands, the hair, and the nails undergo a retrogressive metamorphosis.

The second stage is accompanied by the formation of clear, yellowish blisters, whose contents lift the corneous layer from the stratum rete Malpighii. The inflammation is well marked, the tension great, and the pain considerable. Escharotic destruction of the skin marks the third and most violent degree. The tissues have an appearance of brownish-black, dry gangrene; a dry, granulating ulcer marks the site of the injury, and cicatrization may require months.

He places the latent period before the appearance of the burn at an average of ten to fourteen days, and is of the opinion that absolute immunity does not exist, although it is approximated in many cases.

[1] New York Medical Journal, May 24, 1902, pp. 881–885.

Inadvertent Burn. The rays often impinge upon surfaces of the patient's anatomy which have been regarded as secure from exposure. The reasons for this are a lack of understanding on the part of the operator of the peculiarities of ray distribution from the tubes in use, and, perhaps, to the secondary rays which are developed in different parts of the circuit of the rays. The reasons are difficult to determine accurately, and sometimes the most careful screening of the patient will not prevent it.

In the experience of the authors, the rays have produced dermatitis of the mouth and eye region when these locations were apparently safely shielded from the action of the rays, which were being applied to the neck. Again, the hands of the patient or the operator may be affected by the rays coming off in a direction entirely unsuspected. It is therefore of the utmost importance that great care should be exercised in the study of the direction of the rays from the tube and in the shielding of the patient in every individual case. A shield which is calculated to protect certain parts of the body should be examined after it is adjusted to determine whether or not it covers the parts fully. This is accomplished by means of the fluoroscope. The detection of fluorescence in any position in which there is no necessity for the ray effect indicates the necessity of special shielding at that part. The necessity of this extra observation is probably because of the extra rays that are generated in various places and whose existence can be determined easily in this way. It is generally accepted that the *x*-rays from the tube are propagated in straight lines, and if care is exercised these will not cause any untoward effects.

Beck[1] observed that when suffering from slight Roentgen dermatitis the symptoms are very much increased in sultry weather.

Dr. E. W. Reid,[2] Professor of Physiology in University College, Dundee, describes a personal experience of dermatitis. Having to deliver a popular lecture on Roentgen's discovery, he desired to obtain a photograph of his own

[1] Medical Record, January 31, 1903.

[2] London Lancet, February 6, 1897.

chest and abdomen through the clothing, to exhibit the contents of the pockets in addition to the skeletal structures. The exposures to which he was subjected were as follows: abdomen, twenty minutes, followed by forty minutes; chest, fifty minutes, followed three days later by ninety minutes. The coil was of ten-inch spark, fed by 10 ampères, and the tube was three inches from his waistcoat as he lay supine upon the table. On the evening of each exposure marked erythema of the skin of the abdomen and chest was noticed immediately beneath the position of the tube, and in addition slight redness of the skin of the back over an area corresponding to the exit of the rays from the body. In seventeen days the cuticle began to peel off, leaving a surface which was "raw" and "weeping," but not very painful. The discharge next became seropurulent and some thirty square inches of cuticle were lost, but in thirty-three days healing was complete. There is, he says, apparent immunity of the structures deeper than the skin.

It has been found that the seat of pathological conditions on the skin are much more sensitive to the rays than is the normal skin. Scholtz[1] cites two instances of favus in which the hair fell much more promptly in the affected areas than in other portions. Others have made similar observations on favus, acne, etc.

How Produced. Schwarz[2] believes that solar erythema and Finsen as well as Roentgen dermatitis may be caused by metabolic products in the cells becoming insoluble, leading to stoppage or stasis and the lack of elimination, bringing on a chronic process after a period of incubation.

Knowing the stimulating effect of the ray on the vasoconstrictor nerves, it has seemed to us as if a dermatitis was the logical result of an overstimulation of these nerves, bringing about a gradual paralysis of the nerve filaments, thereby destroying the elasticity of the vessels, producing a dilatation and hyperæmia. The degree of burn depends entirely on the degree of paralysis of these nerves, and where the overstimulation is not carried beyond a certain point will merely result in a temporary hyperæmia, disappearing

[1] Loc. cit.

[2] Wiener klin. Wochenschrift, No. 40.

as the nerves regain their action and re-establish the tone of the vessels. When the paralysis is carried to a higher degree the resulting impairment in circulation will produce the œdema and other symptoms accompanying it. If the paralysis is complete, the vessels cannot regain their tone, and proper circulation of the parts cannot be re-established; here we get the necrosis and gangrenous degeneration observed in burns of the more severe type.

The action of the *x*-rays is very similar to that of the rays emanating from radium. It has been found by experiments that animals exposed to the rays of radium for a sufficient length of time will die as the result of paralysis of the cord. It seems to us quite logical that before the rays can accomplish this they will produce a paralysis of the smaller nerves which they must pass before they can reach and show their effect on the cord.

This theory would explain the network of dilated blood-vessels so often observed in scars left by *x*-ray burns. In fact telangiectatic scarring is almost characteristic of *x*-ray burns.

Crocker has seen this condition in two cases after long and repeated exposures where there was no breach of surface and no marked scarring, although there was some atrophic change in the skin.

Scholtz has shown that a degenerative process is set up in the cells of the intima of the bloodvessels.

Kienböck believes that the burn is due to chemical changes as the result of the absorbed rays.

Statistics. In a statistical study of all the cases he could collect (less than two hundred) Codman[1] found that half were serious and that one-third occurred in *x*-ray workers themselves. The static machine is least likely to produce burn.

In two cases no symptoms appeared for five months. He has never heard of a burn developing from an exposure of equal to or less than five minutes at ten inches. He thinks that if no dermatitis appears within three weeks after the last exposure there is not likely to be any.

[1] Philadelphia Medical Journal, March 15, 1902.

As to the frequency of burns he has found that in the last five years the average was 1 to 1000 from x-ray examination. Within the past year the averave dropped to 1 to 10,000. More than two-thirds of these injuries occurred in the first two years of the use of the x-ray. In the current year only one mild case was reported as the result of examinations. One-half of all the cases generally show within ten days, but in rare instances it may show as late as five months. He believes that the reason the abdomen is more often burned is due to its thickness, requiring longer exposures, but this fails to explain why this happens in therapeutics where it is not exposed any longer than other parts.

In the report of the Hamburg Epindorf Hospital of 1898 we find 2000 exposures reported, with one burn. We have administered the ray in the neighborhood of 8000 times, with one severe burn of the abdomen in a patient treated for carcinoma of the liver; one much milder burn of the vulva, one of the shoulder, and a dozen mild forms of dermatitis.

Septic Burns. Pratt says that these are due to impurities and microbes driven into the tissue.

Treatment. On the general treatment of the x-ray burn little can be said in the way of routine measures. The conditions met with are so numerous and diverse in character, that it is not within the range of possibility to include them all within the scope of any volume. From what has been observed up to the present time, it is more than probable that there are a limitless number of conditions and phases of the lesions which we will encounter as the number of cases treated and reported increases. In the main the treatment is the same as in ordinary burn, but it must be said that the measures generally employed do not have as good an effect as in the case of burn from other causes. The treatment in any particular case will be dictated by the exact conditions that arise. In very obstinate ulcerations which manifest little or no tendency to heal, there will be indicated such applications as the nitrate of silver and weak chromic acid solution. The lesion in these cases must be kept as clean as the circumstances will permit of. All exudations are to be carefully removed and the application of any medicament made to the cleansed surface only. Films of false skin found to develop at the margins and over the surface have the appearance of the membrane in diphtheria, and adhere very tenaciously to the underlying structure. These, where they persist too long, are to be removed and the surface underneath swabbed lightly with weak nitrate of silver solution, 2 per cent. to 5 per cent.

Where the condition is one of hypersensitiveness, there are indicated sedatives and cooling and soothing measures, as the benzoated zinc ointment, which may contain a small percentage of cocaine in very severe cases, or such other drugs as orthoform, boracic acid, or pyoktanin. Starch is indicated where there is a great deal of discharge.

In dressing the lesions it is always a good measure to first apply hydrogen peroxide on a swab for the purpose of removing the exudations, and then gently dab with a cotton sponge to remove the moisture. It should be remembered that all burned surfaces are extremely sensitive, and that any application of a stimulating nature will cause great suffering. For this reason it is well to confine these applications to cases in which there is great need of stimulation and avoid them under ordinary circumstances.

All dressings should be thoroughly aseptic, the more so in these cases than in others, as the weakened condition of the tissues renders them prone to harbor infection which in any way may gain an entrance.

This is illustrated in a case of carcinoma of the chest wall which had been treated by the rays until there existed a large denuded area that occupied the whole site of the mammary gland. The patient was attended with the utmost care and was confined to one room for over one year. Yet, while everything was done by skilled nurses, the patient developed, on two different occasions, a pseudoerysipelas which extended over almost the whole body.

When the burn is of a mild nature and the skin has not become denuded, the application of a 3 per cent. solution of pyoktanin has a very potent effect in lessening the pain and promoting healing.

The pigmentation resulting from the rays gradually disappears in most cases, but in some, when the duration is of annoying length, it may be hastened in its departure by the application of compresses of very weak mercury bichloride solution. This is generally poor practice, as the solution may not be applied in sufficient strength to be of any great benefit without producing disagreeable results.

The use of a weak watery solution of picric acid has a beneficial effect on lessening the pain in all cases of burn, and at the same time exerts a beneficial effect on the healing of the condition. A general strength of 1 per cent. will be found of the greatest applicability.

The tough, continuous membrane often formed on the site of the burn when forcibly removed leaves a smooth surface behind, which, however, is extremely sensitive, and, while it looks very healthy, has a tendency to form crusts, which dry and crack, causing bleeding. Renewed exudation soon removes the crusts, leaving a smooth, exuding area, which heals slowly from the margins.

The most frequently attacked region of the body is undoubtedly the abdomen. This is hard to account for excepting by the fact that it was formerly a region frequently exposed and that it is covered by the thickest layer of fatty tissue. After this come the hands and face, while the conjunctiva and mucous membranes of the mouth and nose closely follow in order of frequency.

Thus far no measure has been unearthed capable of stopping the course of this condition. Methylene blue in 3 per cent. aqueous solution painted upon the surface of the skin seems to have a good effect in lessening the liability of the occurrence of burn, and the same solution acts beneficially in hastening healing after it has occurred. When the first symptoms of burn are noted, viz., itching of the skin, if all radiation is stopped, and the surface is carefully treated with cooling and soothing agents, the burn will frequently progress no farther. Tanning of the skin will frequently occur, and apparently renders the skin immune from further attack. Perhaps the best treatment and that which has proved of value in the hands of the author is the so-called L. L. L. ointment. It consists of lime-water, lanolin, and lard in equal proportions. The ointment is of a fluffy consistence. It affords great relief, is cooling, and stimulates healing.

Carron oil, which consists of equal parts of olive oil and lime-water, has given relief in a great many cases and will generally prove satisfactory. Benzoated zinc ointment has been suggested and in some cases works well. The oxide of zinc is, perhaps, the best all-round material that we possess for the treatment of the burn. It may be mixed with various other drugs, and seems to be satisfactory in relieving pain and promoting healing.

Another very valuable preparation for reducing the inflammation and lessening the pain is liquor Burrowii diluted with four to six parts of water.

Burdick uses petrolatum to hasten vesication.

Walker[1] has found the following formula of extreme value in the treatment of these burns:

℞—Cretæ preparatæ,	15.0
Olei olivæ,	8.0
Adipis,	4.0

Engman suggests the following preparation in mild superficial forms of dermatitis:

℞—Acidi borici	45.0
Zinci oxidi,	
Amyli,	
Bismuthi subnit.,	
Olei olivæ,	āā 30.0
Aquæ calcis,	
Lanolini,	āā 90.0
Aquæ rosæ,	45.0—M.

Sig.—Apply locally on gauze.

Kaiser[2] has used blue-light rays with good results.

Strebel[3] has not seen much benefit from the blue light, but has found that the violet and ultraviolet rays had a decided effect in improving the trophic changes.

In stimulating indolent ulcerations, we have seen considerable benefit from the application of the high-frequency

[1] British Journal of Dermatology, 1904, i. p. 695.

[2] Naturforscher Congress, Hamburg, 1900.

[3] Fortschrit. a. d. Geb. d. Roentgenstrahlen, B. vi. p. 74.

currents by means of glass vacuum and carbon-point electrodes with mild sparking.

Dusting powders of the insoluble sort, as dolomol mixed in varying proportions with such medicaments as pyoktanin, picric acid, acetanilid, boracic acid, will prove of value where the skin is denuded over large areas. Squibb's compound alum powder has also been found of more or less value. Xeroform-lanolin ointment has been used with success. Torpid granulations may be stimulated by solution of zinc chloride.

When the suffering is intense, cocaine has the greatest effect in lessening the pain.

Hot applications are always better than cold, and as a rule lotions are superior to ointments.

In a number of instances of redness and pigmentation after dermatitis high-frequency sparks have hastened the return of normal appearances.

In ulceration resulting from burn the high-frequency spark seems to act almost as well as it does in ulcer from other causes.

Bibliography—Leopold Freund, Elements of General Radiotherapy, London, 1904, p. 337. Wiesner, Beiträg zur Kenntniss der Roentgendermatitis, Münch. med. Wochenschrift, 1902, xlix. p. 104. Freund, Die gegenwärtige stand der Radiotherapie, Wiener med. Wochenschrift, 1900, No. 37.

CHAPTER XIV.

OTHER DELETERIOUS EFFECTS OF THE X-RAY.

The X-ray in the Production of Cancer. The case of the unfortunate tube-maker which I reported two years ago at the American Dermatological Association was, I believe, the first to be recorded of the transformation of an *x*-ray burn into carcinoma.

The subject is one of perhaps greater importance than appears on first thought. A single case might be set down

FIG. 80.

Deep ulceration following *x*-ray exposures. Dr. Varney's case.

as a curiosity, but these cases are multiplying, which opens an entirely new field—or, to speak more correctly, two new fields for investigation: 1. What quality is it residing in the ray which can now produce, now destroy the same thing? 2. Can the fact of production of cancer in this way lead to or aid in discovering the cause of cancer?

We must recall, in this connection, the analogous influence of arsenic, which too, at times, in a quasi-homœopathic manner causes and cures this same disease.

Varney reports an instance in which the ray was applied to an ulcer following the prick of a rose-thorn. Dermatitis had been twice produced by the *x*-ray previous to treatment by the reporter. At this time there was no appearance of epithelioma in the ulcer, which had a bright base and shelving edges, the skin surrounding the ulcer being in a state of dermatitis. Almost instant irritation was produced by the ray at ten inches. Amputation was advised and carried out. Sections from different areas revealed squamous epithelium with unusual increase of the fibrous tissue, which the pathologist attributed to the action of the ray.

This will be found more fully described in the section on Histology.

Varney considered the patient idiosyncratic to the ray.

One of the most interesting cases in our personal series is that of a manufacturer of *x*-ray tubes, who in the pursuit of his vocation developed carcinoma on both hands. Radiotherapy persisted in for a considerable period failed to effect any lasting benefit. He was, therefore, referred for operation, and one arm had to be amputated above the elbow, with a wide excision of tissue in the axillary and pectoral regions, for the removal of carcinomatous nodules, and subsequently excision of a portion of the opposite hand. The case, though most distressing from the patient's point of view, should prove interesting from the side of the physician and *x*-ray worker. The fact is to be remembered that this patient did not come into contact with subjects of carcinoma, so far as is known, and when cutaneous carcinoma develops in radiotherapists, as it undoubtedly will at times, the mistake must not be made of regarding it as a positive evidence of transmission from some patient being coincidently treated. We know that the ray is capable of producing a precancerous keratosis which may undergo malignancy, just as does any other repeatedly irritated tissue, and presenting such a condition as is seen in cancer following psoriasis or the taking of arsenic.

"It has also been noticed that while cancer is not generally considered contagious several persons who have been treating the disease by the *x*-rays have been affected. A number of these cases unquestionably might have been avoided if proper precautions had been taken."

Rollins falls into the probable error against which the above warning is made, recommending means to prevent accidental infection of patients from others in offices, etc., which recommendations are well enough on general principles.

Dr. Blacker, who is said to have cured the King of England of a rodent ulcer, has since died from malignant disease following *x*-ray dermatitis. The original burn upon the hand gradually extended in the form of a dermatitis upon the arm, with malignant growths developing in its course at the elbow and afterward in the axilla. Sir Francis Travers contemplated amputation at the shoulder, but there was such a rapid extension and wide involvement that operation was given up.

Epidermoid cancer resulting from severe ray irritation occurred in an operator in Boston. Three fingers were lost from one hand and two from the other.

Among others, J. N. Hyde and O. S. Ormsby[1] say that at times it appears as if in exciting inflammation in a cancerous growth we encourage dissemination of the cancer cells to the normal surrounding tissue and also favor metastases.

Mr. C. M. D., aged thirty-six years, a worker in an *x*-ray laboratory. First seen June 2, 1902. Patient states that for three years he had worked continually, making and testing *x*-ray tubes. A year after beginning this work he noticed a sunburnt condition of the hands. He stopped work for two or three days until the pain and swelling had subsided and then resumed his occupation. There was subsequently more marked effect which resulted in scars and contraction. For over two months before coming under observation a raised ulcerated lesion, as shown in Fig. 81, occupied the region of the wrist, measuring $3\frac{1}{2}$ x $2\frac{1}{2}$ inches in diameter. Phlyctænæ, or purpura-like spots, were scattered over the skin upon the arms and wrists and over the backs of the hands. On the right hand the tendons are

[1] Journal of the American Medical Association, January 3, 1903.

exposed in an ulcer which showed for a time signs of improvement. This patient was seen by me several times in consultation with his physician in a neighboring city, who was applying the x-ray with the hope of undoing what the ray itself had done. Deciding after a time that this was a futile course, the patient was advised to submit to amputation, which was carried out by Dr. Lloyd at the Postgraduate Hospital.

Histological examination of the tissues disclosed little change aside from those common to cicatricial tissues, excepting as it showed hypertrophy of the skin papillæ and the usual appearances of carcinoma. Dr. Lloyd has reported a second operation for cancer due to the same cause.

FIG. 81.

Carcinoma following x-ray burn

The X-ray as a Cause of Gangrene. Dr. E. M. Foote mentions a case of recurrent carcinoma of the breast upon which he operated after it had been exposed to the x-rays eighteen times. There was a burn which occupied the site of the original incision. The burn was neither very large nor very deep, and was entirely removed in the operation; nevertheless, in a short time a gangrene developed, which occupied the site of the original burn.

Such reports cause a hesitancy in advising preparatory or anticipatory raying in patients we expect to come to operation.

Too early raying after operation may also have its drawbacks in preventing early union.

Dr. Samuel Lloyd mentions several cases of epithelioma whose growth was greatly stimulated by applications of the x-rays. In one of these cases in which the ray treatments were continued up to the time of operation, although the parts were brought together without any tension, a gangrenous patch appeared which covered nearly the whole area that had been exposed to the rays.

A second case of the same kind has led him to very seriously consider the condition. This was a carcinoma of the breast, in which there is no reason to believe that any fault in technique had been present; still gangrene supervened.

He draws from this the conclusion that exposure to the rays causes interference with nutrition.

Skinner, after four treatments of postoperative raying, noticed a dark discoloration which became gangrenous. We must remember that the ray delays the absorption of clots, and that one effect of it is to diminish blood supply, a condition not desirable in flap operations. Ante-operative raying should precede operation by a time sufficiently long to obviate possible gangrene, and should be stopped ten days or two weeks before operation. On applying the ray to oozing ulcerative surfaces the first visible change is a brownish discoloration of oozing points showing early effects upon blood elements.

Deleterious Effects to the Operator. The operator is subject to many of the same deleterious effects as the patient, and while the length of exposure is shorter than in the case of the patient, the number of exposures is incomparably greater and the results have been frequently distressing and may endanger life. The largest number of accidents of this kind which are on record occurred in the earlier periods of the use of the ray to demonstrators and operators, who caused themselves serious or irreparable damage by not being cognizant of the necessity of protecting their bodies from the action of the rays. Beck had an unpleasant personal experience in this direction from prolonged exposure to high-tension tubes. His hand became first erythematous, then terra-cotta-like, and the epidermis scaled off in leather-like flakes; perspiration ceased entirely, and during the warm weather there was great distress.

As mentioned elsewhere, the eyes may suffer. I know of one instance of myopia increasing in an x-ray worker of about fifty years, at which age the rule is for the distance sight to improve. An ordinary screen would here not meet the requirements, and a tube-box would have to be employed to shut in all but the necessary rays.

For the hands ray-proof gloves could be worn, especially by those who cannot keep "behind" the radiance, or who are especially susceptible.

Bibbins had considerable difficulty with his hands and eyes, which were quite severely burned. I have seen possibly a score of physicians and *x*-ray workers who have been more or less injured, some severely.

Scleroderma-like Changes. Behrend[1] observed changes in the skin of tips of fingers and other surfaces which resembled sclerodactylia. A sclerodermatization has been observed by a number of writers occurring independently and not as a secondary affection after Roentgen ulcer or burn.

This accidental scleroderma is non-progressive. Trophic changes occur which have a preponderating effect upon the capillaries.

The perturbing effect is so pronounced that nature seems incapable of bringing the molecules again into their former way of acting and arranging themselves.

Oskar Salomon[2] relates a case of his own and refers to three others in literature.

The integuments are thickened, lardaceous, and present a white or ivory-like appearance over a greater or lesser extent of surface, and, what is very characteristic, they are dotted here and there with little islands of reddened or violaceous hue, and on close inspection many of these present a telangiectatic appearance. This condition may commence slowly and without any subjective symptoms. Very much the same effect is at times seen after the healing of a deep dermatitis, producing in place of the cicatrix, as we ordinarily see it, the appearance of a waxy infiltration of the tissues picked out with islands of nævus-like aspect, the whole giving an aspect similar to that seen in some cases of xeroderma pigmentosum. During and after the raying

[1] Berliner klin. Wochenschrift, 1898, No. 23.

[2] Archiv für Dermat. u. Syph., Bd. lx., Heft 2, p. 262

the patient has a feeling of tension of the skin of face and head at times. Sometimes this condition is very slow in making its appearance, in Barthélemy's cases appearing five and six months after the exposures. At times there is decided desquamation.

Hallopeau and Gadaud report sclerodermatic changes in a case of their own. After prolonged exposures for exhibition purposes, three weeks from their commencement the skin of the hand was found dry and free from hair.

Three years later the patient took up radiograph work again, and a year later red spots appeared over the dorsal surface,which could be made to disappear under pressure; there were changes in the phalangeal articulations. Several months later there were two separate attacks implicating the metacarpal articulations of the index and middle fingers, although no exposure had taken place for a long time. Ulcerations succeeded but cicatrized and the articulations remained as though ankylosed. The hand had a mummified appearance. There developed upon the sclerosed tissue small, red, wine-colored spots with delicate arborization effect; these are isolated or run together, forming a meshwork in whose interstices the sclerosed skin shows whiter by the contrast. The color when pressed out by the finger returns promptly. Flexion of the index and middle fingers is absolutely impossible, due wholly to the sclerosis of the skin, which is non-extensible. This appearance presented by the red spot on a whitened, lardaceous area is pathognomonic.

I have observed these in a number of cases, and it was pronounced in the patient whose *x*-ray burn was followed by cancer as detailed elsewhere. The interval elapsing between the exposure and development of some of these changes shows a peculiar latency of effect which is most instructive. Observing the latent activity in these deleterious effects, we have little difficulty in believing the accounts of those clinical cases, especially of cancer, which go on improving long after the ray has been withdrawn. I have once or twice observed an exacerbation, as it were, in deep-seated burn effects months after the last ray had been applied, acting as though there had been a renewed application. Barthélemy speaks of a similar condition of experimental scleroderma, in which without ulceration the skin appeared glued to the bones. In a case of supposed mammary carcinoma (primary) after an erythema and desquamation, there occurred in my own practice a condition of artificial scleroderma, with a slight amount of red points and telangiectasis, but without the mummification, which would in this situation scarcely be expected because of the depth of soft tissue. In the case of radiodermatitis corresponding to the second degree of burn, I have been much interested in watching how these wine-colored dots with their branching, spider-leg-like telangiectases were formed. As cicatrization develops, small, round, pearl-colored islands spring up about the edges, but running often well out toward the centre of the exulceration. As the new epidermis fills in between these rounded areas their central portion remains more highly colored, and as the general redness gradually fades, the wine-colored spots grow in intensity. The scleroderma condition and mummification of the skin in connection with this characteristic telangiectasis suggests to those familiar with the appearance of these patients oftentimes xeroderma pigmentosum. In both this disease and changes produced by the ray the development of epithelioma or carcinoma is to be dreaded. We get malignant degeneration in xeroderma just as we get it in the skin of the old man when senile changes have brought about a peculiar transformation, and it would seem that having these three similar conditions of tissue so dissimilarly produced an inkling might be acquired of the nature of epithelial cancer, or at least of the conditions under which epithelioma flourishes.

Scleroderma-like lesions were noted by Fournier and Barthélemy in a young girl treated successfully for intercostal neuralgia.

Scleroderma-like transformations have been noted in three other cases besides the one recorded by Salomon.

A year after treatment patient presented an ulcer of the forehead surrounded by a hard cicatrix with surrounding telangiectases.

The histological changes are similar to those found in true scleroderma—*i. e.*, thickening of vessels, perivascular infiltration, changes in the connective tissue, papillary degeneration, and hypertrophy of the connective-tissue bundles.

The Production of Toxæmia during the Treatment of Cancer. Evidences of autointoxication occasionally arise in the treatment of cancer and sarcoma.

At a meeting of the American Medical Association in 1902 I called attention to the grave symptoms which might arise when disintegration of large masses is going on rapidly under the rays' influence.

It is always most difficult to differentiate between those effects which a severe disease like cancer can produce *per se* without the question of *x*-ray and those which are to be attributed to the latter.

I have observed joint and muscular pains of rheumatic character during treatment. This suggested to my mind the possibility of a poison being given off into the general system from the growth, and being thrown off so suddenly that the eliminating organs had not been able to take care of it. The source is the mass of broken-down organic elements resulting from destruction of the growth. This is what I meant by saying that the *x*-rays are capable of doing harm, and that their application should not be left in the hands of inexperienced and non-medical men.

Evidences of uræmia, joint affections, metastatic-like conditions might depend in part on the ray.

In severe mammary carcinoma, after a limited number of treatments, there may be a slight headache, rise of temperature, and chilliness.

This is probably not always evidence of systemic infection or toxæmia, but due to other unknown effect of the ray, since it may be observed in even dermatological conditions. We should watch the circulation and temperature carefully and stop treatment as soon as any alarming symptoms arise.

At times we observe, following an intense or extensive Roentgen reaction, a toxic, febrile condition, consisting of a high temperature with remarkable, slight, general febrile symptoms, and a feeling of well-being which distinguishes it from general toxæmia, with or without exanthema.

Holzknecht[1] reports a number of these cases and claims that they are not due to the invasion of septic materials through the excoriated skin surface, but are the result of the resorption of toxic particles produced in the region of the reacting skin by the irritating effects of the rays, leading to a specific cell degeneration.

These cases may be accompanied by an extensive erythema, which have on a number of occasions been mistaken for scarlet fever. The prognosis is very favorable.

Death. A death suspected to have been caused by exposure to the rays is reported by Maurice Rubel.[2] The patient was an unmarried woman, aged forty-seven years, who had been admitted, complaining of "pain in left side, frequent micturition, general weakness, and fever." Abscesses of Skene's ducts and urethritis were present, but no evidence of the presence of calculus was obtained. The temperature was normal. Urine taken from the bladder was intensely acid. On standing there was a heavy, white precipitate, composed of epithelial cells, hyaline and granular casts, and numerous leukocytes. All of the symptoms yielded to treatment and the patient became relieved, but the pain in the left side persisted. It was suspected that there was a stone in the pelvis of the kidney which had not been previously discovered.

"On October 8th a skiagraph was taken. Two exposures, each lasting twenty minutes, were made; a Leeds' coil was used, giving a spark of three inches, with the tube about six inches from the abdominal wall. The picture threw no light upon the case."

A burn developed over the abdominal wall in due time, which became somewhat severe in about one month. At this time the patient was in fairly good condition, well nourished, and the blood normal. Epidermis rapidly grew and covered almost the whole area, when a change took place and the cicatrices broke down and formed large ulcers. These, after suitable treatment, granulated in a healthy way, but no skin grew upon them. Skin grafting proved

[1] Archiv für Dermat. u. Syph., July, 1903.

[2] Journal of the American Medical Association, November 22, 1902.

unsuccessful. The condition of the gastrointestinal tract caused much anxiety, and constipation of an obstinate nature developed. Patient became nauseous and vomited large quantities of bile-stained fluid. Nutrient enemata were substituted for feeding by mouth, and the stomach was washed at intervals, but the vomiting still persisted. The condition improved for a few days, when it became worse for a period, and then improved again.

The abdominal wound was at this time at a standstill. The affected area was excised and healthy skin grafted in place. The condition of the patient was greatly improved, but though she had no difficulty with any of her functions, she grew rapidly weaker and died. An autopsy was not performed. The cause of death in this case cannot be definitely determined, but it is probable that the ray is capable of causing some change in the nerves and vessels of the abdominal organs. That some functional change at least is produced cannot be doubted, in the light of the numerous cases cited in which nausea and even vomiting have followed prolonged exposures of the abdomen.

A few other reports of death following exposure to the ray have appeared in literature from time to time, but none of them seem entirely convincing.

Rodet and Berin, through intense raying in animals, have brought about dermatitis, paralysis, and convulsions, resulting in death. On autopsy they found meningomyelitis, congestion of the spine, hyperplasia of the cells and minute hemorrhages. This could not have been the result of sepsis, as the bacteriological examination proved negative.

Another instance of death following an abdominal burn is reported by Gilchrist.

Alopecia due to *x*-radiation was first reported by Prof. Daniel[1] in 1896. Since then innumerable cases have been observed, this being in fact one of the most frequent of the deleterious effects due to the ray. This power of the ray has been utilized in epilating superfluous hair.

Alopecia, when due to the ray, is directly due to change in the blood supply of the follicles. In some cases the hair

[1] New York Medical Record, April 25, 1896.

commences to fall at the first sign of disturbance in the follicular circulation; so it is well to discontinue treatment the moment a tendency to alopecia is manifest, and to begin employing measures of restoration.

It may occur spontaneously, as it were, as late as three weeks after the exposure occasioning the result. There may be slight œdema of the scalp, redness, etc., but usually the scalp is left smooth and free from evidences of irritation. If the ray has not been given for too long a time, the alopecia produced will be only temporary, and the hair will grow out again in about two or three months, but if raying is persisted in it may be permanent.

Gerwood reports a peculiar case in which the new hair grew in curly to take the place of previously smooth hair.

In some cases we have found that following ray alopecia the hair may grow in black where it has been previously white. Such was the fact in the case of Mr. C., treated for epithelioma of the forehead, where following a ray dermatitis with alopecia on the left temple the new hair grew in black to take the place of perfectly white hair. An increased growth has been several times observed in my own cases.

Atrophy of Skin. Atrophia cutis idiopathica was seen by Schmidt[1] following exposure of the hand for a half-hour; the color was first red, gradually becoming bluish, and finally the atrophic changes were noted. This had remained for five years, the skin having an aspect of wrinkled cigarette paper.

Heart. Perhaps the first observation of the action of the ray upon the heart was made by Seguy and Quenisset[2] in 1897, who found that autoexperiments with the prolonged use of the *x*-rays caused peculiar cardiac palpitation with general uneasiness. At first there was a feeling of oppression, then palpitation of the heart, and, finally, an unbearable and dangerous arrhythmia. By laying a thick metallic plate over the cardiac area the condition improved.

Palpitation has been produced in a number of instances in our own cases, and it is not unusual to find the heart beat accelerated after a ten- or fifteen-minute exposure.

[1] Archiv für Dermat. u. Syph., January, 1903.
[2] Compt. rend., 1897, No. 14.

Effects upon the Mouth and Teeth. The condition of pyorrhœa alveolaris is said to be aggravated by exposure to the rays, but aside from desultory observations on a few cases there is no evidence that the results were to be in any way attributable to the ray.

In a cancer of the lip treated by me, in which there was preceding decided loosening of the teeth from pyorrhœa, the patient complained much of soreness of the gums during and after treatment, and a year after his lip was well he still maintained that the ray had aggravated the pyorrhœa.

Gastrointestinal Effects. Whether or not the rays produce of themselves profound disturbance of the functions of stomach and bowels is a question not so readily answered as it would seem.

That such symptoms as nausea, vomiting, diarrhœa, constipation, and the like follow their administration is beyond question. When such men as Walsh tell us that they have observed digestive disturbances, we can do no less than believe them. We must remember the ease with which neurotic, nervous, and emotional subjects are influenced by many things less formidable than an *x*-ray apparatus. Still the possibility of an influence upon the sympathetic nerve cannot be put aside. I have myself seen many times, in the course of a single case of extensive breast cancer which was treated for a year, derangements of digestive function which I could scarcely put down to the conditions of the disease present.

Gastritis, it is thought by Oudin, Barthélemy, and Darier,[1] has been brought about by intense raying of the abdomen. There was vomiting, diarrhœa, and severe palpitation of the heart, but no physical signs could be made out. These observers even attributed the development of tuberculosis of the lungs in one case to the administration of the rays.

On the other hand, Freund, in his very extensive experience, claims never to have observed any gastrointestinal effects attributable to the rays.

Scholtz likewise failed to observe any digestive disturbances follow even such intense raying of the abdomen as to

[1] La France médicale, Paris, 1898, pp. 113, 129, 145, 162, 179.

produce necrosis. Nausea seems to have been first attributed to prolonged raying by H. C. Drury.[1] It has since been observed quite frequently by others.

We may conclude from a personal experience and study of the matter that in severe abdominal disease no functional disturbance of sufficient gravity is likely to occur to necessitate our withholding the treatment or hesitancy in applying the rays in diagnosis.

Vertigo and Fainting. General faintness is one of the effects of prolonged exposure to the rays, and it is not uncommon in the experience of those who have an opportunity of observing a large number of cases. Patients are frequently in a condition of great weakness at the termination of the treatment, especially those suffering from severe disease, and not infrequently faint. The reason for this is not wholly explainable, and though there have been advanced a number of hypotheses to explain it, none of them seems worthy of discussion.

The patient should never be allowed to stand when taking the treatments, or in lengthy exposures for diagnostic purposes, but should be comfortably seated or recline upon a chair or table. The heart is undoubtedly at times affected by long exposure to the rays, and it is necessary to carefully watch this organ during the whole course of treatment.

Bibbins noted fever and collapse after a short time, especially in cases of internal growths.

Gibson observed cerebral disturbances from treatments with a high tube.

Effects upon the Nerves. Extreme nervousness, perhaps accompanied by profuse perspiration, has been observed at times. Effects resembling sunstroke have been seen by Walsh, and also referred to by several European writers, a number of mild forms of which we have observed in several instances when the rays have been applied to the head. Among the symptoms are vertigo, headache or disagreeable, full feeling of the head, palpitation, vomiting or nausea, faintness, abdominal colicky pain, and rarely looseness of the bowels.

[1] British Medical Journal, November 7, 1896.

Effects upon Head and Brain. Headache as a probable result of raying is suggested in a case reported by A. L. Brookaw.[1]

Several patients, in the experience of the author, have developed headache after the treatment had been continued some time. These patients were all suffering from some lesion of the head.

Irritating effects in treating diseases of head and face especially occur with a high tube. Anteroposterior rayings are considered less dangerous than lateral (Gibson).

Telangiectasis. This may occur as the sole ill-effect in operating for superfluous hairs, as related by Ehrmann.[2] The dilated vessels may follow long sittings or frequent rayings of slight intensity, and may appear first only after a considerable interval.

Effects upon Bones. Ohmann-Dumesnil reports injury to the metatarsal bones of nine months' duration following *x*-ray exposure.

In Schmidt's reported case of atrophy of the hand, produced by a half-hour exposure, thickenings on finger bones persisted for five years.

Gilchrist's case, mentioned elsewhere, of periostitis and ostitis still persists.

Grindon[3] mentions observation of ostitis and periostitis with much thickening, severe neuralgic pains, and paralysis due to involvement of nerve trunks.

Bullous Dermatitis. It has been found by Heidingsfeld[4] that a peculiar form of bullous dermatitis often followed the application of the *x*-ray. After an exhaustive research upon the subject he was led to the conclusion that these bullæ were formed spontaneously, and did not require the agency of any traumatism as a causative factor.

In the case of Mr. C. treated by us, a bullous dermatitis developed on both sides of the nose, though one side was not exposed to the rays.

Besemer, of Ithaca, reports an outbreak of bullæ cover-

[1] St. Louis Courier of Medicine, November, 1902.

[2] Wiener med. Gesellschaft, May 23, 1902.

[3] American Text-book of Genito-urinary Diseases and Syphilis, Philada., 1898

[4] Cincinnati Lancet-Clinic, August 2, 1902.

ing three-fifths of the surface of the arm upon the third day after a rather long exposure in a girl aged sixteen years. The next day pulse and temperature were normal, but a new crop of bullæ appeared; there was fretfulness and insomnia present. Three days later, after taking a dose of trional, she was found dead. The supposition of a septicæmia does not seem to be perfectly established in this case.

The ray was applied in the diagnosis of a fractured condyle, which was operated by wiring. Post-mortem examination showed a bullous dermatitis on the hip below the waist-band, of the same nature as that on the arm. The heart was fairly normal, but contained small white clots which proved to be pure cultures of streptococcus. Death was attributed to septicæmia, but there were no signs of septic infection of the wound and no rise of temperature.

Coley has seen a severe type of eczematous or bullous inflammation of the skin with abundant exudation and crushing which began in the area subjected to the rays and spread over the entire body. Improvement was very slow.

Roentgen Ulcer. Rodent ulcer may be changed into a Roentgen ulcer, which must be recognized so that there will not be continuation of the influence which determined the change.

In *x*-ray ulcer there is found a permanent dilatation of capillaries and a scarcity of granulation tissue and blood-vessels (Allen[1]).

Keratotic Changes. All we can say is that the ray produces the kind of keratotic tissue which, as seen in senile changes and in presenility such as xeroderma exemplifies, and such as at times is caused by arsenic, is seen in psoriasis, and which tends to degenerate malignantly.

Pigmentary Changes. These include both increase and decrease, or at least, to speak quite correctly, a displacement of pigment, making a clinical picture which suggests at times an atrophy of pigment or vitiligo. This is perhaps more properly referred to as a depigmentation.

In one instance I observed a displacement of pigment lasting for months upon the chest of a very fair young lady

[1] Seabury W. Allen, Journal of American Research, June, 1903.

to whom the ray treatment had been administered for supposed incipient phthisis. The appearances were similar to those of a mottled chloasma and not unlike those at times seen in chromophytosis.

I have observed in another case a persistent erythema surrounded by a band of pigmented skin, which also persisted for several months and gradually returned to normal.

In Fig. 82 is shown depigmentation in a colored girl treated by Dr. Thomas L. Butler[1] for lupus of the larynx and face.

Fig. 82.

Showing loss of pigmentation over area treated by x-ray.

After decided improvement had occurred there was found to be a loss of pigment in the area treated.

Dr. Pancoast showed some very striking examples at the last meeting of the American Roentgen Ray Society.

Sehrwald, Gocht, Gassman and Schenkel all observed a depigmentation of the part exposed to the ray and a hyperpigmentation of the margin of the surrounding parts.

Freund and Schiff observed the same thing in cases that have been under treatment for some time. I have observed it in vitiligo treated by the ray.

[1] Louisville Monthly Journal of Medicine and Surgery, December, 1902.

Effects upon the Ear. No reports bearing upon the question appeared until Salomon's article. His lupus patient had rapid diminution of hearing after a burn in the treatment of a lesion of the face and ear.

Muscles and Soft Tissues. Peculiar impairment of the arm is reported from Paris, where at the Hospital St. Louis a man who had been used repeatedly as a subject for x-ray experiments became affected. The muscles of the arm became swollen and painful, and the skin was parched and cracked, the nails being also affected. The exact nature of the injuries to the muscles of the arm and, perhaps, to the nerves has not as yet been determined, and the disability is gradually increasing.

Effects on Nails. The changes produced in the nails are both characteristic and pronounced. Many instances of shedding of the nails have been placed on record.

Dystrophy without loss is more common. It has seemed to me that the nail-bed was quite as vulnerable as the hair papillæ, since in many instances in which the nails become brittle, friable at the ends, longitudinally striated, misshapen, incurved at the free border, or inflamed about the periphery, there is no loss of hair upon the hand. In others the hair falls coincidently.

Under continued irritation by the ray the nails soften at times and fall, growing again in an irregular manner.

At other times they are not reproduced, but the tip of the finger remains either atrophic and pointed or thickened, and is for a time the seat of a painful suppurative process.

Occasionally preceding the shedding there is, along with the onychia, a paronychia with pain and pus formation. Many who administer the ray—physicians and workers in laboratories—suffer from a dry keratotic or verrucous inflammation at the sides and beneath the free end of the nail, with painful, annoying, and disabling fissuring. The histological change is an hypertrophy of papillary elements.

This condition, unless cured and protected from further exposure, may persist and eventually degenerate into epithelioma.

This precancerous keratosis has been described by Johnston, and this would seem to have been the early condition present in the English surgeon who died from generalized infection, and whose case is mentioned elsewhere.

The treatment is somewhat unsatisfactory, as the condition is obstinate and the nails continue to exfoliate long after the exposures have been discontinued.

Unguentum diachyli with pyoktanin 1 per cent. has given the most satisfaction in the hands of the authors. While the ordinary remedies for burn are unsatisfactory, the L. L. L. ointment mentioned under the treatment for *x*-ray burn has proven of great value.

Effects upon the Eye. Very little is found in literature bearing upon this question. Himmel[1] speaks of inflammation of the optic nerve. Kienböck[2] describes a temporary clouding of the cornea in a guinea-pig which he had rayed for experimental purposes. Coleman has noted ulcer of the cornea after treating epithelioma of the lid. The author has also seen corneal ulcer during a course of treatment, but did not attribute it to ray influence. Neiswanger. reports cellulitis of the upper lid as a consequence of raying[3] Goodspeed, Rollins, Barthélemy and others, as well as myself, have noted impairment of vision among those working much under exposure to the *x*-ray. Rollins has recently had occasion to examine a man who had been exposed to a considerable extent since 1896, and, though not yet forty years of age, he cannot read the daily papers. To enable him to see his work comfortably at a distance of 43 cm., it was necessary to provide him with double-convex glasses, No. 26.

A non-radiable box to include the tube is most urgently recommended to secure the necessary self-protection.

Hahn has observed an intense conjunctivitis, and Freund has seen it in a mild degree in several instances. Very mild conjunctivitis has occurred twice in our observation, but has promptly disappeared on discontinuing the treatment. When it is known that we have exposed the globe directly perhaps several hundreds of times, and have treated

[1] Unna's Monatsschrift, Bd. xxv., 1897.

[2] Archiv für Dermat. u. Syph., Bd. l.

[3] Wiener med. Presse, November 20, 1901

cancer of the globe itself without harm resulting so far as we can now judge, the slight inflammation of the lids occasionally seen seems almost insignificant.

This conjunctivitis is rarely serious, and is readily controllable by some such simple astringent eye wash as—

℞—Sodii biborat, 0.1
Aq camphor, 10.0—M.

Sig.—Bathe eyes night and morning.

Various forms of shields are described in the chapter on Apparatus, which are used in protecting against or preventing burn. For the eyes we know of no better method than the simple expedient of folding a piece of lead-foil (about 20 gauge) in a towel and binding it around the head and over the eyes, fastening at the back with a safety-pin. The whole may be gently moulded to fit the eyes and nose after being adjusted.

Prophylaxis of the deleterious effects mentioned in the foregoing pages can be, in a large measure, carried out by the routine practice of making test exposures to learn the susceptibility or possible idiosyncrasy of the individual.

CHAPTER XV.

HISTOLOGICAL CHANGES CAUSED BY THE X-RAY.

Scholtz has conducted a series of experiments on the skin of various animals. He exposed them to the rays, and after various intervals excised the exposed patches and examined them under the microscope; he found the following conditions present:

A swelling and œdema of the epithelial cells, accompanied by a clumping and shrinkage of the nuclei, with the appearance of vacuoles here and there in the protoplasm of the cells. Many of the cells of the epithelium presented nuclei which seemed to be in process of division without the production of mitotic figures. Mitoses were rarely observed. The corium was markedly œdematous; its fibres were swollen and stained badly. The elastin seemed to be more resistant than the collagen. The connective-tissue cells were affected in much the same way as those of the epidermis; their protoplasm was swollen and homogeneous, and occasionally vacuolated. Similar changes were present in the cells of the sweat coils and hair follicles, and in those of the intima of the larger bloodvessels. There was an abundant inflammatory infiltration of cells around the vessels, chiefly consisting of leukocytes. Masses of leukocytes were also present beneath the epidermis and extending here and there between the degenerated cells. The number of mast-cells in the corium was definitely increased. Toward the centre of the lesions there were superficial vesicles in the stratum corneum. When the latter broke down ulceration seemed to follow quickly.

He concludes that the pathological action of the *x*-rays on the healthy skin could be thus summarized:

1. They cause a slow degeneration of the cellular elements of the skin in which not only the epidermal cells, but also the mesoblastic cells of the corium and the cells of the

epidermal appendages participate. This degeneration affects the nucleus as well as the cell protoplasm. They also cause, but to a far less extent, a degeneration of the fibrous elements, the collagen, elastin, and the muscles.

2. As soon as the cellular degeneration reaches a certain degree an inflammatory reaction occurs, in which the blood-vessels become dilated and there is an extravasation of serum and leukocytes. The latter seem to act as phagocytes and completely destroy the degenerated cells.

J. C. Stuart[1] finds that the important early changes consist of fatty degeneration and vascularization of the epithelial pearls, leukocytic infiltration, and degenerative processes. Bodies indistinguishable from Plimmer's bodies multiply as epithelia degenerate.

Christian found that epithelial cells in the cell nests are dead, sometimes surrounded by foreign body giant cells; no polymorphonuclears present in a cancer of the cauliflower type.

Nichols, of Boston, says the changes following the use of the *x*-ray have shown no peculiar characteristics. He believes that the ray acts as a mild irritant, causing first increase in epithelial cells and later disintegration.

According to the researches of Kaposi, the action of the rays upon the skin causes an alteration in the tone of the bloodvessels, causing healing and a resorption of the granuloma either by a fatty degeneration or a molecular change. Neisser has likened this change to that produced by injections of tuberculin.

The vessels are occluded, closed, or destroyed, and on the surface elastic tissues develop and grow with great rapidity.

The epidermic layer is thickened; there is an abundant, rapid desquamation of rather large scales, and the new epidermis is rapidly formed.

By using a special stain for elastic-fibre tissue Unna found that the ray effected in human skin a change in the collagen; it was basophilic, but the elastic fibre was not stained.

Grossman found in the vessels a degeneration in the intima and muscular layer of the vessels. The cellular

[1] Journal of the American Medical Association, July 18, 1903.

elements were swollen, the intersubstance increased, and the epithelia showed the characteristic vacuoles.

Beck found thickening of the tunica intima of the smaller bloodvessels and the fibrous tissue in a reticular arrangement. He thinks that the changes in neoplasms is in the nature of a chronic inflammation.

Allen[1] finds that the effect on superficial capillary circulation is like that of an irritant, producing vasodilatation; this may explain the relief of pain. On the heart of cold-blooded animals the ray acts as an inhibitor. There is an immediate local increase in the leukocytes of the blood.

A hair extracted after prolonged irradiation is found to have lost its structure. It ends in a point instead of a root. A specimen of the skin showed thickening in the tunica intima of the small bloodvessels; fibrous tissue in reticular arrangement is deposited and the tunica muscularis and tunica adventitia are affected in the same manner. The tissue changes taking place in neoplasms are also of the nature of a chronic inflammation; the nutrition of their superficial strata is disturbed, the cells starve, and if the exposure is continued necrosis results.

When tissue which has necrosed under the action of the ray is examined we find that the cause of death has been stasis in the bloodvessels.

Schwarz finds from a study of the ray on sea-urchin eggs, and other experiments, that there is no inhibitory effect or cell division such as Lopriore has proven in plant cells. The influence on morbid growths cannot be explained in this way. He thinks, however, that the ray as well as Finsen light and long exposure to sun renders metabolic products within the cell insoluble, impeding elaboration and elimination.

Albers-Schönberg,[2] in experimenting on animals, found that the ray produces in them an inability to reproduce without any decided effect on their general state of health. Whether this is transient or permanent is still to be determined. It accomplishes this by killing the spermatozoa,

[1] Seabury W. Allen, Journal of Medical Research, June, 1903.

[2] Münchener med. Wochenschrift, l., No. 43.

which soon reaches the point of complete azoöspermia. He experimented with 5 rabbits and 6 guinea-pigs, with from 377 to 518 minutes of ray exposure in different cases; 195 minutes' exposure did not produce a complete effect.

Action of the Ray in Carcinoma. The frequency of giant cells found in carcinoma of the skin led Peterson to investigate 120 cases very carefully in regard to this point. The examinations were critical as to the exclusion of tuberculous complications. He pointed out that the histological appearance of these cases appeared to favor the assumption that the giant cells are engaged as phagocytes in removing the epithelial cells and other degenerated horny substances. It is possible, then, that the giant cells might indicate a healing process taking place in the tissues. The citation by the writer of authentic examples of the probable removal by phagocytes of early metastases led to a consideration of the possibility of the production of an anticarcinoma serum. The peculiarities connected with the distribution of the metastases of carcinoma are still not quite clear.

Histological examinations have been made of carcinomata while undergoing the process of healing by the *x*-rays, from which it appears extremely probable that phagocytic giant cells play no part in this process.

No satisfactory explanation of what actually takes place has as yet been offered by pathologists. From specimens of malignant tissue which had been examined after being subjected to the rays, it appears that a change takes place which is unlike anything heretofore noted. A cancer of the uterus to which Dr. Snow had applied the rays for a long time, and which had steadily improved up to a certain point, was removed by operation. It was found to be friable to such an extent that it came away in small fragments.

We may assume the action of the ray to be due to a stimulation of the tissues, which progresses until it amounts to an irritation and then a cauterant effect. All tissues react to the influence of the rays in proportion to their vital factor, for if the tissue is of low vitality or high differentiation, as in the nails or hair, or is in the nature of a new-growth, as lupoid or epithelial tissue, the action on them will be greater than on healthy muscular tissue. The disease is so far beyond the healthy tissue in point of vital resistance to the action of the ray, that the diseased tissue is broken down and utterly destroyed by the time the healthy tissue begins to respond to its stimulating and proliferative action.

This theory lacks the substantiation of actual proof, but has been suggested by a number of independent observers.

A. G. Ellis[1] has studied the effects in scirrhous carcinoma after a portion of the breast had been given eight ten-minute exposures at intervals of two days, the remaining portion being covered with a leaden shield. The breast was then removed and the two portions studied.

A softened area, noted after the fifth exposure, was found to be due to a cavity containing a fluid showing many large cells the protoplasm of which was almost filled by fat-granules. Surrounding the cavity were necrotic portions of the tumor, the epithelial cells being granular and broken, with destroyed outline and fragmented or entirely degenerated nuclei.

In two other cases, epithelioma and endothelioma, studied before and after raying, the same general form of degeneration was noted.

1. Necrosis of cells and trabeculæ in varying degrees.
2. Increase in elastic tissue.
3. A tendency to occlusion of vessels by deposits on their inner surfaces.
4. Practically entire absence of infiltration by polymorphonuclear leukocytes.

The effects attributed by Beck and others to obliterative changes in bloodvessels is in a measure combated, for, while they may occur, they are not in proportion to the necrosis. This suggests their being the result of the same influence rather than cause and effect.

The presence of immense numbers of bacilli and cocci in one specimen after twenty exposures argues against the bactericidal influence of the ray.

In the epithelioma which was but slightly influenced by the ray, many "pearls" were found. This, the writer

[1] American Journal of the Medical Sciences, January, 1903.

thinks, shows the importance of operation or curetting before the ray is given.

Besides abundant proliferation of the connective tissue, Doutrelepont found in lupous tissue that the epithelioid cells and the lymphatics are much degenerated. The lesion of the cells is indicated by the formation of vacuoles, which is so pronounced that a preparation resembles a sieve. Some isolated vacuoles were found in the internal membrane of the vessels. The action of the ray in producing curative effects seems to depend first on a hyperæmia which produces an abundant immigration of leukocytes outside of the vessels. In lupus the leukocytic infiltration commences at the periphery and penetrates in lines the lupous foci, to become transformed into fusiform cells and fibrillary connective tissue.

Buschke[1] found, consecutive to a bullous dermatitis, an atrophy of the skin having the clinical features of idiopathic atrophy. It differs from the latter, however, in remaining stationary, while the idiopathic form begins in one or more points and follows a progressive course. The effects upon the deeper structures in the case studied are of interest. The subject had exposed his hand for one-half hour at a distance of 20 cm. The phalanges of the fingers showed thickenings which developed coincidently with the atrophy of the skin.

Histology of Carcinoma Modified by Ray Dermatitis. In the report of Varney's case, given on page 334, the histological examinations were carried out by Dr. Gibbes, who found that in thickened portions along the anterior edge stained in logwood showed, as the most striking appearance, trabeculæ composed of cells which had stained deeply. This ran directly into the tissue away from the surface of the ulcer.

They were slender and only two or three cells in thickness, were long and many were branched. These cells were evidently part of a squamous epithelioma, as other and larger masses were seen in the deeper parts and also in those places where the epithelium of the surface was still intact.

[1] Ann. de dermat. et syph., October, 1902.

Aside from the trabeculæ running away from the ulcer the way in which they had reacted to the stain, in taking it deeply, showing acute vitality, and the fact that they ran into the deep tissue until they met dense fibrous connective tissue or muscle was noticeable.

At one place there was a transverse section of a nerve trunk with complete disintegration of the nerve elements.

It should be noted that the floor of the ulcer was mostly composed of cancer cells at this part.

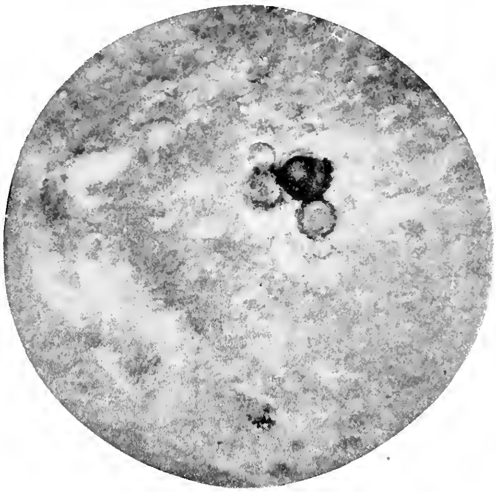
Passing farther along, there is an acute inflammatory process going on and the cancer cells stain faintly, while the spaces between them are filled with deeply stained leukocytes or pus cells. The bloodvessels are in many places surrounded with epithelial cells; in fact, they appear to be in the cancer trabeculæ. This condition does not extend very far into the deep tissue, but stops at a layer of parallel bundles of white fibrous tissue.

Passing still farther along the floor of the ulcer another change is met with; the acute inflammatory condition has disappeared, and the floor is almost entirely composed of stratified, squamous epithelium. Processes varying in size pass from this into the deep tissue and here come in contact with striped muscle fibres which in that portion, nearest the neoplastic growth, are being replaced by cancer cells. Passing back to that part where the superficial epithelium is intact, numerous processes of the epithelioma are seen in the cutis vera and some of them present carious appearances; while some have typical "nests" of horny cells, in others the centres have become disintegrated and are full of granular débris, while others have tubes in them with well-defined walls. Some of the conditions resembled those found in blastomycetic dermatitis, but special staining failed to show any of the blastomycetes. The above conditions are seen in Figs. 83 and 84.

Another marked change is found in the cutis vera which is an alteration in the chemical reaction of some part of the white fibrous tissue and an alteration in its structure.

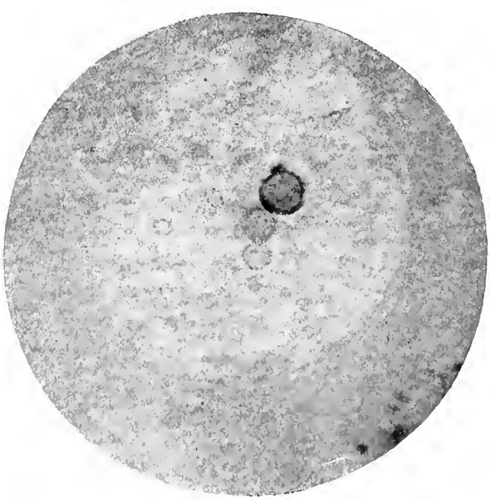
A band of tissue is seen which has taken the logwood stain in a different manner to the rest of the tissue. This band is seen to begin at the floor of the ulcer and to extend under the intact epithelium for the whole length of the section. It occupies the deeper part of the superficial cutis vera, that is, dividing the normal cutis vera into two parts,

FIG. 83.



Varney's case.

FIG. 84.



Varney's case.

the superficial consisting of felted fibrous tissue on which the epidermis rests, and through which the ducts of the sweat glands pass. There is a layer of the superficial cutis directly under the epidermis which is entirely unaffected. The changed portion consists of altered fibrous tissue which has stained a different color to the adjoining normal fibrous tissue. A high magnification shows this altered tissue as a mass of fibrils which in many places resemble long threads; with these fibrils are amorphous, irregularly shaped portions of probably disintegrated white fibrous tissue and numerous deeply stained nuclei of connective-tissue corpuscles. These altered fibres occupy a distinct layer of the superficial cutis and are differentiated by the peculiar color. This layer is separated completely from the epidermis by a layer of normal connective tissue.

There are no cancer cells in this layer except at its commencement in the floor of the ulcer.

In the deep layer of the cutis vera the sweat glands show considerable change. The duct gives an inflammatory reaction to the stain and the cells are swollen. The coiled portion in many places has its lumen destroyed by germination of its cells, showing an irregular collection of nuclei.

The bloodvessels in some places have their intima thickened and their lumen reduced to an irregular slit. The nerve trunks have the perineurium thickened and the nerve fibrils disintegrated.

Pacinian corpuscles have thickened capsules.

In this case it is a difficult matter to apportion the morbid changes to the two conditions, the cancer growth and the *x*-ray effect.

All the conditions described are met with in ordinary squamous epitheliomata growing in the epidermis with the exception of the change in the fibrous connective tissue.

An ordinary epithelioma exerts no influence on the fibrous connective tissue in which it grows except to cause its absorption when it is in the way. On the other hand, a glandular carcinoma causes the fibrous connective tissue of the part to grow and form a supporting framework in which run the bloodvessels for its nourishment. There is no similarity to either of these processes in the present case.

In the first place the chemical reaction of the altered fibrous tissue is entirely changed; this is plainly shown in the sections. Then the action on the fibres is one of disintegration; it is not a formation of granulation tissue as might be expected, but the white fibrous tissue is changed into small homogeneous masses and long, slender fibrils; this differs entirely from any phase of normal fibrous tissue growth, and this condition may be attributed to the action of the *x*-rays, since, taken as a whole, the condition is a new one in pathology.

CHAPTER XVI.

BACTERICIDAL ACTION OF THE X-RAYS.

Many conflicting reports are in existence as to the bactericidal action of the x-rays, some positively holding that the rays will cause inhibition of growth or even death of most bacteria, while others as stoutly contend that the rays exert no action upon these micro-organisms.

Zeit[1] was not able to kill bacteria in bouillon or hydrocele fluid after forty-eight hours' exposure to the x-ray at a distance of 20 mm. from the tube. Those exposed upon agar plates for four hours were not killed. Sputum from tuberculous subjects after being exposed for six hours had not lost its infectious properties. He assumes that the ray does not possess any bactericidal effects.

The bactericidal action of the ray is generally said to be of little or no importance in the therapeutic uses to which the rays may be applied. Certain streptococci are destroyed or their growth inhibited by the rays, but, on the other hand, the ray seems to stimulate growth in certain staphylococci of pathogenic variety. When it is applied to certain conditions in which there is an offensive discharge, which is seroacrid, this is rapidly changed into an alkaline, non-offensive discharge.

Beck, Scholtz, Beauregard, Guichard, Berton, S. Brunton, Blaikie, Blaise, Sambue, Grunmach, Minck, Pott, Sabrazés, Rivière, Sormani, Wittlin, M. Wolff found that the x-rays do not influence the life of bacteria in any way whatever. Bonomo, Gros, Fiorentini, Lurashi, Frantzius, Lortet, Genoud, Muhsam, Rieder, Holzknecht and Spieler claim that they have not only succeeded in producing a destructive effect on bacteria cultures, but also in impeding and influencing the development of bacterial infections.

[1] Journal of the American Medical Association, November, 1901.

F. Berlioz[1] exposed a bouillon culture of diphtheria to the ray for sixteen, thirty-two, and sixty-four hours, injected this into guinea-pigs, and found that the action of it was not in the least weakened by the exposure.

Wade and Minck report the same result.

Potts'[2] experiments with tuberculous germs show conclusively that these germs are not affected by the ray.

This indicates that the improvement in tuberculosis of the lungs, if it does exist, is due to some other cause and not to its bactericidal effect.

J. Sabrazés and P. Rivière exposed the bacillus prodigiosus to the ray for twenty days, one hour each day, and found absolutely no modification in its action.

H. Rieder[3] reports experiments that he has made with the bacteria of cholera, typhus, diphtheria, the pus-producing and coli bacilli. He claims to have destroyed these germs by exposing them to the ray for forty-eight minutes.

Scholtz exposed cultures of various germs to a low tube daily from one to four hours without any result.

Freund says that the bactericidal effect of the rays, if it does exist at all, is so slight that it can hardly be taken into consideration; it is even slighter than that due to the electric discharges emanating from the tube.

In experimenting with cultures of pyocyaneus Holzknecht[4] noted retarded growth under exposure to *x*-rays.

Burdick, in experimenting with guinea-pigs inoculated with tuberculous sputum, found that they either showed immunity or the incubation period was prolonged several weeks when exposed to the ray. There was a complete recovery in four of the pigs, while those used as control all died.

In many pigs the disease did not enter beyond the inguinal gland, where caseation occurred.

Pigs inoculated with sputum previously exposed to ray remained in good health for nearly double the time required to cause death of animals injected with unexposed sputum.

[1] Compt.-rend. Acad. de Sci., 1896, vol. ii. p. 109.

[2] London Lancet, November 20, 1897.

[3] Münchener med. Wochenschrift, 1890, No. 4, pp. 101–104.

[4] Deutsche med. Zeitung, 1901, 15.

The conclusions drawn are, that the ray exerted an inhibitory effect, since a ten-hour exposure failed to completely kill the bacilli. Portions of culture protected by lead went on undisturbed, while in portions exposed growth was found checked.

Grubbe says that experiments on guinea-pigs are of little value when applied to man.

Rudis-Jicinsky succeeded in killing tubercle bacilli in a few seconds, when exposed to the ray in an acid medium.

Dunham, of Cincinnati, found no change in the bacilli due to the ray.

Bean has exposed cultures of bacteria for one hour at a distance of ten inches without any effect.

Seabury Allen finds that prolonged exposures are fatal to vinegar worms and protozoa.

The practical demonstration of the slight effect upon bacteria in general is furnished in the therapy of parasitic affections. In ringworm not alone are active germs of the disease to be demonstrated in the fallen hairs, but unless antiseptics are used on the surfaces treated a variety of affections due to bacteria are prone to develop in the rayed areas.

CHAPTER XVII.

EXACT MEASURES OF DOSAGE.

While it must be admitted that there still exists in the application of the ray to therapeutic purposes a lack of precision and exactitude which is greatly to be regretted, still we can to-day congratulate ourselves that haphazard conditions which existed two years ago no longer pertain. Accuracy in dosage must always be sought in therapeutic work, but in the history of medicine it has not been an unknown condition that absolute accuracy in drug-giving and physical methods has fallen short of our aim and desire. No rules of procedure formulated in the early days of ray treatment could take the place of the experience gained by the individual in constant daily work and observation. Each operator was a law unto himself, and most divergent were the views held upon the proper kind of tube, the energy by which it was stimulated into action, and all that pertained to posing and posology.

Since equally favorable results were reported from widely varying technique, one had to admit that upon the powers of observation, the caution exercised, and the skill of the individual operator depended in large measure the outcome in any given case. The ray of itself has been amply proven to possess the ability to effect results which follow each other in a regular and invariable sequence, and which will be constant for a given set of circumstances. If the factors under our control—viz., the resistance of the tube, the amount and nature of the exciting current, the distance from the patient and the time—be rendered constant, the only variable factor will be the patient, and in order to get uniform results eternal vigilance upon the part of the operator is indispensable.

A critical review of the literature of radiotherapy leads to the conclusion that there was until recently at least widely divergent views as to the dosage and duration of each individual application in the various pathological conditions which have been treated. Different authorities vary the sittings from one to fifteen, twenty, or even thirty or more minutes, and some operators expose patients for an hour. Generally, however, the tendency in the earlier days was toward long exposures, but more recently there has been noted a constantly decreasing length of séance. It would be highly desirable to secure as nearly a uniform procedure as possible for various conditions, and thus in time establish the method upon a scientifically exact basis.

In our own practice the aim has been to follow a simplified method or technique in which, so far as possible, all the factors entering into the treatment are rendered practically uniform, thus requiring little attention or observation of details aside from those relating directly to the amount of effect produced upon the patient. As far as possible the resistance, degree of penetration of the tube, the distance from the patient to the point of generation of the rays upon the anode, and the exact value of the current of excitation are so far as may be made uniform in every case treated, and where possible are measured in quantities which bear exact ratios. So far as possible, only in the length of each exposure are variations made, and these are determined largely by the result in the individual case, and in similar conditions.

To give an example: In an ideal method of procedure the diameter of the bulb of the tube is kept as nearly as possible uniform in all of the tubes in service. This ensures the distance from the anode to the point of impact upon the patient being constant when we measure the distance by the only known method, viz., from nearest point, the wall of the tube, to the patient. The tubes used are always of the same pattern, quality of glass, and internal medium. This ensures uniformity in results as far as these elements have an effect. The mode of excitation of the tube is kept constant for each case—*i. e.*, the same coil or the same static machine is used each time; if a coil be used the current in the primary circuit is carefully regulated so that the difference in potential and the exact ampèrage are kept as nearly as possible identical in each case, and the number of interruptions is the same each time; if a static machine be employed, the same machine is always used, the condition of the interior of the case is carefully noted by means of a hygrometer, and regulated to the utmost degree of accuracy, the plates are revolved at the same speed in each case, and the length of the air gap is kept constant. When the tube requires an alteration in the length of the air gap it is indicative of its having changed its vacuum, and another tube nearer the uniform standard is substituted or the same tube is regulated. Connected with the static machine there are so many obscure considerations that it is unsatisfactory when great accuracy is desired. The penetration of the tube offers the greatest difficulty that we have to contend with in maintaining a constant uniformity. To this end the penetration is measured by a standard the degrees of which are so graded that the geometric ratio between any two degrees of penetration may be satisfactorily and readily computed, so that if one tube is higher than another its exact value is known in terms of that of the other, and the effect produced is compensated for by altering the time of exposure or the distance from the patient. The use of the radiometer renders this extremely easy. The distance from the patient to the anode is kept uniform, alterations being made only when one of the other uncontrollable factors departs from the standard rendering it necessary to increase or decrease its relative value. The length of exposure is also the same in every case, variations being made when it is found necessary for the purpose of creating more or less reaction.

An example of a hypothetical case would be as follows: The tube is of the Müller pattern, self-regulating, having a hydrogen vacuum, the bulb being about 30 cm. in diameter. The penetration measured with the radiometer of lead-foil to be described, should be about eight-thousandths—*i. e.*, the fourth space should be visibly penetrated. The excitor is a coil of the Ruhmkorff type operated on any kind of current, it being understood that the conditions be the same, and at every treatment the distance from the patient being about 15 cm., or six inches.

Theoretically this is all very well and readily written, but in actual administration of rays almost every factor is in a constant state of vacillation. The energy varies, the vacuum of the tube runs up or runs down from moment to moment, and its penetrating quality changes. Since the latter is the essential element in radiotherapy, the operator must carry out processes of tube-regulation which will keep the ray at about the desired degree of penetration.

One may keep in mind the way a certain tube acts, with a certain number of revolutions of the machine, under constant conditions. It must be remembered that with every change of temperature of the room and of the tube the vacuum changes. Records of many cases kept day by day assist at formulating our procedure.

Experience teaches us that with a twelve-inch coil and a medium tube at a distance of six to eight inches with a current strength of about 3 ampères, with 110 volts, ten minutes is often required to produce a superficial dermatitis. To employ radiotherapy with satisfaction, one must be able to measure more or less definitely the quantity and quality of the ray output, or to know how to recognize the intensity of the ray in use, and be able to modify it to suit the requirements of the case. To judge of the amount of *x*-ray produced at a given time requires experience. It is well to remember as a quasi law, that the more the tube resists the passage of the current, the more will be the penetrating quality of the ray produced. Even before the introduction of more exact methods we could adopt as a useful working basis the formula:

Long Spark. Hard tube giving out penetrating, non-irritating rays.

Short Spark. Soft tube producing a surface effect and irritation.

Indeed, the simplest way of computing the vacuum is by measuring the length of spark backed up in the prime conductors, but this is not an accurate measure. Machado claims that of two sparks of equal length the deeper or thicker one will correspond to the more intense ray.

The distance of the patient from the tube, or rather from that point on the anode from which the rays emanate, will have a direct and potent influence upon the amount of reaction produced. As the rays originate in a point on the anode and radiate in every direction, the amount of rays impinging upon a given area will be inversely proportionate to the square of the distance from the anode to the surface. This is not absolutely true, since the ratio of the radius of the bulb to the distance in air from the bulb to the patient's skin will, in a small measure, influence the result.

It is impossible to measure the distance from the anode to the patient directly, but if the radius of the tube be added to the distance from its outer surface to the skin the result will be sufficiently accurate. The distance from the anode should be the same in all cases if we desire to maintain an equable standard. This distance may vary for different tubes, but should be the same for any tube for any patient. It is better to have a set distance for all tubes and cases, and vary the length of exposures wherever a change is indicated. This has been our rule of practice so far as consistent with the many varying conditions.

In measuring the distance between the tube and the patient, a very useful device is a pair of large calipers, made of two thin sheets of red fibre, such as is used for making insulating plugs, fastened by a pivot screw at one end.

In speaking of various degrees of excitation of the tube, misconceptions are engendered which make the subject seem more difficult than it really is. For every tube there is an amount of current that will excite it to its best performance, and anything over that amount will ruinously heat the tube. The expression "powerfully excited" tube does not justly convey the meaning intended and should be discarded.

The dosage in any case is regulated by the endurance of the patient, the degree of reaction that the patient shows to the ray, and the effect that it is desired to attain. For instance, if it is desired to secure simply stimulation, the dose will be smaller than when it is desired to produce inflammation, and the dose proportionally increases as it is aimed to secure atrophy or necrosis. It should be remembered that the action of the ray is very apt to be delayed until some time after it has been applied, in rare instances two to three weeks.

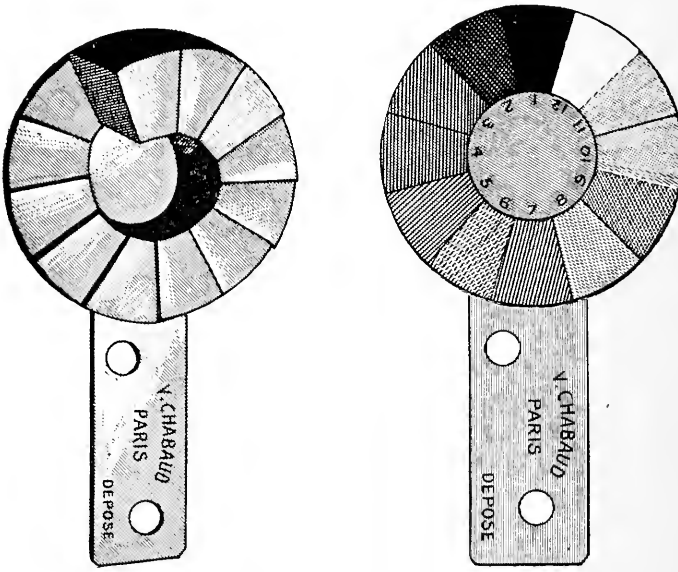
For this reason it is well to be somewhat conservative in treatment.

Radiometers. A satisfactory method of determining the condition of a tube is to observe the degree of penetration of which it is capable upon the fluoroscopic screen by the aid of regularly graded resistances. In Dr. Franklin's device these were of glass and made as follows: Strips of glass are selected, about one inch wide and varying in length from two to about eight inches by one-half-inch gradations. These strips are cemented upon each other so as to form a series of steps, each one higher than the last one by the thickness of the glass used. In the centre of each step is cemented a small piece of thick sheet copper, to act as an opaque marker. The whole is held upon the screen of the fluoroscope and exposed to the rays. The exact number of plates of glass that the rays traverse can thus be noted at a glance and a very satisfactory estimate made of the penetrability of the tube in question. At the same time an estimate of the volume and of the light may be secured.

In subsequent work Dr. Franklin found that a measure giving satisfaction could be readily constructed from thin lead and tin-foil in the manner above described, and we made one of large size to entirely cover the fluorescent screen, as well as small meters to use over a small aperture through which a beam of ray was passing. Subsequently our attention was directed to the radiometer of Benoist.

It was only on returning from the Madrid Congress that I was able to secure this instrument in Paris. It consists, as shown in the photograph, of a central disk surrounded by twelve sections of varying thickness. Thus far the idea is identical with that of Dr. Franklin, and as I have since learned of Roentgen's original skiameter, of basing a measure upon the unequal degree of penetration of the ray. The metal forming the steps is aluminium of gradually increasing thickness; the central disk is of silver and serves as a basis of comparison, the aluminium step which corresponds to the penetration of this disk being the one recorded. Dr. Stern has improved, I believe, upon the instrument since we have had it in use by placing in the centre of the third, sixth, and ninth divisions a small lead-foil strip to serve as opaque marker. This enables one to see at a glance during the séance just which thickness is penetrated. This can be calculated in known terms, since each thickness is one millimetre greater than the last, ranging from 1 to 12. We have found it better in using this, as well as our own meter, to place it in the beam as it emerges from a constricted opening in a protecting screen, so that the outside rays and brightness of the fluoroscope do not confuse the eye.

Fig. 85.



Benoist radiochromometer.

A convenient plan is to attach the instrument to the margin of the fluoroscope, as shown in Plate I.

Monell has invented a gauge for the measurement of the penetration, consisting of "a plate of lead sandwiched between two plates of brass, making a solid metal base six-sixteenths of an inch thick. This base is made larger than the screen so as to exclude all rays excepting those passing through the window. In the centre of the base is cut a round window three inches in diameter. Four wires next make a cross-base at right angles to the window. External to the window are twenty shutters of 28-gauge B. & S. sheet brass stamped and numbered. The set of shutters is swung on a pivot, so that one at a time can be cut out from interference with the rays or inserted as desired. Each shutter is four inches square and a set-screw on the pivot permits shifting them to suit."

This is a very efficient apparatus, and with its aid the penetrating power and defining power of tubes may be measured. The disadvantages are, first, the cost; second, the weight, which renders handling unnecessarily inconvenient; third, the operation of testing any tube is long and requires the continual adjustment of the shutters until the desired number is attained.

Our own device or that of Benoist gives the same results in a much shorter time and more conveniently.

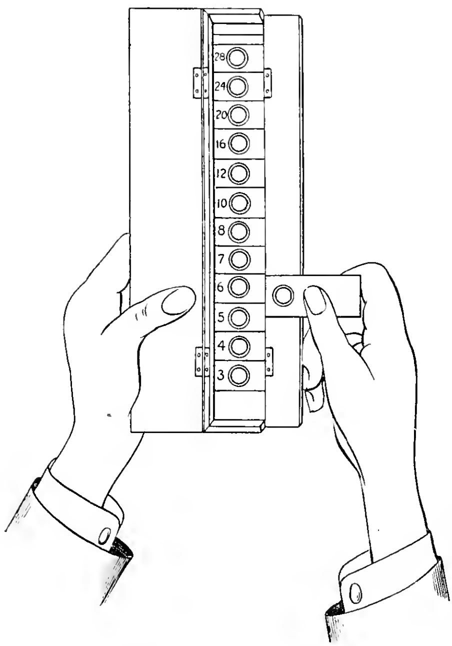
Another form of apparatus devised by Dr. Franklin for the measurement of the definition and penetration of tubes consists of a sheet of fibre such as is used for electrical insulations, on which is pasted a number of sheets of lead-foil, each, excepting the first, having a slit one inch wide and one-half inch longer than the one preceding it in length. In the centre of the fibre base is a slot in which is placed a lead wire such as is used for fuses, and it should not be smaller than a 50-ampère fuse. In the centre of each of the steps made by the different lengths in the slots in the foil sheets is glued a disk of foil one-quarter inch in diameter and one-sixteenth inch thick. The number and thickness of sheets, the length and width of the steps, are matters depending on the size of the fluoroscope to be used, the fineness of the graduations desired, and the inclination of the maker. The whole may be attached to the base of the fluoroscope by means of small screws in the corners, or by brass spring catches.

In using the apparatus the tube to be examined is regarded through the fluoroscope, and the number of steps or disks that may be seen mark the penetrative power of the tube, which may be compared with that of any other tube. Thus, if with any tube ten of the disks may be discerned, then the penetration of that tube may be spoken of as ten, etc., the exact ratio of the penetration of a tube which will show twelve disks to the one showing six will be as 2 is to 1, or twice the penetration.

In the Crookes radiometer the vanes are painted with some phosphorescent substance which glows when the electricity causes them to rotate.

HOLZKNECHT'S CHROMORADIOMETER. In devising this measure for the quantity of ray absorbed the originator based

FIG. 86.



Holzknecht's chromoradiometer.

the instrument's construction partly upon the law of Kienböck, that the degree of reaction in the skin depends essentially upon the quality of the ray and partly upon the ray's power to change the color of certain salts.

His studies led him to the knowledge that what the cathode rays did for the surface the Roentgen ray could do for the whole mass of such a salt as bromide of potassium —*i. e.*, color it blue just as common salt is colored yellow.

During the exposure of a patient one of the disks shown in the figure is held upon the rayed surface, being removed at frequent intervals to compare it with the control scale of colors (Fig. 68), which bear arbitrary numbers from 3 to 28. By experiment and experience it has been found that certain degrees of coloration in the test disk correspond to the quantity of ray absorption which usually results in definite physiological change in the tissues or the production of distinct influence upon normal or pathological states.

Holzknecht finds that the difference between the absorbing properties of the skin of youth and old age corresponds to that between the numbers 3 and 4 of his scale. Flexor surface requires 4 to 6 units, extensor 5 to 7, as do also the palms.

In order to cause a reaction going on to superficial erosion, 5 to 7 numbers must be reached for the one class of surfaces, 7 to 10 for the other. Going beyond 10 units will probably result in ulceration.

Kienböck[1] demonstrated that for a given quality of *x*-rays the degree of intensity of the resultant dermatitis will depend essentially upon the quantity of rays striking the skin. That is to say, it will depend upon the quantity of rays which are absorbed by the skin. In order that a given surface of skin should absorb rays equally over its whole extent it is necessary that the surface should be concave, and this is rarely or never the case, especially as it would be necessary for the concavity to have its centre exactly at the point of emission of the rays at the anode. The surfaces treated are generally plane or convex, and thus the rays striking at any part will be less than at the point falling in a perpendicular line from the centre of the anode, and the decrease in the rays will be proportionate to the distance from this line and to the amount of convexity of the surface, and inversely as the distance from the tube to the surface of the skin.

The chromoradiometer measures the exact quantity of rays which impinge upon and are absorbed by a given tissue in a given length of time. The radiochromometer of

[1] Wiener klin. Wochenschrift, 1902, No. 50.

Benoist measures the quality of these rays. By combining these two instruments the exact dosage of the rays can be measured with very great accuracy, even as the spectroscope in connection with the photometer will measure the exact quality and quantity of light rays. The chromoradiometer is made up of a series of reagents in connection with a graduated scale. The scale is made up of twelve chemicals of the same color, having a bluish-green value, and increasing in intensity from one end to the other. Each division carries a number, which signifies its value in relation to the others. In using the apparatus the test reagent is placed upon the skin close to the part to be treated, and is compared at frequent intervals with the scale. When it is seen that the reagent has assumed a color equal to one of the graduates of the scale, the number corresponding with that color is taken as a standard, and when the same effect is desired at another time the exposure is continued until the test reagent assumes the same color as in the former case. The utmost care is necessary in the handling of this apparatus, as it is found that the slightest exposure to the cathode or x-rays changes the value of the reagent, and for this reason the reagent is kept in a hermetically sealed and ray-proof box while not in use.

At the present time there are no standards set for all cases, and the greatest use of the instrument is to produce uniform effects in a series of treatments of the same case, but it is to be hoped that in the near future there will be tabulated exposures and quantity reactions corresponding to different diseases, ages, complexions, physical conditions, and all other elements entering into a case. By means of this reagent the therapeutic activity of the different radioactive substances which are now creating so much interest may be determined and compared.

By employing several disks simultaneously the test might be used to determine upon which area of a given surface exposed the action is most intense. The frequency of removal of the disk for comparison during a short exposure makes the method somewhat troublesome, and the exact shade produced is not always readily determined.

Guido Holzknecht presented his instrument in Berne, on

September 4, 1902, at the Second International Congress of Electrotherapy and Radiotherapy.

It had been the discovery by Goldstein that certain salts became colored when exposed to the cathode rays, while their phosphorescence increased, and this led Holzknecht to devise his chromoradiometer, finding that the same changes took place when the salts were exposed to the *x*-rays.

Sodium chloride was found to turn yellow, while potassium bromide turned blue, but while the cathode rays affect only the surface of the salts the *x*-rays penetrate and color the entire mass, and at the same time he found that the intensity of coloration was proportional directly to the amount of rays absorbed in the mass. He fails, however, to mention the exact strength of the solutions of these salts which he used.

Exner,[1] in employing the chromoradiometer, notes the figures on the scale corresponding to each test disk, and adds them up as they accumulate from day to day, while the desired therapeutic result is being obtained; the total thus reached indicates the amount of rays the patient has received during the whole course.

The application of these radiometers appears on paper to approach scientific accuracy. In actual practice it has seemed to me that the human element comes in for a large share in the result arrived at. When the eye of the operator has become sufficiently educated to detect the slight shades of difference in the disks as compared with the colored scale, it is probable that the eye, in common with his senses in general, will enable him to detect by other means changes in the quantity and quality of ray he is producing. Thus, the greenish light within the tube indicates by its intensity in a manner the amount of *x*-ray incorporated with it. For the employment of the chromoradiometer especially time and practice are required, but these factors also permit one to become quite expert in estimating the quantity and quality of ray with the aid of such other means as we have enumerated. There is no doubt, however, that these devices are of great worth and have been worked out in the proper

[1] Wiener klin. Wochenschrift, June 18, 1903.

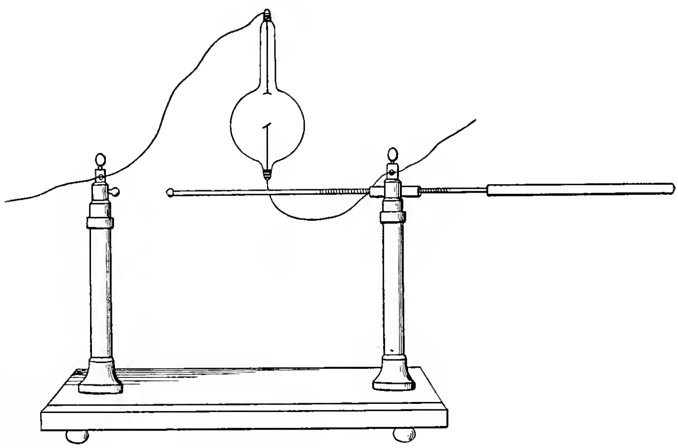
spirit of investigation, and lead, indirectly if not directly, to better knowledge of how to regulate and control our use of this wonderful power. We must bear in mind the length of time required to carry out this color test, and that sittings may become so reduced in time that the treatment will be finished before the quantity of the dose has been determined.

Theoretically, there would seem no reason why, by approaching the source of ray, the time should not be diminished considerably. It is well established that the intensity of any ray varies inversely as the square of the distance of the surface operated upon. Thus the effect of a tube at different distances can be calculated. For example, the difference in exposure for a tube placed at twelve inches as compared to that for one placed at three inches varies directly as $144:9 = 16$ times as long. Hence, there would be some justice in the claim that an exposure at three inches need be only very brief. Looking on the opposite side, long exposures at great distance would fall far short of the requirements and could not be expected to secure brilliant results. In exposures of an hour at six feet, for instance, the effect would be as compared with six inches, 144 times less. Thus, as compared with a five-minute sitting, such an exposure should be of twelve hours' duration.

Beclere's Spintherometer. On a recent visit to the laboratory of Prof. Béclère in Paris, an opportunity was graciously afforded me to see in use the various instruments of precision, the utility of which this gentleman has done so much to bring before the profession. Among the various devices was his own invention for measuring the changes from moment to moment which occur in the vacuum of the tube, and hence in the penetrating quality of the ray, by indicating the resistance offered by the tube to the current. It is a matter of observation that with a given tube connected with a generator of electric energy, a constant relation is established between the resistance which is opposed to the passage of the current through the tube and the penetrating value of the rays produced. This point has been presented in a variety of ways in various portions of this work, but it is of sufficient importance to bear repetition.

To measure and note this resistance at a given sitting so it can be utilized in another, by regulating the tube, Béclère devised an instrument based on the fact that when in action the spark which fills the air gap between the two poles at the precise moment the body of air which separates these poles ceases to oppose to the passage of the electricity a resistance greater than that existing at the moment in the interior of the bulb. This is a short circuit and follows the well-known law that electricity will flow in the path of least resistance. The instrument devised to measure this spark equivalent to the resistance consists of a long metallic rod marked off in centimetres and half-centimetres, ending

FIG. 87.



Béclère's spintherometer.

in a metallic ball at one extremity and having at the other an ebonite handle. This rod moves through a groove mounted on an isolated upright. The second ball is fastened to another isolated upright at about 25 cm. distance. The sliding bar and the fixed ball are placed in circuit by attaching each to the respective poles of the static or coil on the one side and with the poles of the bulb on the other. On starting the current the bar is drawn out until the spark no longer jumps the air space between the bulb, when the distance in centimetres can be read from the marked rod.

If it indicates too great or too little resistance in the tube, it can be lowered or raised to meet the requirements if the tube is, as it should be, one susceptible of regulation. This has the disadvantage that it gives the result by a secondary deduction, as it does not directly measure the penetrability of the rays, which latter depends upon other factors besides the resistance of the tube.

Exometer. Buguet has devised an apparatus thus named for determining the fluorescent quality of the ray in comparison to units of candle-power.

Actinometer. This is a small screen in a box arranged with two rows of circular disks, ten in each row; these are made of tin-foil punctured with holes so that any number of layers can be brought before the screen and tube. Since one set of disks is ten times as thick as the other, the penetration can be accurately determined. The amplitude or quantity of ray is not indicated any more than it is in the device of Benoist or other similar instrument.

Fluorometers. Williams has devised an instrument for measuring the amount of rays given out by the tube. A description too long for reproduction will be found on page 640 in his excellent book.

Stern's Photoradiometer. This has for its fundamental principle the action of rays upon photographic films. It has been devised by my associate, Dr. Stern,[1] and it offers a method for measuring the quantity of ray penetrating any particular surface. It is very simple, easily carried out, does not require any elaborate apparatus, and, I believe, is thoroughly accurate. It is based upon the fact that the effect produced by light on a sensitized surface is in direct ratio to the intensity of the light rays to which it is subjected and the time of exposure. These two make up the amount or quantity of light affecting this surface.

The preponderance of evidence at the present day seems to favor the theory that the *x*-rays consist of very minute wave lengths of light vibrations. This seems to be substantiated by the fact that they possess a great many of the qualities of light. Among these one of the most important

[1] Journal of Cutaneous Diseases, December, 1903.

is its ability to affect photographic plates in a very similar manner to that of ordinary light rays.

We all know that in taking radiographs the darkness of the picture will depend on the quality of the ray, the length of exposure, and the distance from the plate; these combined making up the quantity or exact amount of rays passing through the sensitive plate. If it is conceded that the changes produced by light on a photographic film are in proportion to the length of exposure and the intensity of the light-waves acting upon it, and if we can further concede that the supposition of the *x*-rays being a form of light is correct, it is evident that the same principle which enables us to judge the amount of light rays by its effect on a photographic film could be utilized to measure the quantity of *x*-rays emanating from any particular source. Most authorities admit that the effect of the *x*-ray is exactly proportional to the amount absorbed, whether it be by a photographic plate or the vital human tissues. It is a very simple matter to put a piece of sensitized paper directly upon the surface to be treated, so that the rays will pass through this film before they enter the parts. The film will not diminish the intensity of the rays in any noticeable way, and will accurately register the exact amount passing through it. This can be readily judged by the depth of discoloration on the film, which, compared and marked with a corresponding number of an established standard scale, will give the quantity of rays in numbers easily put down for future reference or to be computed. A scale may be established by using a certain standard film and exposing it at a known distance from a tube of definite vacuum, in which the rays are generated by an apparatus of an established spark length, running at a known amperage. If we expose a film for each successive minute under the above conditions, numbering each with the number of minutes exposed, until the film is completely black, we possess a standard for future comparison. This standard may be printed on every film used, so that the discoloration on the film as the result of the exposure may be readily compared and marked with its corresponding number. These numbers may be added, the sum total giving at a glance the amount of rays the patient has received. The films can be enclosed in black envelopes, so that they may be handled without being affected by ordinary light. Their developing requires only a few minutes, and may be done at any time after a number of films have accumulated. The chief difficulty has been found in getting a photographic film which will answer the purpose. The majority of films act too rapidly, becoming black after a few minutes' exposure, so a special film has to be used which is not rapidly affected. If such a standard could come into universal use, it would facilitate the accurate dosage and would give a better understanding of reports of cases by different observers. It is quite probable that the same method could be utilized in measuring the effective activity of radium.

Exact methods of dosage should include blood examination as a test of efficacy of the treatment; a decrease in the polynuclear leukocytes during treatment should cause apprehension.

Freund[1] proposes a radiometer based on the chemical power of the rays to liberate iodine in a solution. He uses a 2 per cent. chloroform solution of iodine, which retains the color in the dark, but changes its tint rapidly under the influence of the *x*-rays.

This change in tint is a purely chemical oxidizing process capable of mathematical demonstration. Test-tubes 1 cm. in diameter are filled with 5 c.c. of the solution, and after six minutes of exposure to a medium soft tube—an intensity corresponding to that required for fluoroscopy of the thorax of an adult at a distance of 1.5 metres—he found that 0.59 mg. iodine was liberated. This imparted a distinct purplish tint to the fluid. This is his unit. The test-tube, wrapped in black paper, is placed alongside the exposed surface.

[1] Ein neues radiometrisches Verfahren, Wiener klin. Wochenschrift, 1904, xvii., No. 14.

CHAPTER XVIII.

MEDICOLEGAL ASPECT OF THE X-RAY.

Almost as soon as the *x*-ray was discovered and experimenting with it begun, the fact was made patent that it possessed the property of causing injuries of varying degrees of severity to certain tissues of the human body. In fact, as early as April, 1896, accidental alopecia was reported by Dr. John Daniel, and from that time onward until the usage of the ray had assumed a more scientific aspect, accidents ranging from a simple erythema through all degrees of "burn" to deep sloughing, precancerous keratosis, and carcinoma itself, have been recorded. It is not difficult to understand that patients who had applied to the surgeon to have obscure internal conditions diagnosticated by means of the ray should have suffered from burn in the early days, when through lack of perfection in the then existing apparatus very long exposures were made necessary.

The improvement in apparatus has rendered possible exposures so short in comparison, as to almost warrant their being called instantaneous. As could have been anticipated, numerous suits have arisen in which damages have been claimed from the ray operator for injuries resulting. The medicolegal value of the *x*-ray as evidence in the courts was first recognized by the Supreme Court of Nebraska. In the case of the City of Geneva *vs*. Burnett it was held that, under proper precautions and with necessary explanations, what are known as "*x*-ray pictures" may be used as evidence to show the condition of the internal tissues of the body. The complainant brought suit against the city for injuries to the ankle due to a defective sidewalk.

Medical witnesses testified that in a young person, as was the party suing, a result of the injury might be a calcareous deposit, and that they had examined the foot of the plaintiff and had made skiagraphs showing the presence of such deposits, and that in their opinion the deposits were the direct results of the injury. Some of the pictures were admitted in evidence. The defence objected on the ground that they constituted secondary evidence and as such were not admissible. The pictures were accompanied by a very thorough and complete explanation of the time, manner, and circumstances under which they were taken and the condition they indicated to the medical mind. The case was decided in favor of the complainant. Under appeal the Supreme Court sustained the ruling of the lower court, being convinced that no better evidence of the interior condition of the injured member could possibly have been obtained without surgical operation, to which the party suing was not called upon to submit.

Undoubtedly in many cases no better evidence can be brought forward than that of an *x*-ray picture, and it must be taken into consideration that though the ray puts us into possession of a marvellous method of determining the conditions existing in the interior of the body, it is subject to many grave inaccuracies and may lead to very erroneous conclusions. In the case of a foreign body, such as a bullet or needle embedded in the tissues, a single picture is of little value in indicating the position in more than one plane, and consequently may be of no worth as evidence in a court of law. Two exposures should be made, either by means of a stereographic apparatus or they should be made separately and be viewed in a stereoscope. By this means the exact location of the foreign body in any plane may be determined. In the case of certain oblique fractures, if the picture is taken from one side, it may entirely fail to show any abnormal condition of the bone at all; but if it be taken in such a way that the rays travel in the plane of the cleavage, the fracture will be clearly revealed. It is of very common occurrence since radio diagnosis came into vogue that a supposed sprain of the ankle turns out to be a fracture.

Upon a recent visit to a friend in France, I found him limping badly from the effects of a "sprain," which had occurred three months previously. I advised a skiagraphic examination, predicting that a fracture would be found, and such it turned out to be. On the other hand a supposed fracture of the malleolus has been demonstrated by the ray not to exist, and the symptoms have been explained in damage suits as due to "hysterical joint," such as occurs in traumatic neuroses and neurasthenia. In another instance, mentioned by Rudis-Jicinsky,[1] a supposed psychic trauma due to a railroad accident was found to be a fracture of the astragalus.

Interpretation of Radiographs. To be able to definitely recognize the condition of the tissues shown in the radiograph is one of the most difficult as well as important points in connection with the use of the rays in the diagnostication of disease. Grave errors have been made in this direction, and the tendency that has been manifest from the first, to regard the ray as a means of certain and plain detection of the condition existing in the tissue radiographed, is responsible for the wide adoption of the method by men who are in no way fitted either by education or experience to properly use it. The radiograph may be likened to notes written in shorthand; they may contain a sure and accurate record of what has been impressed upon the ear of the stenographer and transmitted to paper, but at the same time it is not always an easy matter to read and translate these stenographic symbols so they can be read understandingly by everybody.

The peculiarities of the rays must always be taken into consideration; that they undergo no refraction within the body; that they are propagated in straight lines, and therefore will produce images which are larger than the original, and that this distortion of the picture will increase in a certain mathematical ratio of the distance from the plate and from the central rays of the tube, and as the distance of the tube from the plate; that the rays will give only a shadow of the object, and that these shadows may be confounded with those of other objects in the body which may be very far in one direction or another from the object that it is supposed to represent. All of these errors may be of very serious import, and are to be as rigidly avoided as the development of the science will permit of at the present time.

[1] American X-ray Era, June, 1903.

Misleading interpretation of skiagraphs has been illustrated in a number of instances, such as in exploratory laparotomy, in which the expectations raised by the radiophotograph were not realized.

The readiness with which one may fall into error is well shown in the report of Dr. Crile.[1] A patient was believed to have swallowed a set of false teeth. He attempted to remove them himself, and probably succeeded, but mistaking the hyoid bone for a remaining portion of the plate continued his efforts until laceration occurred. It was finally believed that the teeth had been carried along the œsophagus. An examination with the *x*-ray revealed a heavy shadow at the lower portion of the œsophagus. This led to an exploratory operation, which showed that the œsophagus was empty. Post-mortem examination indicated that the *x*-ray shadow was caused by extensive calcification of the abdominal aorta.

In skiagraphic work which is at all likely to enter into suits at law, the most careful records should be kept of the conditions under which the work was done, with full description of technique, so that a just estimate may be formed of the value of the evidence which attaches to the radiophotograph presented in evidence.

The judge and jury should bear in mind the great necessity of a knowledge of anatomy, and the relation of parts on the part of the operator. This knowledge should embrace not alone anatomy as previously taught, but living anatomy as it is to-day so much better known—in what we might call the science of radioanatomy.

Photographs have for a long time been received in evidence when they represent something concerning which a witness can testify as to the truthfulness of representation. This applies also to the radiophotograph, which is from the legal standpoint a "photograph," and as such takes its place as legitimate evidence of an existing condition, provided a competent witness testifies that he saw the process of its production and that it is a truthful representation of the condition which it is claimed to represent. The skiagraph is not looked upon as necessarily showing the condition of

[1] Cleveland Medical Journal, December, 1902.

parts or objects as they really exist, excepting as witness is borne to the manner in which the skiagraph was made, by one whose acknowledged skill in these matters gives weight to his statements.

According to the *Medicolegal Bulletin*, the witness to be of the most value must be the one who took and developed the plate or was a witness at the exposure or developing of the same, for, unless he knew the plate and the print from it to be the result of the exposure to the *x*-rays of the particular subject, his testimony would be useless.

It is always well to place some identification mark, such as a metallic initial, over the object to be radiographed, so that it will appear in the plate and print, enabling the operator to testify that the plate was the identical one he exposed. On the whole, the skiagraph thus fortified offers the best evidence obtainable of hidden conditions aside from their exposure by operation. This form of evidence has received the approbation of some of the higher courts of Massachusetts, Ohio, Nebraska, Washington, and Wisconsin.

Suits for Damages Caused by X-rays. A case in point is that of McDonald *vs.* Shields and Jernigan and O'Connor. The plaintiff was a young woman who had consulted Nelson F. Shields and George F. Jernigan, dentists, in June, 1897. She was then suffering from a disease of the jaw, and the defendants advised an *x*-ray examination as the only means of determining the exact condition present. The plaintiff consented and accompanied Shields and Jarnigan to the office of O'Connor, who made a personal examination of five minutes' duration and took two skiagraphs, requiring respectively eleven and eighteen minutes. The plaintiff testified that she had felt intense pains over her face and shoulder in a day or two thereafter and that she found she had been badly burned. Experts for the complainant testified that the exposures had been of too long duration, and that it was inadvisable to everexpose anyone for more than thirty minutes, and that from five to ten minutes was sufficient in most cases. Numerous experts for the defence declared that the operator, O'Connor, was an able and competent man, that he had used every precaution, and that he had done the best that could be done in the state of the science as it existed in 1897. Other expert witnesses testified that the exposure was perfectly proper and that at that time burns might easily occur and were unavoidable. The complaint was dismissed by Justice O'Gorman, of the Supreme Court.

Dr. Mayer[1] has mentioned a case in which the question of fracture or tuberculosis of the hip-joints came up. There had been an injury with pain persisting for three years, when an impacted fracture was shown, tuberculosis developing subsequently.

In the case of Shelly *vs.* Dr. G. W. Spohn,[2] of Indiana, the Circuit Court decided in favor of the defendant. Dr. Spohn had treated Shelly for a cancerous growth on the under part of his tongue. The patient was told of the possibility of a burn, and consented to the treatment. After a slight dermatitis developed on the patient's face the treatment was discontinued. He brought action for malpractice, claiming $10,000 damages for injuries to his face and hand.

The Supreme Court of Nebraska has rendered a decision in the malpractice suits of Carlson *vs.* Benton and others.

To constitute a foundation for the introduction of the radiograph in evidence, it is not essential that it appear that it was taken by a competent person, nor that the condition of the apparatus with which it was taken and the circumstances under which it was taken were such as to ensure an accurate picture, provided that it has been shown by the evidence of competent witnesses that it does truly represent the object it is claimed to represent. Where the evidence as to the accuracy of the radiograph leaves no room for a difference of opinion, its exclusion on the ground that a sufficient foundation has not been laid is an abuse of discretion. Such was the Court's ruling in the case above mentioned. A radiograph of the leg taken after an injury was shown by witnesses to be an accurate picture.

That the evidence furnished by the *x*-ray has become indispensable in many legal cases there remains no longer any doubt. The feature of this method of examination has

[1] Lenox Medical Society, 1902.

[2] Review of Reviews, April 25, 1903.

been brought out by Brautlecht, of Bremen, who has experimented with inorganic poisons in the human system, finding the ray of decided aid in furnishing confirmatory evidence to that of the more tedious chemical analysis. Such poisons as arsenic, bismuth, mercury, antimony, copper, and their combinations being opaque to the light and of heavy atomic weight, throw a shadow which will prove of great advantage by way of demonstration in judicial investigations.

The use of radiophotography in this connection must, however, be considered in the nature of preliminary investigation. Naturally the quantity and the nature of the poison in the tissues could not be determined by this method in the present state of knowledge.

CHAPTER XIX.

VARIOUS USES TO WHICH THE RAYS HAVE BEEN PUT.

Locating Stolen Coin. A curious use to which the rays have been put by the Japanese government has recently come to light. It appears that dishonest mint employés had been in the habit of swallowing coins and thus avoiding discovery at the customary examination at the close of the day. Examination of the guilty parties revealed the coins resting in their stomachs, and so successful were the first trials that the government is said to have ordered a complete apparatus for each mint.

Anthropometrical Signalment. Among other curious devices for utilizing the ray, Rolands has designed an apparatus for making exact measurements of the bones of criminals. It possesses the advantage over hand measurements of having a wider range and greater accuracy

The X-ray in Examining Candidates for Life Insurance. The radiographic examination of the internal organs is of great importance in examining for life insurance, especially that of the thorax, as it permits one to estimate the dimensions of the organs and often enables one to recognize conditions that would perhaps escape every other kind of examination. The greatest value of the method appears in cases of suspected tuberculosis of the lungs, in hypertrophy of the heart, and in aneurysm of the aorta; in suspected stones of the kidney and bladder or in any suspected foreign bodies in any part of the body. It could always be used with advantage when the risk is large and when the candidate is to be examined by two physicians.

Applications of the X-ray to Experimental Study. One of the most interesting uses to which the ray has been applied is the study of the movements of the intestines of different animals. This was first accomplished by Cannon in 1898. The experiments were confined to cats and other small animals, and the method of procedure was as follows: A proportion, varying from one-tenth to one-third of subnitrate of bismuth was added to all of the food taken by the animal. The animal was kept without food for one whole day, and then canned salmon with the proper amount of bismuth subnitrate was fed to them. When the desired time had elapsed the animal was examined by means of the rays, the position of the bismuth subnitrate being readily seen in the alimentary tract, and the movements of the intestines could be studied.

The ray has been introduced into a field of utility in mapping out hollow organs such as those of the alimentary canal, the trachea, œsophagus, stomach, etc., and in studying peristaltic action.

In the study of topographical anatomy and physiology in both animals and human beings, metals of heavy atomic and great specific weight have been utilized. Bismuth is the substance most generally employed in methods of localization, in the digestive tract especially.

F. Lommel[1] has experimented on dogs fed with chopped meat mixed with bismuth to study peristaltic action. Among other interesting findings is that peristalsis is long delayed by emotions, or the psychic factor, and he believes his demonstrations indicate that the human stomach is capable of being more influenced through the psyche than by any of our therapeutic measures. Two minutes after ingestion of milk, if the animal was not annoyed, rhythmic wave motions could be seen by the aid of the x-ray in the greater curvature.

In determining cases of still-birth, Walsham has found that when a child has not breathed the lungs are opaque to the ray.

The Determination of Death by X-rays. Professor Ottolenghi, of the University of Siena, has "discovered that, while it is easy to apply the rays to the lungs of a person who is alive or in a trance, it is extremely difficult, indeed, practically impossible, to apply them to the lungs of a person actually dead." The reason is that some intervening

[1] Matthes' clinic, Jena.

obstacle prevents the rays from penetrating into the body. He has repeatedly made a test of this kind, always with the same result. Professor Ottolenghi therefore suggests that, as this test can easily be made by any practitioner, it should in future be employed in all cases where there is any doubt of the reality of death.

PART IV.

LIGHT.

CHAPTER XX.

THERAPEUTIC INDICATIONS FOR THE EMPLOYMENT OF LIGHT.

INTRODUCTION TO ACTINOTHERAPY.

All judicious practice should be based upon theory, and the use of light in phototherapy is no exception to the rule. It is here, as elsewhere, often difficult to make theory and fact agree.

In order to have a just appreciation of the wonderful discoveries in light science of recent times as it bears upon therapeutic application, it is necessary to pass briefly in review the various theories advanced concerning the nature and transmission of light. We must even go a step farther and review the physical and chemical properties of light and its effects upon organic life.

THEORY OF LIGHT.

Up to three centuries ago little advance had been made in the science of optical physics. Image formation from reflecting surfaces was a phenomenon obviously familiar in most ancient times, the cause of which was sought by the earliest scientists. That burning-glasses were in use quite early is shown by the writings of Pliny and others, who mention heat production and ignition by means of globes filled with water and exposed to the sun. Aristophanes speaks of burning-glasses in use prior to 420 B.C. The laws of rectilinear propagation and reflection were known to Plato and his followers, but Ptolemy seems to have been the first of ancient philosophers to treat of refraction. It was only as late as 1621, after Vitellio had improved upon Ptolemy's table of angles of incidence and refraction and Keppler had worked out the laws of lenses, that Snellius evolved the law of sines, establishing the relation of the angle of incidence to that of refraction. Snell's law is "the ratio of the sines of the angles of incidence and refraction are constant for any two media." Up to 1666 refraction was held responsible for colored light. Newton made at this time the very important discovery that white light is composed of various colored rays which could be separated by a refracting prism. Ten years later Römer inaugurated a new era by showing that light consumes time in travelling. It was only, however, as late as 1849–50 that the actual velocity could be ascertained by instruments invented by Fitzeau and Faucault. When penetrating atmospheric air this has now been found to be about 186,600 miles per second. The wave theory of light developed between the years 1678, when Huygens first stated his belief definitely, and 1690, when he published a satisfactory explanation of reflection and refraction, based on the theory of light being due to wave motion in ether. It was only, however, after Young's brilliant discovery in 1801 of interference of light that the wave theory began to apppeal strongly to the scientific world. The greater number of the obstacles surrounding the wave theory were removed when Fresnel directed attention to Hooke's previous assumption that the direction of the vibration was transverse to the direction of the ray and not in that of its propagation. The corpuscular theory of light which has recently been revived by discoveries in connection with radium has been for years in almost universal disrepute, although there are many really convincing points in its favor. This theory, popularly attributed to Newton, is known at least to have had his ardent support. Preston, in his "Theory of Light," in speaking of the emission theory, says that the objections raised against it might be met by certain fundamental postulates. "These necessary postulates endow the corpuscles with the periodical characteristics of a wave motion, and when this is introduced the corpuscles themselves may be eliminated, for the wave motion alone sufficiently explains the phenomena."

We cannot enter upon a lengthy discussion of the various media whose existence have been assumed in connection with the wave theory. Many facts in science point to such a medium, but from the time of the "pellucid" of Aristotle down through the ethers of Newton, Descartes, Pardes, and Huygens, various speculative hypotheses have had to be advanced regarding its nature and properties. To cover certain difficulties of the "elastic solid" theory, Greene assumed an ether which was incompressible. The "fluid ether" of the ancients could not be accepted, since such would be incapable of transmitting transverse waves, offering as it does no resistance to distortion. Preston thought the theory offering the most promise was that which regarded the ether as a turbulent fluid.

The emission theory supposes that a ray of light travels faster in a denser or more refracting medium, and the wave theory assumes the reverse. The experiments of Faucault and the exact measurements of light speed in many media have conclusively demonstrated that light travels more slowly the more refracting the medium, and these proofs are taken by some to be the crucial points in settling the controversy. Also it can be mathematically demonstrated that refraction is caused by retardation of the ray in the denser medium, and Snell's law gives the proof of this.

The interesting fact which has been established, that electricity and light both travel at about the same enormous rate of speed (186,600 miles per second), suggests the possibility of an identity of action under certain conditions.

In much of the therapeutic work accomplished, both by the Roentgen and the actinic ray, electricity is in intimate association with the light produced in most forms of apparatus, and, indeed, the question has arisen whether certain therapeutic and other results obtained might not be due to the influence of electricity.

I am not now speaking of the theory that light and electricity may be interchangeable terms, and that the action within an x-ray bulb is electric. It is well known that Thomson has succeeded in measuring the speed and weight of the mass of the "corpuscles" which go to make up incandescence within the x-ray tube, although individually they are believed to be the smallest things in the world. He calculates the velocity of the corpuscles in a Crookes tube at 10,000 miles per second.

While the visible colors of the spectrum may be roughly estimated in wave lengths of five hundred billions per second, the ultraviolet approximate two trillions, the Becquerel rays having still a higher number and the x-rays the highest of all.

THE SOURCE OF LIGHT.

A substance is regarded as luminous when it will emit from its own energy transverse rays from 638 to 330 μ in length. There are two main types of light to be considered, depending upon the amount of heat as the source of its energy; that is, cold light when the luminous material is of a low temperature and warm light when this temperature is higher.

The cold light (luminescence) is divided as regards its source into those (1) where the chemical energy is the source (chemiluminescence); (2) where the source of light is derived through friction (triboluminescence); (3) where the light is derived from crystallization of various substances (crystalluminescence); (4) where the source of light is produced from electric energy (electroluminescence); (5) where light of other wave lengths acts as the source, such as phosphorescence and fluorescence of various substances (photoluminescence).

A light which will appear below the glowing heat is called thermoluminescence.

In contradistinction we have the glow light, which only becomes luminescent at very high temperatures. At a temperature of 525° C., aside from its heat rays, substances begin to emit waves of a shorter wave length than 683μ;

that is, they begin to emit light rays. The length of these waves gradually increases, producing red heat.

If the temperature is increased, the waves gradually grow shorter (yellow heat); on further increase we find that all the light rays will be represented, giving the effect of white heat, and after this the higher we raise the temperature the more rays of shorter wave lengths will be emitted; that is, the higher the temperature the more violet and ultraviolet rays will be given off.

Phosphorescence. The difference between this and fluorescence must be clear in our minds, since the terms are so commonly employed. Many phosphorescent substances exist in nature, such as the sulphides of barium and calcium. Some substances retain their phosphorescence a long time, others for only a minute portion of a second. Radium mixed with sulphide of zinc causes the latter to phosphoresce practically for an indefinite period.

Many substances undoubtedly retain by night phosphorescence imparted by the sun during the day; thus snow, clouds, etc., may phosphoresce in this way.

A radium salt of 240 activity is now furnished which has a phosphorescence of its own; other combinations of the salt have an acquired phosphorescence; that is, they become incandescent in a dark room after exposure to light.

Fluorescence. This differs from phosphorescence in the light emission persisting only so long as the fluorescent substance is stimulated by the source of light. Among fluorescent liquids may be mentioned æsculine, petroleum, quinine, eosin, safranin, thallin, and many others which present beautiful color changes when stimulated by light waves of certain lengths.

Luminescence. This is the term suggested by Wiedemann for the phenomena of fluorescence, phosphorescence, and other light emissions not attended by heat waves, flame, etc.

Radioactive Substances. These differ from the phosphorescent by giving off light from their incipiency which persists, and they differ from fluorescent substances whose light-giving qualities are still more fugitive and necessitate stimulation.

CHAPTER XXI.

THE PHYSICAL PROPERTIES OF LIGHT.

LIGHT travels through ethereal substances at a rate of 300,000 kilometres per second.

The effect of luminous rays thrown in all directions from the source of light we call illumination, and the long, straight rays running in any particular direction we call the light rays. So we see that the amount of illumination derived from a source of light will equal the amount of light rays that it emits.

The various light rays are differentiated from one another as regards their quality and quantity. Most of the light rays are made up of a combination of various wave lengths (colors), and the color of the rays which our eyes perceive is the product of their color combination (polychromatic).

There are rays which contain only waves of the same length; these we call monochromatic or homogeneous. For example, the yellow ray emitted by glowing sodium, which cannot be divided into any other components. Most of the light rays, whether they are polychromatic or monochromatic, contain waves which travel transversely and in all other directions, so that a cross-cut of these rays would not produce a straight line, but more of a cross-surface. Still some substances send out rays in which the waves travel only in one direction, and we also have various apparatus (Nickel's prisms or a polarization apparatus) which can produce such rays from ordinary light. This we call polarized light. If we can conceive of monochromatic polarized light, then we have the individual ray of which all illumination consists and the number and character of which determines the amount of illumination. A monochromatic, completely polarized ray, is a ray consisting of uniform wave lengths running in the same direction.

We know that the classification of the ether vibrations into heat, light, and chemical rays is purely relative, and that the point where each class is merged into the next is very indefinite and variable. Where the heat and light waves have their conjunction, both classes of phenomena are excited by the same waves for a certain distance, and the same state of affairs prevails at the point of junction of the light and chemical rays. In fact, it is well known that waves of a length far shorter than those generally known as heat waves are capable of producing heat if they fall upon a suitable object, and it can thus be said that the light waves are capable of producing heat. The waves that are generally classified as light-producing may cause chemical change under suitable conditions, and, indeed, Abney has photographed a hot kettle from which none but invisible heat waves emanated, and on which no outside light was allowed to fall. In the same way it might be shown that the invisible rays that are commonly termed actinic, or chemical, are in reality visible to the eyes of a few people for a considerable distance above the point in the spectrum where the light waves are supposed to cease.

The chemical action of all of the rays from the red to the blue are generally considered as *nil* for animal organisms. It is customary to include the blue-violet and ultraviolet rays among the chemical rays, and this usage has descended from the time when there were no other chemical rays known than the blue and violet.

It is now definitely understood that all of the chemical effects of light which amount to anything are due to those rays which come from the ultraviolet region of the spectrum, and that these may be called chemical or actinic *per se.* The chemical action of the blue and violet rays may be considered as coincident with light and merely a by-product.

CHANGE OF VELOCITY AND DIRECTION OF LIGHT IN PASSING THROUGH SUBSTANCES.

Light rays passing through a vacuum are not subject to any appreciable change, but when these rays pass through different substances they are subject to various changes, influencing their rapidity, direction, intensity, and composition. The change in rapidity of transmission through substances is of theoretical interest, but the change in direction is of a marked practical interest. The following important phenomena are produced when light enters one medium from another:

Reflection. Rays striking the surface of a body are either permitted to pass through or are absorbed by it or thrown back—that is, reflected. Various colors are due to this reflection of substances permitting certain wave lengths to pass through, absorbing some and returning others, thus producing the color of the different wave lengths which it returns. For instance, a body which will reflect most of the waves in an equally strong manner we call white; those that reflect very few waves, black; and those that return the red rays only, red, etc. If the surface of a reflecting body is rough and uneven the reflected rays are thrown out of their course in an irregular manner, giving the effect of a dull light. If the surface of the reflecting body is smooth, the reflected rays are sent back in a regular manner and the eye will perceive the effect of the picture of the luminous body. If the surface of the reflecting body is smooth, mirror-like, but curved, such as a ball, egg, or other spherical forms, we get the effect of concentration or refraction of light rays which exhibits its great value in lenses of various character.

Refraction. Rays striking the surface of a lens perpendicularly, being neither absorbed nor reflected, pass through that body in a straight line; but as rays rarely enter these bodies at a normal angle, they are turned out of their straight course, producing the phenomena of refraction. The angle of refraction may be larger or smaller than the angle at which the light enters the substance. This depends entirely upon the medium from which the light emanates and through which it passes. If the surface of the body through which the light rays pass is rough, there are different angles of entrance and refraction, the rays are refracted in an irregular manner and thrown out of their parallel course, the degree of which determines the opacity of a substance. But if the surface of the body be smooth and the various rays in passing through it retain the same angle of refraction, we get the effect of a clear transparent substance. If a refracting transparent body with parallel sides is surrounded by the same medium, as, for instance, glass with air on both sides, the rays, refracted in passing from the air into the glass, are again refracted back in the same manner, in passing from the glass into the air, producing parallel rays. But if the opposing surfaces of this medium through which the light passes are not parallel, then the rays entering will be refracted at a different angle in leaving the medium, giving the effect of refraction observed in various prisms, etc.

Dispersion. We find that light passing through a prism is refracted according to its wave length, and the smaller the wave length the greater the refraction. This rule also holds good for invisible ultrared and ultraviolet rays.

The difference in colors is due to the greater or lesser vibratory motion of the ether, causing different wave lengths. Any given region of the spectrum is characterized by its length of wave. Aside from the luminous spectrum whose waves are appreciable by the human eye, there are two regions whose rays can be computed only by physical or chemical means—the infrared and the ultraviolet. Those from the ultraviolet end of the spectrum produce little heat and possess the property of making an impression upon the salts of silver. These rays, it is important to remember, *are absorbed by ordinary glass*, but quartz permits their passage. To study the ultraviolet rays properly we should employ prisms of rock-salt, fluorspar or Iceland spar, and to study the action of the most refrangible rays a quartz prism or a reflecting refraction grating is necessary.

Different solutions may be employed as absorbing screens to obtain isolated radiations. Most screens permit the violet, indigo, and blue, as well as the ultraviolet to pass. An ammoniacal solution of sulphate of copper is the one mostly employed. Pure water permits the whole luminous spectrum to pass, as well as the ultraviolet, but absorbs the infrared waves.

It is well to bear in mind in connection with Finsen's treatment of variola that photographers' red glass permits only the infrared and the red rays to pass. It is not so important that glass colored with cobalt permits, besides the blue, also the violet, indigo, and at times the green rays to pass, since these all have an almost identical chemical power.

It is found by experiment that a small portion of the violet and a smaller portion still of the ultraviolet rays to points varying with the glass are transmitted by almost all specimens of glass. If a spectrum formed by a reflecting, refraction grating, ruled upon some hard metal, such as rolled silver, having a small absorption factor, be examined it will show the spectrum lines to extend into regions beyond the violet, that are entirely absent in the spectra formed by glass prisms. When the spectrum is formed by a rock-crystal prism, the length of the ultraviolet region is much longer than that of glass, but owing to the abnormality of all prismatic spectra it is impossible to calculate the relative length of this region. Approximate results can be arrived at by measuring each region at the exact angle of incidence.

Diffraction. If we permit light rays to pass through a very thin opening we find that on the other side of this narrow opening they will change their direction, and each ray will be changed into a luminous point. The angle which the various diverging rays form with one another is larger the smaller the opening through which they pass, and it may reach 180° or even more. If we permit polychromatic light to pass through we find that there is a production of various colors, and that the angle of diffraction is different for different colors. The larger the wave length, the larger the angle.

All these various phenomena are made use of in the analysis of light in determining its constituents, wave lengths, etc. Certain substances have a property of changing or turning the light rays passing through them on their axes. This is called the property of torsion. As the majority of light sources permit their rays to oscillate on their axes in a transverse manner, they do not permit the observation of this phenomenon, but we find that in polarized rays which only pass in one direction in passing through these substances these rays are turned on their axes. This turning is in proportion to the specific turning qualities and to the quantity of these turning substances.

THE ABSORPTION OF LIGHT IN VARIOUS SUBSTANCES.

Even of greater interest than the refraction of the light rays is the diminution of the energy caused by the substance through which it passes by means of absorption. No substance is entirely capable of permitting all the light rays to pass through, nor is any substance capable of keeping out all the light rays, but the difference in the amount in which they permit this light to pass determines their character.

The most transparent medium next to a vaccuum is air, but even this absorbs the ultraviolet rays, while water will absorb the ultrared.

THE CHEMICAL ACTION OF LIGHT.

The fact that a certain substance, called horn silver, turned black upon exposure to light was known to some of the alchemists; but in 1777 the first investigations of the action of light on the different salts of silver were undertaken by the scientist Scheele. At about the beginning of this century Wedgewood and Davy made extensive experiments upon the chemical action of light on silver salts with a view toward producing pictures on paper, leather, and other substances. M. Niepce, in the year 1814, made similar experiments with bitumen of Judea, and discovered that this substance was capable of producing pictures when exposed to the light with a suitable opaque object. These seem to be the first experiments of any importance with substances other than salts of silver. Niepce made use of the camera obscura, and the bitumen was spread upon thin metal plates and exposed much in the same way as are the modern photographic plates. It is a peculiar property of bitumen that when it is exposed to light it becomes hardened to such an extent that it will not be affected by ordinary solvents.

One of the earliest observed phenomena was, that of all of the regions of the spectrum the violet produced the greatest effect. This was announced by Scheele, and afterward confirmed by Sennebier, who found that the chemical action upon salts of silver was twenty-two times greater in the violet than in the yellow, and eighty times greater than in the red. The experiments of Berard, Gilbert, Seebeck, and that versatile philosopher, Goethe, all tended to show that the blue and violet rays were much stronger chemically than the green, yellow, orange, and red. Ritter, in 1801, discovered that the rays that lie beyond the violet in the spectrum had a marked reducing effect on the salts of silver, and thence concluded that there were two kinds of invisible rays—those beyond the red and those beyond the violet. The former were known as the "invisible heat rays," and the latter were at once called "the ultraviolet chemical rays," on account of the fact that they possessed, above all, chemical powers. It is now known that sunlight possesses numberless invisible rays, whose effects may be determined upon different substances.

The actions of the violet and the ultraviolet rays exert the most powerful effect upon organic compounds and upon living animal tissues. In 1840 Robert Hunt[1] first showed that the photograph of the spectrum on an ordinary Daguerreotype plate was visible only above the G line, and that a portion of the spectrum, known as the ultraviolet, which had been observed by Stokes by means of fluorescence, was also impressed. It was also proven at this time that the lines H, L, M, N, O, and P of the spectrum, which Stokes had mapped out by means of quinine, were seen in their proper order upon a photographic plate of the wet-collodion kind, which had been exposed fifteen minutes, thus showing that they were capable of producing chemical change in the same way as they produced fluorescence. In 1857 Helmholtz presented some very successful photographs of the ultraviolet end of the spectrum, and since then the solar spectrum has been repeatedly photographed.

The nature of the material of which the prism or lens is constructed has a very important bearing on the visual,

[1] Researches on Light, 1840.

heating character, and chemical strength of the different regions. In 1819 Seebeck first published researches on the subject of material for constructing optical apparatus, though he had long before that been at work on the subject. The question is of great importance, especially as bearing upon the subject of actinotherapy, and has presented one of the most difficult problems in the construction of suitable apparatus, viz., that of finding a medium that will transmit the chemical rays and at the same time be obtainable in sizes sufficiently large to be of use.

The first reference we find in literature to the chemical action of light on organic compounds is by Regnault and Laurent,[1] and refers to the action of chlorine in combining with benzine and naphthalin in the presence of light.

Most organic matter decomposes and combines in the presence of light with the greatest activity. It would seem that light affects oxidation in the majority of cases and many coloring matters are faded by oxidation. Vogel, Herschel,[2] Capronnier,[3] Chastaing, Cloez,[4] Labord,[5] Grotowsky, Marbach,[6] Swan,[7] Becquerel, and many others found that such organic substances as aldehydes, amyl nitrite, asphaltum, chlorophyl, cyanide blue, the colors from coal-tar, ether, gum guaiacum, oils, sulphate of quinine, turmeric, tincture of aloes, wings of butterflies, xanthophyll, xylene, and many other substances are greatly affected by light; that the blue and violet rays are the most active, and that the action is generally an oxidation.

Many and exhaustive experiments have been made on the action of light upon plant life since it was observed in 1778 by Bonnet, Duhamel and Meese that the bleaching of plants was due to lack of light. All evidence seems to point to the presence of light as absolutely necessary to all forms of animal life, and to indicate that the rays below the blue are the active agents.

Chlorophyl makes its appearance in plant life only from

[1] Ann. de chem. et de phys. (2), pp. 60–71.

[2] Phil. Trans., 1844.

[3] Photo. Mit., vol. xiv. p. 50.

[4] Compt.-rend., 1865, pp. 321 and 981.

[5] Bull. de la Soc. phot., 1858.

[6] Phys. Lex., vol. iv. p. 487.

[7] Photographic News, 1872.

the time of exposure to luminous radiations; that is to say, although the elements of chlorophyl may develop in obscurity, chlorophyl itself appears only when light is introduced. There are some exceptions to this general rule, and while plants may live for a time in obscurity, nutrition has its distinct limits under these conditions.

Heliotropism, or the influence of light on the structure of plants, and their unequal growth upon the side illuminated and that protected from light is very interesting, but is a question which we cannot very well enter upon here. In a general way it may be said that without light there would be no vegetation, and that light determines many things connected with the inclination of the stem, the position of the flower, and the movements of the growing plant. These effects are due to the chemical end of the spectrum.

In studying the effects of light on various substances it is of the utmost importance to note that only the light absorbed by the substance will manifest any chemical action on it, so that by examining the absorption spectrum of a substance it is possible to state what colors will affect that substance. Draper is the authority for the principle that all chemical rays which act upon a substance are absorbed by it.

Abney has amply shown that, with certain substances at least, the action of the red rays was distinctly one of oxidation, and later[1] propounded the theory that wherever there was no absorption of light there could be no chemical action. He has assumed that there were two classes of substances—those which absorbed the red rays and those which absorbed the violet and ultraviolet—and that with combinations of these all effects could be secured. Abney later proved that in the presence of certain gases, and in the absence of oxygen, certain substances became sensitive to rays to which they were otherwise insensitive. This fact may have a bearing upon questions connected with actinotherapy.

It is impossible to state at the present time the exact action of light. The many experiments that have been carried out in the past have not put the subject upon a

[1] Bull. de l'Association Belge de phot., 1878, vol. v. p. 115.

secure basis. The following observations are taken from the publications of Eder and Chastaing:

1. It may be stated that in general the action of white light is reducing and rarely oxidizing. In this respect it is very similar to violet and ultraviolet light.

2. Violet and ultraviolet light act very much in the same way as white light, but with greater activity.

3. Green light has little or no chemical action.

4. Red and yellow light are at first sight apparently without any chemical action, but in reality they have an effect the reverse of the violet.

5. Chastaing concluded that the chemical action of the spectrum is double, reducing for one part and oxidizing for the other.

6. The reducing chemical action is much more pronounced than the oxidizing, and the state of the sky he thought caused oscillations in the intensity of the action.

7. The action of the green rays is too feeble to be of any value, but the little action observed is similar to that of the violet rays.

8. From the fact that there are two opposing actions in the spectrum, it follows that there should be a point where there is no action, and that point is found between the D and E lines.

Chastaing's conclusions of the chemical effect on organic bodies is substantially as follows:

1. The photochemical action on organic bodies is oxidizing.

2. The intensity varies with each body, but the proportion remains about the same.

Many contradictions have been found in the rules which observers have sought to establish as regards the chemical action of the spectrum, but the condition of our knowledge at the present time will not permit of better classification. The following conclusions may be drawn from the combined investigations of Vogel, Eder, and Chastaing:

1. Rays of every wave length, from one end of the spectrum to the other, are capable of exerting chemical action.

2. All of the rays which exert any action upon a body are absorbed by that body, and *vice versa*.

3. The action of the light, from whatever region of the spectrum, may be either oxidizing or reducing, depending upon the nature of the substance acted upon.

4. Roughly speaking, the action of the red rays is reducing on metallic substances.

5. The action of the different regions of the spectrum varies greatly with the condition of the atmosphere, so much so that rarely can the same action be observed on two occasions.

It is known that all rays may produce heat, light, or chemical action, according to the body upon which it falls.

With ultrared ether waves we get mainly the effect of heat rays, which act chiefly on the nerves of the skin and scarcely affect the optic nerves. The rays of the spectrum between the red and the ultraviolet, however, produce little heat and much effect upon the retina. This action increases toward the yellow, greatly decreases toward the blue and violet, and reaches its minimum in the ultraviolet waves, which are practically the chemical waves.

With the shortening of the ether waves a new quality of the rays appears, that is, its photochemical action; this is nearly naught in ultrared; weak in red, orange, and yellow; strong in blue and violet, and reaches its maximum in ultraviolet. Hermann claims that the leukocytes are not affected by light, while the red blood corpuscles show a distinct reaction. The chemical exchange in animal tissues is much greater in light than in dark, and it is not only the skin which is stimulated through the effect of light to this increased change. The pigment in the skin is nature's safeguard for the protection of the vessels against the irritating effect of light. Heat alone will produce only inflammation, but no pigmentation.

CHAPTER XXII.

THE ACTION OF LIGHT ON BACTERIA.

We enter here upon a most important practical question bearing upon therapy. The early experiments of Downes and Bluont[1] made with tubes covered with lead, thus protecting them from light without protecting them from heat, were used along with culture tubes not thus protected. The latter remained sterile while those protected with a coating of lead rapidly showed a development of germs, proving that the germs were killed by the action of the light. These were the first experiments which drew attention to light's bactericidal action.

Duclaux's[2] researches on the bacillus of milk, and upon a coccus found in biskra button indicate that the resistance to the sun offered by the spores of the various bacilli varies with the variety of the bacillus, and varies also for the same bacillus with the nature of the fluid in which it has been cultivated. Bie attempted to express numerically the bactericidal powers of each radiation. His experiments were carried out with the bacillus prodigiosus, using an arc lamp operating with 35 ampères and 46 volts. All the non-chemical radiations of the spectrum—*i. e.*, the red, orange, yellow, and green—inhibit the development of the bacteria in a period which, according to Bie's experiment, was six minutes. The same action with the entire spectrum was accomplished in only one-quarter minute, indicating that the total light was twenty-four times stronger. In representing by 100 the bactericidal power, Bie calculates that 96 per cent. belong to the chemical rays and 4 per cent. only to other radiations. He studied also the action of light on various saccharomyces, monilia, a pigmented torula,

[1] Royal Society of London, 1877.

[2] Traité de microbiologie, Paris, 1898.

aspergillus niger, etc., and found that, while their resistance was greater than that of bacteria, a sufficient light was fatal to them all.

Experiments by Duclaux, Downes and Bluont, D'Arsonval and Charrin, Arloing, and others have shown that sunlight was in a powerful degree bactericidal, at least in so far as the bacillus anthracis and the bacillus pyocyaneus are concerned, and that it is the blue, violet, and ultraviolet lights that produce the bactericidal effect.

The researches of Duclaux led him to conclude that sunlight was the strongest and cheapest bactericidal agent known, and that there was a great future awaiting the development of the use of sunlight as a general antiseptic measure. Arloing, experimenting on the bacillus anthracis, observed that the organism grows better in the dark or in the regions of the spectrum conspicuous for their small amount of chemical action. Geissler had results of a similar nature with the typhoid bacillus, while D'Arsonval and Charrin had like results with the bacillus pyocyaneus.

FINSEN'S EXPERIMENTS ON VARIOLA.

The theory that first led to the experiments of Finsen were of a negative character. He knew by observation and later by experiments upon his own person that the chemical rays of sunlight were capable of exerting powerful action of an injurious character upon the human skin. Further observations upon patients suffering from smallpox suggested to him that in the stage of vesiculation, if the skin were protected from all external irritating influences, the stage of suppuration might not be initiated, and thus the patient would escape with little or no scarring. He performed experiments by placing patients in rooms in which all of the light admitted was obliged to pass through thick curtains of deep-red cloth, or windows of dense-red glass, thus filtering out all or very nearly all but the red light. The results were so startling that the method has steadily gained adherents throughout the civilized world, though it has not been invariably successful.

Finsen[1] has shown that the bacteriological action of light bears a direct ratio to the degree of its concentration, and that in the proper strength for the particular species is invariably effective if the time of exposure is sufficiently extended; further, that the bactericidal power resides exclusively in the chemical radiations.

Dieudonné, Finsen, Bang, and Strebel claim that the red and yellow waves have no bactericidal effect whatever, in contradistinction to the blue-violet and ultraviolet rays. Kitasato, Tizzoni and Catani claim that we have no better bactericidal agent than light. We cannot count on the chemical reaction of the ultraviolet rays to any depth in the tissues, as they cannot penetrate deeper than the skin. Blue and violet rays will only affect underlying parts when the skin through which the rays act has been made anæmic. Upon mucous membranes the conditions are somewhat more favorable. Therefore, we can expect very little from the bactericidal effect of these waves on deeper tissues, but its effect on the skin and mucous membrane may be decidedly beneficial, especially so when artificial anæmia has been produced, but not quite as well when hyperæmia exists.

The bactericidal influence of light has thus been clearly demonstrated, but we have learned that the action is a slow one; therefore, when in therapeutic use with this object in view heat rays must be excluded, or they would prove too irritating to the tissues in the long exposure required to secure the bactericidal effect.

THE ACTION OF LIGHT ON ANIMAL ORGANISMS.

The action of light on the living animal organism was first discussed scientifically by Lavoisier[2] in France at about the end of the eighteenth century. William Edwards, in 1824, made a series of lengthy investigations on lower forms of animal life. He observed that frogs' spawn if left in the dark would perish, while in the light it hatched. Also, that the

[1] La photothérapie, Paris, 1899.

[2] Traité élémentaire de chemie.

hatching of perch was retarded in the dark. To Béchard[1] is due the credit of the observation that flies' eggs hatch more quickly under the influence of blue or violet light than in that of white, red, yellow, orange, or other colors. His experiments were carried on under glass of the various colors, which had been carefully tested with the spectroscope. Rather indefinite reports by Guarinoni hint at a favorable effect of ultraviolet light upon the silkworm's growth and activity.

The investigations of Salma and Piacentini[2] show that animals give out more carbonic acid under green or yellow glasses, which fact leads Eder to remark that these colors ought to favor respiration. According to Molschott, frogs are observed to breathe more freely in the light than in the dark.

Tanning. The action of the sun in tanning the skin has been the subject of considerable speculation on the part of Darwin and others. It has been observed that the Esquimaux become much paler during the long winters. Exposure to light has a well-known action on the blood, increasing the amount of hæmoglobin. Sunstroke and some other conditions are due to the action of too intense effect of light, while eczema solare, hydroa æstivale, xeroderma pigmentosum, lentigo, chloasma, and some other affections are either due to or markedly influenced by light, and the absence of sufficient light has been observed to favor the development of some forms of what was formerly known as scrofulous disease, tuberculosis, etc. The visual violet in the retina, discovered by Kühne, is greatly affected by light, being first bleached and afterward recolored. It is very sensitive to the yellow and green rays and very insensible to the red, which indicates that the action is analogous to the absorption of light by chemical substances.

The phenomena of sunburn and pigmentation have long been noted, and the general opinion for a long time was that the effect was caused by the heat rays in sunlight. In 1859 Charcot[3] advanced the opinion that these effects were caused by the chemical and not by the heat rays of the spectrum. It was in the study of several cases of dermatitis produced

[1] Compt.-rend., 1858, p. 441. [2] Fortsch. der Phys., 1871, p. 463.
[3] Compt.-rend. de la Soc. de biol., 1859, p. 63.

by the arc light that the attention of Charcot was first directed to the similarity existing between this type of affection and eczema solare. He advanced the opinion that they were identical in character and caused by the chemical rays, as the exposures which subsequently resulted in burn were unaccompanied by any feeling of heat discomfort. This was practically the only premise upon which Charcot based his theory, and the result was that the point was much debated and opposed. It was not until thirty years after the publication of Charcot's view that the first real scientific proof of its truth was advanced by Widmark. Experiments made with white light transmitted through many different media enabled him to determine the action of each of the different regions of the spectrum separately. Thus he found that ordinary glass transmitted all of the rays excepting the violet and the ultraviolet.

It is known that light has different effects upon different living organisms. The blue, violet, and principally the ultraviolet have the most marked effect upon man and other animals, and the yellow and the red rays have the most effect upon plants. The action upon plants seems to be in the main beneficial, and upon animals it seems to be at first mildly stimulating, but very irritating and finally destructive, in the prolonged exposures that have been endured experimentally or accidentally produced.

Other experiments on animals have shown that the lower the form of animal life the more irritating is the blue and violet ray. Animals have been repeatedly exposed to rays corresponding to the blue and violet end of the spectrum, and have always manifested a tendency to travel in the direction of the red rays. Experiments with germs have shown that in many cases the violet and ultraviolet light have the power of inhibiting entirely or greatly retarding the life of some varieties.

The first important step in the scientific determination of the action of light on the animal organism as a constant quantity was undertaken by Jacques Loeb,[1] who published

[1] Der Heliotropismus der Thiere und seine Uebereinstimmung mit dem Heliotropismus der Pflanzen, Würzburg, 1890.

the results of a series of careful and exhaustive experiments on the phototactic response of animals under varying conditions. These experiments covered a vast number of different species, and with the numerous experiments which have been carried on since then the subject can be said to be established upon a firm foundation.

The researches of Loeb were undertaken with a view to establish a relation between the so-called heliotropism that had been investigated and described by Sachs.[1] Loeb was surprised to note the great similarity in the action of light upon animals as compared with that upon plants. Where Sachs had noticed that the direction of the light had an effect upon the orientation of the plant, or its change of position in respect to the direction of the light, Loeb noted that where there was one source of light the animal placed itself so that its axis was parallel with that of the ray of light, and where there was more than one source of light the animals so arranged themselves that similar portions of the body were illuminated by light from equal angles.

It was noted in both cases that the greatest effect of the light was due to the violet, blue, and ultraviolet rays. In the case of plants it was found that light of a constant strength acted as a stimulation, and in the case of animals that it is undoubtedly a stimulant to animal cells. In the latter case, however, it is with some difficulty that the conclusion is arrived at, as the point of stimulation is easily passed and the action of the light becomes first chemical and then destructive.

PHOTOTACTIC INFLUENCE OF LIGHT.

Two modes of action of light as a stimulus on the movements of animals are recognized and frequently alluded to in the literature of the subject: one, through the intensity of the light, and the other through the direction of the rays.

That many animals are influenced in a great degree by their surroundings has been noted from the earliest times,

[1] Vorlesungen über Pflanzen-Physiologie, Leipzig, 1887.

but the observation is of comparatively recent date that the light color and intensity of illumination are extremely important factors in determining the life-histories of some animal forms. This factor is of the first importance.

The motions of animals influenced by light are designated as phototactic and are called negative or positive phototaxis, as they occur from or toward the source of light. Lower animals when subjected to strong illumination rarely fail to show some response. In some this is manifested in the change of color of the animal itself, either to make it conform with the color of the light or in a manner not so easily explained. These changes have been found to be due to changes in the distribution and position of pigment cells in the animal's tissues.

In all of the changes which animals undergo it is found that they are much more stimulated in white light than in red, orange, yellow, or green, and that the action of the blue is greater than the others and only less intense than the white, and that the violet rays exert a power quite as great as the white, from which it is deduced that it is the violet end of the spectrum in the white light that is in the greatest measure responsible for all of the effect.

The relative effect of the ray and the intensity of the light in these reactions has been carefully investigated by Holt and Lee in a series of experiments upon four classes of animals. Their conclusions are that: "Light acts in but one way; that is, by its intensity. The light operates, naturally, on that part of the animal upon which it impinges. The intensity of the light determines the nature of the response, whether contractile or expansive; and the place of response—*i. e.*, the part of the body stimulated—determines the ultimate orientation of the animal."

That the point of the body stimulated determines the centre of motion has already been seen, and that the intensity of motion is determined by the location of the area affected by the source of stimulation has been determined, for the common earth-worm, at least, by Parker and Aikin.[1] A statistical study of the movements of the anterior portion

[1] American Journal of Physiology, 1901, vol. iv. pp. 151–157.

of the worm when one side only was exposed to the light showed that the species is negatively phototactic. When the whole length of the worm was illuminated, 26 per cent. of the head movements were away from the light; when the anterior third only of the body was illuminated, $10\frac{1}{5}$ per cent., and when light was applied to the posterior third alone, only 1 per cent. of the movements were away from the light.

It has been noted that in some cases the same animal manifests a totally different phototaxis in the red or lower end of the spectrum than at the violet or upper end; thus the animal may be negatively phototactic in one region and positively phototactic at the opposite end. It would appear from this that the known oxidizing action of the lower end of the spectrum upon some metals[1] and the reducing action of the upper end exert different influences upon animal organisms. It has also been observed that in these special cases, while the action of white light is the same as that of the violet end of the spectrum, it is somewhat weaker. This is explained on the ground that the light effects of the two opposite ends in a measure counteract each other, and the action of the most refrangible rays being relatively stronger predominate in the mixed or white light. This fact might be of value in the construction of phototherapeutic apparatus; for while it has been generally supposed that the only objection to the heat rays in concentrated form was their painful and injurious cauterant action it might be argued that from the above facts the efficiency of the apparatus will be lessened in exact proportion to the amount of heat rays left in the beam of light.

Leredde and Pautrier, in their interesting work on *Photothérapie et Photobiologie*, Paris (1903), give some personal experiments made to determine the influence of radiation of different wave lengths upon the development of batrachians. One set of tadpoles were placed in a red aquarium, another lot of the same shape, size, and development in a blue, and a third lot were kept as a control in a white glass vessel; all conditions were alike. One died in the blue and red

[1] J. Eder and Abney, Photographic Journal (Brit.), 1881–1882.

aquarium each after a month; the three surviving the red aquarium still presented the appearance of tadpoles, and had preserved their caudal extremities. On the other hand, the three which had passed the month in the blue and violet light had lost or almost lost their caudal membrane, and their two pairs of extremities were completely formed, while breathing was carried on by the pulmonary route. An interesting point is to note the movements executed under the influence of different radiations in creatures whose nervous system is rudimentary.

Finsen has recently carried out experiments to decide why certain movements on the part of the fœtus of the frog and salamander took place; he discovered that under the influence of blue light these movements were very numerous, while under red illumination they were infrequent. The larvæ of frogs just born showed the greatest activity under the influence of blue radiations, while tadpoles kept for several weeks in the shade swam with vivacity under the same conditions.

Positive phototaxis is very frequently observed in the zoöspores of algæ which are attracted toward the luminous source and place themselves in the direction of the incident rays, but always turning toward the latter their non-ciliated extremity.

CHAPTER XXIII.

THE EFFECT OF LIGHT IN PRODUCING DISEASE.

Besides the solar erythema and ordinary sunburn in all its degrees of severity which we have considered, there are several striking abnormal states of the skin; some with attending general symptoms of greater or lesser severity, directly attributable to luminous rays.

Vernal hydroa, which has been more commonly known as *hydroa æstivale,* has been the object of much careful study on the part of a number of observers, though its occurrence is infrequent.

It is at times vacciniform, and in another type vesiculo-bullous, while in some instances lesions conform to both types. It occurs so much more frequently in boys that one form at least goes under the designation of *hydroa puerorum.*

Its initial attack is rarely after the tenth year, but having begun, recurrences are to be anticipated in each succeeding spring.

The onset can be referred to an unusual exposure to intense sunlight from six to thirty-six hours before a burning erythema, with swelling and blistering in circumscribed, rounded lesions, makes its appearance. The bullæ may be multilocular and are at times hemorrhagic. The bullæ, surrounded by an erythematous zone, soon dry up and their contents form a crust, which in falling leaves no scar, unless the lesions become secondarily infected.

In the vacciniform variety described by Bazin in 1860, the centre of the bullæ sink in and become almost black. After a tedious desiccation pittings remain.

Succeeding years bring with each renewal of the blebs an increased number of cicatrices until much disfigurement may result, and there is usually decided pigmentation and telangiectases.

An instructive as well as interesting fact is that of conjunctival involvement in rare instances; making an analogous state to that seen in another rare disease, also depending in a measure upon solar ray effect, viz., pigmentary epitheliomatosus, more generally known as xeroderma pigmentosum, but probably better called melanosis lenticularis progressiva.

It has been a frequent observation of many who have used Roentgen rays in treatment that general symptoms, with malaise, faint feelings, vertigo, nausea, and the like, are at times complained of.

It is noteworthy, therefore, that in the onset of hydroa similar gastric and general phenomena have been observed with cephalalgia, etc., while Möller and MacCall Anderson both report red urine, due, in the case of the latter observer, to hæmatoporphyrin.

Möller excluded conclusively in his case all influence save that of light, while other observers admit an influence exerted also, but in much less degree by cold and wind.

The chemical rays have been quite clearly convicted in these cases, and the occasional occurrence of lesions upon covered parts indicates that the chemical rays may at times traverse clothing.

Xeroderma Pigmentosum. This is a rare and curious affection occurring often in several children in a family, in the development of which light is a not unimportant etiological factor. Since in the later stages at least there is carcinomatous degeneration in the pigmented and keratotic areas, leading to death in from ten to thirty years with evidences of carcinomatous cachexia, the disease assumes a decided interest from the various standpoints of cancer etiology, pathology of skin changes produced by light and therapy, since we have found that the condition may be beneficially influenced by *x*-ray treatment.

In the pathogeny of the affection, while a congenital defect, either anatomical or nutritive, plays the most important part, the sun's influence in producing lentigo and a telangiectatic condition of the vessels hastens the more serious malignant changes. The onset is often noticed after exposure to strong light has effected a sunburn, which disappears slowly to be succeeded by brown pigment spots.

Prophylactic protection of exposed parts, by having predisposed children wear thick veils and keep out of the sun as much as possible, goes to prove the injurious effects of chemical rays. In an instructive case published by Allan Jamieson the disease made no progress after the child was systematically protected by a dark-brown veil.

PSEUDOXERODERMA PIGMENTOSUM. In a number of instances I have observed a condition almost identical with the xeroderma of youth, but occurring only in late life. I have no doubt this is the same affection which Unna has called seafarers' carcinoma.

I have recently removed by aid of the *x*-ray a rodent ulcer from the nose of a man who has spent his whole life upon or on the borders of the water. Upon the cheeks and about the eyes tenacious, hard, horny keratoses continually form, and interspersed between them are many small, dilated vessels and pseudoatrophic areas. (See Fig. 54.)

In other cases a generalized epitheliomatosus over the face would present scattered lesions of horny seborrhœa, together with pigment marks; flat, black, sebaceous, senile warts; telangiectases, and whitish, atrophic areas.

These patients are also improved by *x*-ray exposures, and the flat, waxy, multiple epitheliomas are made to disappear.

In elderly people, and especially men whose life has been spent in exposure to sun and inclement weather, warty growths, permanent redness, areas of chloasma and multiple epitheliomata occur, bearing a striking analogy to the pigmentary epitheliomatosus of youth, as Besnier calls it.

The relatively great frequency of epithelioma upon the face may well be attributed, at least in part, to the irritative agency of chemical rays, since we know what a decided influence these rays exert at times upon skin structures.

Lentigo. After exposure to spring and summer sun many persons, but especially those whose pigmented tissues are of pronounced type, as in red-haired individuals and in delicate-skinned blondes, small red dots appear beneath the skin of the face and neck, and in more advanced life, especially upon the backs of the hands. Instead of disappearing entirely as does the more diffused sun erythema, these telangiectatic dots are replaced by a deposit of pigment, making the well-known freckle which persists at least until winter.

Histologically the epiderm is chiefly involved, but numerous pigment granules may be found in or outside the cells of the Malpighian layer.

Predisposed subjects may freckle without undue exposure, much in the same way that solar erythema of severe type may follow exposure of usually covered parts on a dull or cloudy day, especially on or near the water. That actinic rays exist in abundance in the atmosphere, even in the absence of direct strong light, accounts for this influence.

Chloasma. Almost all pigmented areas exposed to summer sun take on a deepened hue, and some chloasma seems to be produced by the luminous agency alone.

The pigmentation surrounding the white spots of vitiligo becomes intensified under the sun's influence, and even in pityriasis versicolor, which upon the trunk may be pink, becomes at times almost coal-black upon the neck.

Other influences besides light are active, as is well shown in the chloasma uterinum, but this, too, grows darker under exposure to light.

Pellagra. While it has been demonstrated that this disease depends largely upon the ingestion of diseased grain, still the power of the sun's rays in Southern climes is fully recognized as the important factor in the erythema. The solar redness is distinctly limited to the exposed parts.

It has been experimentally demonstrated by Bouchard[1] that the chemical ray is here the injurious agent.

Variola. While Finsen deserves the credit of practically demonstrating the injurious effect of light upon the smallpox vesicle, its role in the transformation of the bleb into the pustule was long since suspected, and in this country, as early as 1832 Pictou advocated the red-light treatment.

Finsen has pretty clearly shown that the chemical rays influence injuriously the stage of suppuration, and thus increase the mortality, to say nothing of the pitting in those who survive.

[1] Recherches nouvelles sur la pellagra, Paris, 1862.

Light as a Cause of Cataract. Dr. William Robinson[1] has made a most interesting observation on the frequency of hard cataract in bottle-finishers, whose work exposes the eyes to the intense light and heat of molten glass. Eighteen out of seventy-five hard cataracts operated on in the Sunderland and Durham Eye Infirmary were in bottle-finishers, of whom there are only about two hundred to three hundred in a population of nearly a million and a quarter in the country.

The bottle-finishers' eyes are exposed to the glare of the furnace for about five and a half hours a week in the aggregate.

Both eyes are practically always affected. The disease begins comparatively early in life—often before the age of fifty, and not uncommonly before forty even—and progresses slowly.

The reason the mischief always begins at the posterior pole of the lens is that the nodal point (which practically corresponds to the optical centre) is situated at that spot. Here all the principal rays of the various pencils of rays falling on the lens cross and pass without refraction, so that at this point the lens receives the brunt of all the direct rays, and their harmful intensity and heat from the furnace, and is therefore the first point to suffer injury. Moreover, other rays which have been refracted at the anterior surface of the lens become crowded on to the same area on the posterior surface, and still further the bright light of the furnace contracts the pupil so that the iris shields the periphery of the lens at first from damage. Dr. Robinson feels confident that the disease might be prevented by the workmen wearing dark-blue spectacles, but when advised to do so the bottle-finishers offer various excuses. There can, however, be no doubt that all men whose work compels them to expose their eyes to such strong light and heat ought to wear glasses, as is done, for example, in steel works and by men employed in certain electrometallurgical processes.

Other Deleterious Effects of Light. The condition of erythema which is commonly though erroneously called

[1] British Medical Journal, January 24, 1903.

sunburn, has been demonstrated to be due, as Wildes ascertained, to the irritative action of the ultraviolet rays, whose active influence in this direction was suggested by Charcot. This erythema occurs in a more pronounced manner in high altitudes, not so much because of the reflection of mountain snow as because the violet rays have here a greater intensity. As to its effects on metabolism, oxidation in living tissues was shown by Quincke to be increased by the action of sunlight. The baneful influence of withdrawal of the sun's rays is well illustrated in the anæmic appearance of human beings confined in dungeons and even in sunless apartments, in the cretinism of dark valleys, and in the marked increase of amenorrhœa among the Esquimaux women during the dark season.

Conversely the injurious effects of too much light is illustrated in the so-called burning of the skin; in the systemic effects produced through the nervous system when the optic nerve is stimulated; by the deleterious effects known as sunstroke, and in the superficial phenomena of pigmentation, tanning, and lentigo formation.

In the living organism the intake of oxygen and the output of carbon dioxide are both increased by the influence of light. Likewise there is an increase in nerve irritability, while it is believed by many that the muscles are increased in functional power.

According to Auerbach, light produces contraction of living protoplasm.

The experiments of Hammer, Boules, Widmarck, and others indicate that the ultraviolet are the rays influencing living tissues. Freund has investigated diffraction with a grating of the ultraviolet spectrum.

The spectre of diffraction obtained by this apparatus has over the spectre of refraction of the prism the advantage of being exempt from influences of absorption and of presenting a diffraction of rays proportional to the length of the waves.

Fresh epidermis, the bullæ following burns and those of pemphigus, Thiersch grafts, and the interpalmar membrane of living frogs were used in the experiments. It was shown that a considerable number of ultraviolet rays coming from different sources of light traverse the epidermis to reach the deeper layers of the skin. The quantity of rays corresponds closely to one-third of the ultraviolet spectrum now known. It is not yet determined whether these are the ultraviolet rays which cause the skin lesions previously mentioned, or whether it is to them we should attribute the curative action of the light treatment.

Change of Form under the Influence of Light. Not only are contractions and elongations of the protoplasm possible, but permanent modifications are formed.

Brefeld's studies on the action of the different coprins led to the conclusion that their development in light is quite different from that in darkness. Not only is there an occasional change in form but also of qualities, such as changing from anaërobic to aërobic existence under the influence of light. Verworn[1] found that certain ciliated infusoria usually in a state of repose were excited to movements mostly by the blue and violet rays.

The Role of Light in the Production of Pigment. The colored surface of animals, fish, birds, etc., is that, as a rule, which is exposed to light, and, as Finsen has observed, polar animals have a bright coat in winter and a darker one in summer.

The influence of environment of color upon animals is well illustrated in the experiment of Poulton, who showed that in certain caterpillars there was other pigment than that of alimentary origin. Placing chrysaloides in boxes lined with various-hued papers, the chrysalis was found to reproduce the colors in which it had been raised. Others have produced the same effect. The protecting action of pigment in animals and human beings has been studied by a number of observers, among them Paul Bert,[2] who found that the blue and violet caused hyperpigmentations, while the red rays remained inactive. Certain fish changed their color under radiations in much the same manner as does the chameleon. This animal has, as is well known, large pigment cells (chromatophores) deeply situated

[1] Allgemeine Physiologie, Jena, 1895.
[2] Revue scientifique, No. 42, 1878.

in the skin, so long as the animal is in darkness; when, however, he is subjected to the strong light, these cells move to the surface, giving him an almost black appearance.

The effect of the summer sun upon the skin usually protected by clothing is a matter of common observation. In severe sunburn we may have swelling of the tissues and elevation of temperature, coming on some hours after exposure. The erythema of mountain climbers and glacier or polar region explorers has been described by a number of observers, including Widmarck. The photoelectric erythema from the arc lamp has recently been a matter of curiosity and study. Charcot[1] was the first to observe the effects on the skin due to electric light. The appearances were exactly those of sunburn, followed by desquamation on the fourth day. The two men affected had been so far removed from the voltaic arc that the theory of heat effect was not entertained.

Since Charcot first attributed the results to chemical rays, other observers have seemed to confirm his view in studying the effects of light in those whose occupation necessitated exposure to intense illumination.

[1] Société de biologie, 1858.

CHAPTER XXIV.

PHOTOTHERAPEUTICS.

ALTHOUGH it has been pointed out from time to time that light was probably used in ancient times for therapeutic purposes, and was at least highly appreciated by the Romans, to whom the sun-bath was not unknown, though it is doubtful whether they had any conception that light was the agent whose benefit they sought, it seems more probable that an idea prevailed that the warmth of the sun had a certain stimulating effect upon the system. It cannot be said, however, that any observer, before Finsen, had attempted to utilize light, in exactly the same manner, for therapeutic purposes. Almost all that had previously been written related to the effect of sunlight upon the whole body and belonged to the realm of metaphysics. The general idea seemed to prevail that the effect of sunlight, and especially of the blue rays, was one of general stimulation of the organism, the whole effect being beneficial.

The work of Finsen was based upon an entirely different hypothesis—the destructive action of sunlight on the human body. The first fruits of his observations were of a negative character, inasmuch as he advised the withholding of the chemical, or, as he put it, the harmful, rays of the sun in patients suffering from variola. The room in which the patient was confined was illuminated only by the red rays of light, which are known to have the feeblest chemical action. This was accomplished by having the light from the sun or other source pass first through thick, red-colored cloth or glass, thus causing to be absorbed all but the red rays. Further researches and observations recounted elsewhere, and the experiments of various observers on the bactericidal action of the chemical rays, led to the employment of these rays in concentrated form, with the view of destroying the germs and the impaired tissue in parasitic and germ diseases. At no time does the treatment assume the form of a simple stimulation to the tissues, the action being always understood to be either a cauterant of mild character or a reducing agent.

And still the basis of all therapeutic value of light rests upon the fact of its being a stimulant to all organic life.

Light is made use of in medicine at the present time under two forms—sunlight and electric light.

The former may be employed directly in its natural state or by methods of concentration and filtration.

Electric light is utilized from the incandescent bulb, from the arc light, or from the electric spark.

These likewise may be made use of either directly or after methods of modification have intervened.

Sunlight is the most important, though not invariably the most practical or available.

Light baths are of three kinds—sunlight, incandescent, and arc electric.

SUNLIGHT-BATH.

Although the therapeutic application of the sun's rays to the entire body was practised by the ancients, we are even at this late day not in possession of sufficient data to establish the exact worth of the method. There can, however, be no question that, both as a curative agent and as a prophylactic measure, solarization of the nude or covered body has a decided value. In considering its action and results, we must not lose sight of the beneficial influence of out-of-door life, which forms a necessary part of natural irradiation in the open air. Never before has the belief that light and life belong together on the one side and darkness and death on the other been made to bear such practical results as in our modern hygienic appointments of public institutions, homes for consumptives and other invalids, as well as for the dwellings of the laboring classes, their working quarters and factories. While the importance of light to life is generally recognized, and while it is known that judicious exposures to the sun are conducive to a state of well-being, still physicians have been tardy in making the most of this powerful natural agent.

We know that the Greeks and Romans of early times exposed the body to the sun, with the view of maintaining the system in health.

The younger Pliny as well as Cicero speak of sun seats and sunning places in gardens and upon roofs, and the solarium of the dwellings of the wealthy is well known as the earliest form of light-bath with which we have any acquaintance.

As a remedial agent Herodotus seems to have recognized the power of light and the stimulating qualities of the sun's ray, both in hastening recuperation and repair and as a protection against sickness. He and Antyllus thought it would dissipate anasarca or dropsy, and recommend it in fluor albus, nervous affections, hypochondriasis, hysteria, and even epilepsy. Aurelianus advised "helios" in numerous pathological conditions, including cachexia, adiposis universalis, and arthritis.

It is by no means to be presumed that there was any conception on the part of the Romans of the chemical action of light. In those days the knowledge of light was practically *nil*, and the ridiculous theory of ocular beams was generally accepted. It was not at that time supposed even that light came from the sun.

The practical observation seems to have been made by Herodotus that unless the bowels were previously emptied the sun might have injurious effects upon the head.

Others more recently have advised protection for the head in long exposures, and partial protection of the skin from sunburn will be found necessary until the latter has become accustomed by gradually lengthened sittings.

The first evidence in modern times of an attempted revival of light therapy, after some centuries of neglect, was the offering of a prize in 1796 by the University of Göttingen for the best essay "on the effect of light upon the human body, both noxious and salutary."

Therapeutic Indications. While the method has been carried out in an almost entirely empirical manner, still there are certain observations which scientifically explain the benefit which is undoubtedly seen in some cases. In anæmia and chlorosis, for example, the improvement would be explained by Graffenberger's demonstration of the increased hæmoglobin-carrying power of the red corpuscles under exposure to light.

We know from recent scientific experiments that there resides in the actinic rays powers which were formerly little dreamed of, and, while in unfiltered and non-concentrated light this power is comparatively weak, it is to the ultraviolet, the violet, and the blue rays that we must attribute the benefit.

It has also been pretty clearly demonstrated that sunlight has an inhibitory effect upon certain bacterial life. This would scientifically explain the good influence noted in tuberculous processes, at least in part.

Besides pulmonary, joint, bone, and skin tuberculosis proper, scrofulosis has been improved. A tonic and sedative action has been noted by Singer,[1] of Berlin, who finds sun-baths of especial service in neurasthenic states.

Others have reported favorably in autointoxication, chronic hyperæmia of the skin, and convalescence from exhausting diseases.

It is especially in states of defective metabolism and imperfect oxidation processes that the sun-bath finds its greatest field of utility; in neurasthenia associated or not with chronic dyspepsia; in those conditions associated with faulty uric acid production and discharge in so-called rheumatism, rheumatic gout, and allied states; in diabetes, especially associated with obesity, and in some affections of the liver and kidneys. Various observers have noted beneficial effect in a variety of skin diseases. While it cannot be put down as one of the most valuable agents, it still has an undoubted influence at times in psoriasis, eczema, and acne. In myxœdema and exophthalmic goitre, Kellogg, says the method is of great value when employed with proper precautions. He also says it is contraindicated in all febrile disorders, excepting in chronic pulmonary disease with slight elevation of temperature.

[1] Fourteenth International Congress.

[2] System of Phys. Therapeut. (Cohen), 1902, vol. ix.

Winternitz has observed the disappearance of tuberculous ulcers under sun-ray exposures.

Quincke found that under the influence of light there was increased oxidation in pus cells and in the blood of leukæmia. While increased oxidation has been shown in human organs ground up, no proof is offered that the same would occur in the living body.

Dr. Kime,[1] of Fort Dodge, Iowa, in 60 cases of pulmonary tuberculosis found the progress arrested in 12, while marked improvement showed in 11 others.

His glass reflectors have a diameter of thirty-six inches, focusing upon the bare chest at three feet over an area of eight inches diameter. An engorgement of blood is noted in the parts rayed, and he believes the blood and tissues absorb a high percentage of the light.

Owing to the form of the apparatus which necessitated the light's passing twice through a plate of glass, one is led to the conclusion that the benefit was obtained by a combination of the blue and the heat rays. The instrument being a reflector, there were necessarily a few chemical rays reflected from the surface of the glass, but the nature and reaction of these rays in concentrated form make it extremely improbable that they were sufficient in quantity to affect the result. While Kime's results were undoubtedly good, his premises and conclusions were faulty, as he attributes the action wholly to the chemical rays, whose action under a concentration such as he secured by his apparatus, if properly constructed, would entirely destroy the tissues. Further, it has been shown by various investigators that the chemical rays are absorbed in the skin to a great extent, while the blue and rays of lesser refrangibility penetrate more readily. Curiously he mentions the fact that, although there is considerable heat in the focus of the rays, there is less blistering of the skin than in sunlight containing less heat, which clearly proves that the instrument occludes most of the chemical rays, which are those active in producing blistering.

Generally the sun-bath includes the whole body, the

[1] New York Medical Record, November 1, 1902.

improvement in metabolism usually being more important than any local benefit to a restricted area. The patient walks about in a gymnasium, roofless apartment, or out-of-doors, or reclines upon a couch or chair in a screened-off area of the housetop, or in a specially constructed solarium. The duration will depend also upon the state of strength, powers of resistance, sensitiveness of the skin, and habituation. The time will vary from a few minutes to half an hour for the more delicate subjects, increased up to several hours for those who have become gradually accustomed, and particularly in dark-skinned individuals or in those whose integument has become tanned by previous exposures. The duration varies somewhat also with climatic or atmospheric conditions. It is well known that the power of the sun's rays, especially in their actinic properties, is materially increased at high elevations. This is also true of the rarefied atmosphere found sometimes at moderate elevations. At the seashore after bathing the sun-and-air bath for the naked body can be somewhat more prolonged, and here the sand-bath can at times be advantageously added. In inland locations a variety of water-baths may be employed after the sun-baths to enhance its benefit. The head should be protected in almost all instances, and especially when insomnia is a feature of the case. If a sun dermatitis is produced, the part implicated can be covered with appropriate dressings to prevent further discomfort or damage while the baths are continued. To prevent this ill-effect Winternitz has suggested covering the body with some material of red color. To secure a pronounced local effect, the rays can be concentrated by the use of concave mirrors, or the same effect can be produced with a lens. These methods of utilizing the sun's rays have been familiar to physicians from remote times. But as focusing effects could scarcely be carried to the point of benefiting without producing painful burning, the methods never came much into vogue. It was left for Finsen to make the necessary separation of the rays, excluding those which produced the painful and dangerous effects while retaining those which gave only benefit. Filtering, as it were, the solar stream, he reduced the heat rays to a minimum point and one which could be borne by the human tissues. The resulting erythema does not show itself immediately but only after a short period of latency.

The beneficial influence of many climes, such as Colorado, Mexico, California, Italy, etc., is attributable to the long, strong, and almost constant sunlight quite as much if not more than to the ability of the patients to pass a large proportion of their time in the open air.

The exhilarating effect is attributable to stimulation of the nervous system, and this makes its value in states of debility. Besides this effect it may cause inflammation, oxidation, and inhibit or destroy bacteria.

Mount Bleyer has studied the effect of the sun and electric arc rays with special reference to their physical influence upon iron preparations after their internal administration. In over one hundred tuberculous and anæmic patients different iron salts and organic preparations were administered and the patients placed daily in the rays of the sun or electric arc light. It was found in this way that the iron salts were taken up much more rapidly and produced more marked beneficial effects.

Alopecia Areata. Schmidt[1] points out the action of light upon the growth of hair and nails, which appears to be greater in summer. This he attributes to the action of the actinic rays, which are more abundant in the warm seasons. A hypertrichosis has also been observed by those using the Finsen and *x*-ray treatment as an accidental effect upon the arms of nurses and attendants. There is no doubt that sunlight, as well as other forms of light, will produce increased vascularity and hence influence the nutrition of hair follicles. Experiments on guinea-pigs, exposing one to sunlight, while the other was placed in a box with a red-glass window, and other experiments made, were without convincing results. He decides that the more rapid growth of hair and nails in summer has not been proven to be a result of actinic ray action, believing it to be more properly attributed to warmth.

Lupus Erythematosus. It has been observed that after sunburn of parts affected an improvement took place.

[1] Archiv für Dermat. und Syph., October, 1902.

Norman Walker,[1] who is a careful observer and a dermatologist of note, has employed twenty-minute to half-hour exposures to sunlight, concentrated by a lens, but without pressure or producing blisters, either daily or every second day. Improvement was rapid after about the sixth or eighth sitting in several cases and some results were brilliant. The lens is placed at about twelve inches from the part.

Dr. Walker says large areas have disappeared at times more thoroughly than under any other method with which he is familiar.

Psoriasis. Hyde has demonstrated for the past twelve years that psoriasis in certain cases has been cured by exposure of the body to sunlight.

TUBERCULOSIS OF JOINTS. As Ridlon and Willard have probably well pointed out, we must not rely upon the sun effects alone. Without mechanical means of immobilization, etc., no form of light treatment will be likely to succeed. Change of environment from sunless quarters to the open sunlight probably has more effect than an increase in the sunlight for those habitually exposed to it.

INCANDESCENT-LIGHT BATHS.

The baths that have come into use of the type called incandescent-light baths consist of a number of incandescent electric lamps usually arranged in some form of permanent cabinet, whose interior is covered with mirrors to reflect all of the light upon the patient within. The patient sits upon a stool, or preferably lies naked upon a couch, for a period varying with the condition of the patient and nature of the disease. A profuse perspiration, general in character, is an almost constant accompaniment of this form of treatment, and is the effect generally sought. It is followed, in the majority of cases, by a thorough massage of the whole body, a cold bath, or both. The most noticeable effects obtained in these baths are not due to any action of the light, *per se*, as the perspiration cannot be in any way

[1] Scot. Medical and Surgical Journal, June, 1903.

attributed to the action of light. That there is any other effect than that of a profuse sweating has not been in anywise proven, though claims are made that the bath has a different effect from an ordinary heat-bath. Most authorities agree that the effect of the incandescent-light baths is confined to the results of diaphoresis. The light effect in these baths is so slight as not to be appreciable by any means at our disposal at present. It does not seem at all probable that there is any effect, as the theory of the whole arrangement on which the method is based appears to be wrong. The spectrum of the incandescent lamp is extremely poor in chemical rays and rich in the heat rays. The glass that surrounds the filament is a screen that almost completely occludes the few chemical rays that the lamp is capable of giving off. If, as in some forms of apparatus, the glass of the globe is of blue or violet tint, the result is that the chemical rays are still further excluded from the light that comes from the lamp, and are transformed into heat rays in the glass. The lamp besides grows very hot from the total absorption of heat rays and then radiates heat as from an independent centre. Also, the light from the lamp is reduced to the blue and green rays, the former being the weakest recognized chemical rays, and the latter being without known chemical action of any kind. All of the rays that are absorbed in the glass are transformed into heat rays, and when the glass attains a certain degree of heat, radiation begins. The life of the lamp is lessened and the heat of the cabinet increased by this condition. The mirrors that line the walls of the cabinet are detrimental to the efficiency of the apparatus, as the heat rays are freely reflected, but the chemical rays only partially by the surface of the glass, and those that go into the glass to be reflected by the mirrors beyond are absorbed in the glass and never reach the reflecting surface of the mercury at the back, as glass will not transmit ultraviolet rays.

Dr. T. D. Crothers has described a light-bath that he makes use of in toxic insanity resulting from the abuse of drugs. The bath consists of a room five feet square and six feet high, lined with tinned plate. The illumination consists of one hundred incandescent lamps of standard sixteen-candle power size. The energy consumed in the bath then is one hundred times fifty watts or five kilowatts distributed over a space of one hundred and fifty cubic feet. Even if all of the energy in such a bath were transformed into light, the result as compared with undiluted sunlight would be insignificant. Supposing that the patient be placed in the geometric centre of the room, and that the lights be distributed equally on all sides of the patient at the distances of the walls of the room. Then the area of the patient, which we will call roughly two square yards, will be illuminated by a light equal to approximately one hundred candles to the square yard, at a distance of one foot. This is enormously overrated, as it assumes that the maximum light falls upon the patient, that all parts of the body are exposed, and that the lamps are placed in a sphere so that they are all at the same distance, not counting the extra distances of the corners of the room. The light of the sun is equal to 670,000 candles per square foot at the earth's surface; so that it may be seen that the effect of the sunlight will, at the least, be greatly superior to such a bath as described. This does not take into consideration the lack of chemical elements in the lamplight, and their presence in great quantities in the sunlight. It is true that the light of the sun illuminates only one side of the body at once, but that may be overcome by a suitable arrangement of a coreflector so that the light may fall upon the surface without interruption, and thence upon the patient. The treatments in the system just referred to last for about fifteen minutes, and the sweating, which is profuse, begins in from two to seven minutes. It is claimed that the sweating is more profuse than can be obtained by any other thermic bath. Granting this, we may look upon the incandescent cabinet as an excellent form of bath for certain purposes, but must not consider it a powerful light-bath. On the other hand, there are claims put forward that when arrangements are made to wholly eliminate the heat the beneficial effects are still pronounced. It is known that red rays at times act as a more or less powerful physiological stimulant and regulator of circulation. As these together with the orange and yellow form a decided majority in those that pass through the bulb, we should attribute any benefit to them rather than to the ultraviolet, which becomes absorbed by the glass. It has also been pretty clearly shown that the increase in perspiration is not always attended with corresponding increase in circulation—a feature of decided importance in the treatment of subjects of heart and vessel disease. The effect upon the circulatory apparatus was, however, found to be the same as after any hot-air bath. The temperature of the cabinet is usually from 120° to 150° F.

Such baths are said to have been in use in America twenty years ago. The light-bath of Fernandino Battistini consists of forty lamps of the usual incandescent variety; and the temperature in the cabinet during the treatments is said to be from 50° to 60° C. This author, as all the others using this method, dwells upon the profuse sweating produced.

Caution. In his presidential address before the Roentgen Society, 1902, Girdwood mentions a burn caused by the hand being held too near an incandescent lamp for a long time. Several hours after exposure there was itching, followed by blistering and injury, which lasted several months.

In one form of apparatus the patient sits or lies in a cabinet or bath-box arranged with fifty lights of sixteen- to thirty-two-candle power each. The head is outside the cabinet. Different rows of lamps are turned on by means of switches, and the current regulated in the bulbs.

Perspiration begins in about five minutes and increases rapidly and may within twenty-five minutes become profuse. It is said that if the heart is sound no unpleasant sensation is experienced, even at a temperature of 70° C. or over, but an erythema of the skin may be noted.

Caution. Too long exposures produce difficulty of breathing, palpitation, and nervousness. Ordinarily the temperature should not exceed 45° C. The head should be kept cool.

Some cabinets are constructed to permit of spraying, making applications over the heart, etc., while others are arranged and ventilated to enclose the entire body.

Therapeutic Indication. Weakness of therapeutic claims advanced rests upon the too wide range of diseases claimed to be benefited and the employment of incandescent lamps so much weaker than daylight in chemical rays. Radiant heat is given out in large amounts and the patient in the cabinet perspires freely, getting the effect of a Turkish bath. Here, as abroad, such baths have been largely exploited by charlatans and unscientific persons, to the detriment of the other treatments by light methods. The bath is well calculated to impress the patient, especially if of a neurotic temperament. In a few skin diseases characterized by dryness of surface, hyperkeratinization, desquamation, etc., the incandescent bath may act well by macerating the horny scales and increasing gland activity, but it should be looked upon as a heat rather than a light effect.

In anæmia Winternitz has demonstrated that there is an increase in the percentage of hæmoglobin after each bath.

Scientific observations upon the definite effects are all too few, and the whole subject must be still carefully investigated. At present there are certain indications for their use, but we must look at them as radiant heat rather than light-baths, excepting where the heat element is eliminated

In a number of cases of arthritis Eve[1] found decided benefit, relief of pain, increased mobility, etc., by exposure to electric-light bulbs of sixteen-candle power. The heat (250° F.) effect is claimed to be enhanced by the light.

Kellogg, who was the originator of this method, says the incandescent bath is the most effective means of promoting the absorption of exudates, not only from about the joints, but in the pleural and peritoneal cavities. In France it has been used in exudates of the cornea and in vitreous opacities. Local applications should be made at least twice daily. Hydrotherapeutic measures, massage, and electricity are considered valuable adjuncts. The chief indications are in the rheumatic and alloxuric diathesis, chronic tuberculosis, inflammatory bone diseases, nephritis, neuralgias, myalgias, anæmia and chlorosis, diabetes, obesity, gout, asthma, etc.

[1] Lancet, May, 1901, p. 1396.

ARC-LIGHT BATHS.

The application of the arc-light bath to the cure of disease is said by Garnault[1] to be an outcome of an accidental observation by a Mr. Touré of its benefit in a workman afflicted with rheumatism, who was completely cured by remaining in the vicinity of an intense arc light used for an electric fountain, and, subsequently, that in works employing electric soldering, in which there is a great effulgence of light, workmen had ceased to be affected by such diseases as rheumatism and gout.

Electric arc light as it is employed for illuminating purposes produces much the same effect as the sun's rays upon the integument, both as regards the erythema, dermatitis, increased pigmentation and perspiration. It is, therefore, not surprising that the arc light should be employed as a substitute for the sun-bath. There are reasons for believing in its powers to affect vital processes, drawn from physiological experiments on the promotion of cell growth and protoplasmic activity in plants. Experiments at Cornell University in 1890 confirmed those of Siemens, carried out ten years before, showing that its effect on plant growth compared favorably with that of sunlight. The arc-light bath can be arranged in a cabinet which does not enclose the head. Such a cabinet of simple construction can be so arranged that a blue screen may be interposed between the patient and the light when the actinic rays alone are sought or a red screen when heat is desired.

Compared with the general sun-bath, decided perspiration can be produced in a much shorter time and a few minutes' exposure is said to produce decided tonic effects. The action upon the healthy skin is to produce at times a reddening of the surface, which has lately come into dermatological nomenclature as erythema electricum. This has been demonstrated to be due to actinic rays by Widmarck, Charcot, and others. The arc light approaches sunlight most nearly

[1] Communication to the Academy of Sciences.

in its luminous and chemical power, and even surpasses it in the quantity of available actinic rays. Exposure to a very powerful arc light is found to produce, besides burning of the skin, chemosis of the conjunctiva with coryza and photophobia.

Tuberculosis. While the actinic and x-rays may inhibit development, growth, and activity of tubercle bacilli locally, the individual must not be left out of consideration. All known means must be employed simultaneously to strengthen the resisting powers.

Freudenthal[1] believes that, while he has never cured a single case of advanced tuberculosis of the lungs by exposure to the arc light, it is of decided value as an auxiliary treatment to other measures. The skin of the chest, due to the trans-illumination, is stimulated to a greater activity, increasing general metabolism, thereby improving nutrition. He notices in a number of cases that the light reduced the high temperature for a few hours just as a bath would have done. In comparing it to hydrotherapy, he claims that it is far superior in removing pain more promptly and in facilitating expectoration.

Tuberculosis of the Larynx. The arc light has been used in the treatment of this disease with very encouraging results.

Freudenthal,[2] who has had a very extensive experience in the treatment of these lesions with the arc light, finds the latter of great benefit in alleviating some of the most annoying symptoms, at times in a remarkably short period. He finds it of most value in cases where ulcerative processes exist that cannot be reached by any other means. The apparatus he prefers is an ordinary search light as used on board ships, which lately has been modified and called the electro-arc chromolume. To prevent heat effects he washes parts with pieces of linen kept on ice as soon as they become too warm, and has the patients turn around slowly in their chair and successively expose the different parts of the chest or larynx to the light rays. The exposures may be given for thirty minutes or more without any inconvenience. In

[1] New York Medical Journal, July 12, 1902. [2] Ibid.

some cases he uses a blue-glass screen at the beginning of treatment until the patients become more accustomed to the light.

Hay Asthma. In this condition the results achieved by the electric light appear very satisfactory. This may be partly attributed to the fact that the neurotic element is a very important factor in this disease.

Freudenthal[1] reports 24 cases treated, out of which 14 were decidedly improved in a very short time, 10 were not benefited very much or discontinued treatment too soon.

He applies the light to the face indirectly by letting it pass through a blue screen. In a number of cases some of the most distressing symptoms were relieved after the first exposure. He finds that the subsequent recurrences are weaker after this treatment.

Hewitt Light (*Mercury Arc Light*). Among the newest discoveries of light in a form which may come to have therapeutic usefulness is the recent finding of Peter Cooper Hewitt, which consists of a vacuum globe containing mercury vapor. The vapor opposes marked resistance to the passage of a current of electricity until the latter reaches a certain high potential, when it gives away suddenly, allowing to pass through it a current of low potential; this produces a light giving out all rays excepting red and causing objects to appear in a greenish-blue tint. Though not adopted yet to any great extent for illuminating purposes, eight times the quantity of light can be produced with the same power necessary for an Edison lamp. In other words, the energy is converted largely into luminous and chemical rays, while heat rays as in the ordinary bulb are practically excluded. It requires a powerful current for a moment to overcome the high resistance of the cold mercury. When this is accomplished a weaker current passes readily and produces a most brilliant light.

Hewitt's mercury bulb possesses, besides, the peculiar power of converting an alternating into a direct current.

A mercury arc lamp for therapeutic purposes has been used by Sinclair Tousey, of this city, but results are not yet published.

[1] New York Medical Journal, July 1, 1902.

TREATMENT BY BLUE LIGHT.

History. It is with no little satisfaction that mention of General Pleasanton must be here made. Not that we consider that his blue-light treatment of consumption was either highly scientific or successful, but we must look back upon him as the pioneer who forced his grain of truth upon the world's field of knowledge.

This little grain has taken years to germinate and fructify, but the actinic-light treatment of to-day, with all its powers for good to humanity, undoubtedly owes its inception to the investigations his work stimulated. This Finsen himself admits, be it said to his credit.

While the fact that in the apparatus used by Pleasanton and Pancoast the sun's rays were passed through blue glass before reaching the patient makes them eligible to our list of blue-light baths, it renders them unentitled to consideration as actinic-light treatment in our modern acceptation of this term.

Blue light challenges somewhat lengthy and careful consideration because of the many forms of apparatus put upon the market with claims of equalling and even surpassing those made for treatment by violet and ultraviolet light.

In 1871 a most remarkable book appeared, by General Augustus Pleasanton, on "The influence of the blue ray of the sunlight and of the blue color of the sky in developing animal and vegetable life, in arresting disease, and in restoring health in acute and chronic disorders in human and domestic animals."

The theory was advanced that all manifestations of nature are due to electricity.

Several remarkable results are reported of increased vitality in plants subjected to the influence of light which had traversed panes of blue glass, and some results upon animals which were confined in blue-glass pens as compared with control animals of equal physical characteristics surrounded by plain glass. The case of a weak calf that grew strong and well in a blue-glass pen is considered sufficiently convincing to warrant the enthusiastic belief that by the aid of blue light one can mature quadrupeds in twelve months with no greater supply of food than would be used for an immature animal in the same period.

This author finds, conveniently for his theories, that "the exuberance of animal life and the rapid growth of vegetable life in the Arctic regions are said to be unequalled in any other part of our world." He then proceeds to show that the reason for this is the same as for like conditions in the tropics, viz., the intense blue color of the sky.

He says: "Let us attempt a solution. The juxtaposition of plain uncolored glass and blue glass in the passage of sunlight, and the transmitted blue light of the firmament, and the eliminated blue rays of the sunlight through them respectively evolves an electromagnetic current, which imparts to vegetable or animal life subjected to it an extraordinary impulse to the development of their respective vigor and growth. Their vitality is strengthened so as to resist disease."

He maintained that the sudden impact of the intercepted rays on the outer surface of the blue glass, striking it with inconceivable speed, produced a great amount of friction. By friction electricity is evolved, and when opposite electricities meet in conjunction their conflict, according to the celebrated Danish philosopher, Oersted, develops magnetism. The electricity produced by the friction is negative, while the electric condition of the glass is positive. The heat evolved sufficiently expands the pores of the glass to pass through it, and then we have within the apartment electricity, magnetism, light, and heat—all essential elements of vital force.

Following Pleasanton's effort, another work appeared in 1877, on "blue and red light," from the pen of Dr. S. Pancoast, "based upon thirty years' study." This writer considers light essentially nature's remedy. The undulatory or wave theory of the transmission of light is unqualifiedly rejected.

There is nothing of great scientific interest in this book, which serves as an example of how little had really been accomplished up to Finsen's time; although Pleasanton and others fearlessly stood forth in defence of principles and beliefs which, in the light of present knowledge, must be looked on as prophetic.

The supposition in the Pleasanton system was that the blue glass added something to the light which rendered it different from white light. It can readily be seen that white light from which the blue glass had not been permitted to extract nine-tenths of the rays would have been much more efficient, and that the insignificant chemical action of the red rays even would have added something to the total effect, not to mention the chemical rays which are almost totally excluded by white glass and entirely so by blue.

In the system of Pancoast it is assumed that the red light exerts one class of chemotaxis and blue another. It is true that such a difference exists in the inorganic chemical, but it is doubtful if the same effect is known in the animal economy. Pancoast, like his predecessor, labored under the delusion that the blue light was the most powerful chemically, and overlooked the fact that green light is equally transmissible with blue light through blue glass.

Action. While all of the work of Finsen and all procedures based on his method are undoubtedly largely dependent upon the destructive action of the so-called chemical rays, which are found in greatest abundance in the ultraviolet region of the spectrum, it is undoubtedly true that the blue rays, which abound in ordinary white light, and which are known to possess along with the violet the most potent chemical powers of any of the visible rays, have a stimulating action on animal organisms. This statement is made in view of the evident results which have been obtained by some reputable observers who have applied this method, particularly in states of general debility.

There is no convincing evidence that concentrated blue light has any of the qualities of the ultraviolet rays. The failures that have almost constantly followed attempts to treat lupus and similar conditions, in which the aim is toward destruction of morbid tissues, by means of apparatus provided with glass lenses and water-baths through which the rays have to pass, is evidence that the action of blue light differs materially from ultraviolet.

There can be no doubt, however, that patients whose bodies are exposed to light become greatly stimulated, and that when the passage of the light is unobstructed the results are better. Some cures of very serious conditions following exposure to light have been reported, and in so many undoubted cases has decided benefit followed treatment by sunlight, that were one to reject light as a stimulating agent he would be open to the charge of not being open to conviction.

It is evident withal that sunlight and electric light, when permitted to fall upon the human body without too great obstruction from clothing for periods sufficiently long, exert a beneficial action.

It is doubtless the same with white light as with the blue rays alone, but in the present state of our mechanical and optical methods it is necessary to exclude the rays below the green in order to obtain proper freedom from heat in utilizing light rays. For this reason the designation blue-light treatment answers very well for all systems of application of light for purposes of stimulation. On the other hand, a possibility exists that there is some difference in the effects of the white light and the blue light alone or combined with the green and the visible violet. This is extremely improbable, however, for, although there has been found a feeble action in the lower opposite or red end of the spectrum, experiments on animals indicate that the action of white light is exactly similar to that of the so-called chemical rays. It seems, then, that the action is the same in either case, and that the reason for excluding the rays lower than the green is simply to render the heat exclusion more complete.

The chemical action of blue rays is extremely slight and must be regarded as insignificant when compared with the ultraviolet.

We are justified, therefore, in attributing any action, secured from apparatus in which the light is permitted to pass through glass, to the blue rays; and although the color of the transmitted light may be white the apparatus is, strictly speaking, a blue-light machine.

The action of the blue light is, in all of the cases reported, apparently a stimulating one, and destructive action is, in all probability, unobtainable from this form of apparatus.

Effects on Bacteria. The action of blue light upon bacteria is at the present time doubtful. Definite experiments have not yet been made to determine whether the action is stimulating or retarding. One would naturally argue, from the fact that lower forms of animals have been shown to have a tendency to shun the blue light, that the action was a harmful one; but in the absence of definite knowledge upon the subject, and in light of the fact that many bacteria are of vegetable origin, and in view of our modern conceptions of heliotropism, it would be quite as rational to argue that the action was beneficial to their growth as retarding. At all events, it is well known that many human parasites are greatly disturbed by light, and are active only in darkness. Furthermore, in many diseases of supposed parasitic origin the pains and other symptoms are greater at night, while in others, and non-parasitic conditions, the pains disappear with sunset.

Loeb's experiments show that blue and violet lights stimulate animal cells. This stimulation is thought to be due to chemical changes produced. Experiments made by Finsen show that blue light retards growth.

Apparatus and Methods of Application. Sterkel claims that all blue glasses before being employed in light therapy should be analytically examined under a spectroscope to determine the quality of the rays passing through them. It is only blue glass of good quality which is of any therapeutic use; others are of no more value than ordinary white glass, permitting all the colors to pass through.

Kaiser[1] reports very good results from blue light produced by a continuous-current arc lamp supplied with horizontal carbons and a current from 15 to 30 ampères. The carbons are automatically held apart.

The "Volta arc," as it is called, has a very high temperature and contains all the colors of the spectrum. The reflector is in a frame so arranged that it may be revolved in any direction. The light rays are collected and reflected through a parabolic mirror attached at the back of the apparatus. Between the light and the patient is placed a

[1] Wiener klin. Rundschau, 1903, Nos. 16 and 17.

blue-glass window as a filter glass. The glass of the filter is made up of a number of narrow strips, as in this way they stand the heat much better.

To prevent the light from passing between the strips, they overlap. The patient sits at the focus behind this screen, the window of which can be raised or lowered at will.

The exposures generally last about half an hour. When the affection is deep-seated and a more penetrating light is desired, there is substituted a metallic box provided with two large hollow glasses and an arrangement to permit the in- and out-flow of fluids. This is mounted in a small, round frame which can be slipped into the reflector stand. It is filled with an aqueous solution of methylene blue diluted with a solution of alum. The affected parts are placed in the focus of the lens. As the fluid in the lens becomes hot, it should be allowed to flow in and out continuously.

The distance from the reflector to the filter, or to the collector, depends entirely on the intensity of the light. They are so placed as not to be broken by the heat. With a continuous current of 20 ampères the distance should be about two metres, with an intermittent current less than half this distance. The patient should wear gray glasses during treatment.[1]

Kaiser claims to have had as good results with this apparatus as the Finsen method can show.

The various diseases to which the blue light is especially or pre-eminently applicable are not numerous. Many amenable to the blue rays are also influenced by light baths in general, and will be found considered in this chapter.

In employing the Betts lamp a number of observers, including Wilson, have seen good effects upon the healing of ulcers, and as a stimulating application after operation to hasten repair.

Therapy. Asthma. Two cases of asthma were believed to have been aborted in Minin's service.

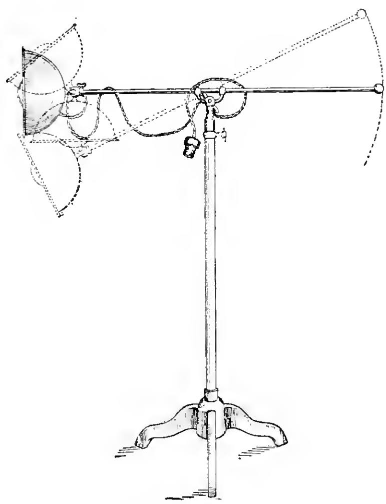
Lupus. The reflex action produced by blue-light exposures Kaiser[2] believes has a powerful stimulating effect on metabolism in lupus and lupus erythematosus.

[1] New Zealand Medical Journal, March, 1901.   [2] Loc. cit.

The influence of these visible chemical rays is directly proportional to the distance and intensity of the light. The light penetrates blood-filled tissues and favors absorption. Pain can be relieved, and it is said actual anæsthesia produced by concentrating the light.

Colquhoun[2] has devised a method for the employment of the blue light in lupus and other diseases. The patient is seated with the back to a window, the sunlight from which is reflected from a mirror placed at some distance

Fig. 88.



Minin's lamp.

in front of the patient. The reflected rays are focused through a biconvex lens of eight to twelve inches' focal length. The rays pass through a bottle containing an aqueous solution of ammoniated sulphate of copper. By the aid of a hand-mirror the patient keeps the diseased area within the focus of the concentrated beam of blue light. The sittings are of an hour's duration.

Neuralgia. Arienzo got good results in six cases, and finds that concentrated blue rays have marked analgesic

[1] New Zealand Medical Journal, March, 1901.

qualities, believing that they penetrate to the deeper tissues, and have an action upon the circulation of the efferent and afferent bloodvessels of the nerve.

The apparatus employed consisted of a bell-shaped reflector sufficient to converge all the light from a thirty-candle power lamp, the patient being at 15 cm. distance, sittings being of ten to fifteen minutes' duration.

Daniloff reports from Minin's service, in the military hospital at St. Petersburg, twelve cases of neuralgic or neuritic affections improved or cured by the application of blue light. The blue light expels the blood from the parts, while the white light causes hyperæmia. One patient who had suffered for nine years from rheumatic neuralgia in one shoulder secured marked benefit.

Tuberculosis. In tuberculosis of the skin and of the articulations Kaiser generally gets his first reaction in from fourteen to twenty sittings. He reports cases of tuberculosis of the lungs completely cured, and others very much benefited.

The visible chemical rays (blue light) increase metabolism through the reflexes. This is mainly attributed to the strongly refracted rays. The chemical rays are the only ones of any value.

The action is in direct proportion to the distance and intensity of the source of light. The light penetrates even the tissues filled with blood so readily that its ability to affect the deeper parts cannot be doubted. It assists resorption and quiets pain. In concentrated form it is even a mild anæsthetic.

The blue-light treatment is instanced in a case, reported by Dr. Antonio Sciascia,[1] of tuberculous peritonitis which was entirely cured by daily exposures to concentrated sunlight which had passed through a filter having glass sides and containing a solution of copper nitrate. The patient was a female child, aged nine years, the etiology being positive. There was considerable ascites and pain in the abdominal region, and the lymphatic nodes of the abdomen were greatly enlarged. These conditions were complicated

[1] La fototerapia, Roma, 1902.

with vomiting, and the urine was scarce and contained a trace of albumin. The treatment consisted in the application of condensed chemical light, which application was made to include the whole of the abdominal and thoracic regions, and was continued for one hour daily. Gradually, though slowly, resolution of the ascites and the size of the chain of glands with amelioration of the pain occurred, accompanied by improvement in the general nutrition. The treatment consumed three months, and now, although five years have passed, there has been no sign of a return of the disease. This result was attained without any internal or external medicinal measures.

NEGATIVE PHOTOTHERAPY.

Red Light. This method, founded by Finsen, is based upon the exclusion of chemical rays just as the positive method has for its basis the utilizing of these same rays of short wave length.

Finsen's attention was first directed to the effect of light upon the skin by some old American and English reports upon its injurious influence in smallpox.

Like many other discoveries in medicine, this one had to fall into desuetude and be almost forgotten, to be revived and firmly established later on.

In febrile infectious diseases the belief has long existed that much benefit was to be derived from surrounding the patient with an atmosphere of red.

Monmenu[1] relates that a son of Edward I., King of England, was wrapped in red material during the whole course of his illness from smallpox. This author has treated measles, scarlatina, and variola with red light and finds it of real worth in the first-and last-mentioned affections, but does not pass final judgment in the case of scarlatina. He believes the mode of action to be not so much the effect of the red light itself as the influence the latter exerts in shutting out other rays which would prove irritating.

[1] Rev. de Méd. y Cir., No. 40, p. 745.

In measles there was a quicker course to the disease and a beneficial effect on the conjunctivitis.

In variola, according to Finsen's observations, daylight has a decidedly injurious effect upon the suppurative stage and course of variola and consequently upon the death rate. Aside from this, if his contention is true that the suppurative stage is prevented or greatly modified, the resulting deformity from pitting will be lessened—in itself a great desideratum. He states[1] that the greatest number of fatalities are due to the suppuration, and that the mortality is surely diminished by diminishing suppuration.

So sure is the author of his position in this matter that he considers it unwarrantable for health authorities to treat these patients in daylight. It is also looked upon as a shortcoming on the part of any physician not to make provision for carrying out this treatment as soon as a diagnosis of smallpox has been made.

All necessary light in a red room may be supplied by a candle.

When treatment is carefully carried out we find, as a rule, that the secondary fever is lacking or only slightly marked, and that the course of the disease is very much shortened.

If it is adopted before the suppurative stage begins, it will in most instances prevent suppuration, but if the latter has already begun it will not stop it. Some authors believe that by preventing suppuration we also lessen the danger of spreading infection.

Empiricism here, as in many another instance in medicine, preceded the scientific explanation and application of the principle. The use of red curtains and similar devices in olden times has been spoken of in Chapter XXI.

Contraindications might be found in a peculiar excitation to which patients and attendants are at times exposed from the continuous red-light atmosphere.

Treatment by Red Light. At the present time Finsen does not consider a red room for treating variola adequate unless it fulfils the requirements of a photographic dark or

[1] British Medical Journal, June 6, 1903.

developing room. As a test for the quality of light he suspends a photographic plate in the room in which the patient is being treated, and if it becomes blurred he regards the method as faulty and does not expect good therapeutic results.

He claims that it is absolutely essential to carry out the following rules to get satisfactory results:

1. The exclusion of chemical rays must be absolute. The skin in smallpox is as sensitive as a photographic plate, and must be protected in the same manner and with similar care. If red window-panes are employed, these must have a deep-red color, and if one uses curtains these must be very thick, and several must hang one behind the other. When the patient has his meals or upon the visit of the physician, artificial light—for example, a weak lamplight—may be used without danger.

2. The method allows of other kinds of treatment being carried out at the same time.

3. It is to be applied as soon as possible; the nearer one comes to the stage of suppuration, the less chance one has of accomplishing his object.

4. The patient must remain in the red light until the pustules are dried up.

That red light may also have some deleterious influence is shown by the fact that a cerebral excitation was noted by Bayle in a manufactory of photographic articles among the men who worked in the red room. When the red window-panes were replaced by green, these symptoms disappeared. He recommends similar substitution in the event of smallpox patients developing psychical or mental conditions not attributable to the disease.

Bouchacourt finds that red light has the same effect on smallpox as darkness, while experiments on animals indicate that those showing a decided liking for light (butterflies) prefer blue chemical rays, and such animals as show distaste for light (tadpoles) prefer red rays. White light being a stimulant, whose action is due almost entirely to the chemical rays, it seems reasonable to suppose that it would exert beneficial action on sluggish, sloughing tissues.

In the vegetable kingdom, experiments by Flammarion show that sensitive plants, such as strawberries, grow exuberantly under red glass, and they have greater fragrance than those grown under other colors.

The influence of different colored light upon the eye opens up a subject of decided interest.

It has been claimed by some German observer that wearing red glasses prevents seasickness. It is doubtful whether the question has ever been tested with sufficient scientific accuracy.

In my own case I can report that on six transatlantic voyages I was invariably made most ill. On the seventh and eighth passages, in which a test of the glasses was made, I escaped without the slightest feeling of uneasiness. In a rather rough passage from Cadiz to Tangier, in which almost all on board a small boat were affected by the tossing and pitching, I again wore the glasses and remained unaffected.

The red has, it seemed to me, a soothing effect upon the eyes, but just how this acts upon the vomiting centre or stomach I do not attempt to explain.

Oculists who have studied the influence of different colored glasses incline to attribute any beneficial therapeutic effects not so much to a direct beneficial influence upon conditions present as to the indirect good effect of shutting out those rays which would irritate and prove injurious. Amber-colored glasses have of late attracted much attention.

Some years ago, it will be recalled, English artillerymen were furnished with amber glasses, which seemed to improve their accuracy of aim.

Courmont calls attention to the distressing features of the red light in variola, and Pleinikoff observed delirium and hallucinations which he attributed to the light.

Schamberg treated two patients under red-light influence with negative results, one patient succumbing, the other being badly disfigured.

Dr. G. H. Fox, at the New York Smallpox Hospital, after extended trial found little benefit from the method. It should be mentioned, however, so far as reports have been made, that no one in this country has applied the method strictly according to the directions of Finsen.

Erysipelas. Recognizing that erysipelas in its highly inflammatory condition would undoubtedly be benefited by any measure tending to lessen the irritation to which it is constantly exposed from all outside sources, H. Krukenberg has treated thirteen patients by the "red-light" method of Finsen. The author thinks there is no action of the red rays *per se*, considering them as inert for the time being, and attributes all of the effect obtained to the exclusion of the irritating chemical rays.

Measles. Monmenu and Lopez Reinoso[1] claim that in measles the beneficial effect of red light on the conjunctivitis is in direct proportion to the amount of other rays excluded. Its effect is purely symptomatic and does not affect the general course of the disease in any way whatever.

Von Puyadon believes that red light exerts a favorable influence by diminishing fever, bringing about a more rapid appearance of the rash and a milder degree of desquamation. He recommends red curtains and says that they should be placed at the windows at the very beginning of the disease.

[1] Klinisch.-ther. Wochenschrift, Wien, June 14, 1903.

PART V.

ACTINOTHERAPY.

CHAPTER XXV.

INTRODUCTION.

As we have seen in considering light therapy, attempts have been made at many stages of the history of medicine to utilize to a greater or lesser extent the supposed healing and prophylactic qualities of the sun's rays.

It is no great matter of surprise that this has been so. Indeed, it would seem strange, if, having as we do daily evidence of the great power in nature of the sun's rays, no attempt had been made to secure its beneficial influence over disease.

Naturally the earliest observations had to do largely with surface effects, and it was noted that the overproduction of pigment and its deposit in the skin exercised a protecting influence against the burning properties of the sunlight.

It was likewise early observed that when the sun's rays were permitted to act too powerfully upon usually protected surfaces this protecting pigment did not have time to deposit in the skin, and the rays, especially in prolonged exposure, produced redness, blistering, and signs of inflammatory irritation. These effects were almost universally believed to be due to the sun's heat.

It remained, however, for our own times and for a representative of to-day's scientific advance—Charcot—to demonstrate by experiments that the long-considered heat effect was in reality a chemical-ray effect.

The sunburn is a sun-cautery. It has been historically well established that focusing lenses or "burning-glasses" have been in use at various remote and modern periods for the removal of growths and cure of circumscribed areas of surface disease.

In the very affection for which light therapy is now so extensively used—viz., lupus—dermatologists employed sun-glasses many years ago. Naturally the application was limited because it was not known that the calorific rays could be and should be excluded, nor how to exclude them.

History. In tracing the history of modern light therapy we must record the story told of a Berlin watchmaker, giving it for what it is worth.

Four or five years ago the man in question having lupus of the face, for which he had been treated in the clinic of Professor von Leyden, but without benefit, left the hospital and resumed work. He was in the habit of using lenses of high power. One day, while examining the inside of a watch, standing close to the window the rays of the sun passed through the lens and focused on a part of the affected area. He felt a sharp pain, and on looking into a glass he saw that the burnt spot had become white. He repeated the experiment on the following days, keeping the lens sometimes for hours between the sun and affected areas. In six weeks cicatrization had taken place, and the patient went to exhibit himself to Professor von Leyden, who had declared that the disease was incurable.

No matter what views were held on the subject by others, or what crude attempts were made in similar directions, the credit for developing a method worthy of the name belongs wholly to Finsen. Many deserve recognition as pioneers who cleared the way and removed the obstacles.

Among such may be mentioned Widmarck,[1] whose experiments with ultraviolet rays led him to utilize in his work the knowledge of the difference in permeability of rock crystal and glass.

Attempts to send the rays through glass were negative, while when passing through crystal erythema followed by desquamation was produced.

[1] Hygeia, Festband; 1889, No. 3.

CHAPTER XXVI.

PHYSICAL EFFECTS OF SUN AND ARC LIGHT.

The lesions of summer hydroa have been reproduced experimentally by Möller,[1] and the erythemas and other effects intentionally caused were similar to those produced by Leredde and Pautrier and showed similar histological changes. Having determined that the physiological effects and histological changes of sun and arc light are practically identical, it naturally follows that the same rays in each source would be suspected. Bouchard[2] found that different colored rays affected the human skin quite differently; that while the red focused by means of a prism upon the skin for thirty seconds produced no result, the violet was capable of producing a blister. While seventeen minutes or eighteen minutes were necessary for the yellow and green to cause redness, the blue produced it in fifteen minutes and the violet in twelve minutes; besides causing a raising of the epidermis. The colorific rays were practically excluded in these experiments from participation in the results.

Finsen[3] repeated these experiments by exposing his arm to an 80-ampère arc light for twenty minutes. Some areas of skin were protected by pieces of glass and India ink, while others were covered with rock crystal. Where the latter was applied, the skin was at first red and hot, like the unprotected parts, but the general redness, being due in part to heat rays from too great proximity to the light, appeared promptly, just like any burn or calorific effect, and, being superficial as this was, likewise soon disappeared, as does the erythematous degree of burning.

[1] Die Einfluss des lichtes auf der Haut, Stuttgart, 1900.

[2] Compt.-rend. de la Soc. de biolog., Paris, 1877.

[3] Mittheilungen aus Finsen's Lysinstitut, Leipzig, 1900

The portion beneath the crystal acted differently. Some hours after the experiment the parts not protected by glass and India ink showed a redness which increased during the next day.

This same thing is seen in the reaction following therapeutic application of actinic rays, and it is seen in sunburn; the effect comes on after some hours and increases for about two days, when it begins to decline and desquamation is practically effected in from five to ten days.

Sunburn may, when severe, lead to internal complications, kidney involvement, and even death in rare instances. The portions of skin on which pieces of glass had been placed before exposure contrasted markedly by their freedom from redness with neighboring parts and those where the rays had pierced the crystal disks. There was likewise a remote or chronic effect shown by redness noted by Finsen some months after personal exposure, due to persistent dilatation of vessels and experimentally produced by him also in the tail of pollywogs.

There is a slowing of the blood current, stasis, and emigration of white and a few red blood corpuscles. Another chronic effect is that of pigmentation, a defence, as it were, against the injurious agent.

Penetrating Quality of Ray. Several observers have demonstrated experimentally the deep penetration of the rays employed in therapy, and Finsen has proven for concentrated light the power of transillumination. Hans Jansen's experiments with rabbits' ears in the Finsen laboratory have been referred to. Gebhardt[1] photographed the bones of the hand with a 9-ampère lamp. Gottheil and Franklin have proven the penetrating quality of the ray by producing photographs with rays which have penetrated the body of a boy. Finsen demonstrated the greater and quicker penetration when parts were dehæmatized; hence the practice of compression, adrenalin application, etc.

Godneff showed the sun's chemical ray penetration of the integument by inserting tubes containing silver-salt beneath the skin of animals. Those exposed turned black, while in

[1] Die Heilkraft des Lichtes, Leipzig, 1898.

the animals kept in the shade no change took place in the salts. That the luminous rays also penetrate is readily demonstrated by various processes of transillumination.

Originally, exposures were carried to the extent of several hours, but due to the improvement in apparatus, enabling us to get a much more concentrated light, the exposures have been very much shortened.

Dehæmatizing or Exsanguinating Methods. In the employment of ultraviolet rays, whether the original method of Finsen or any of its modifications are used, it has until recently been necessary to employ one or another method of compression of the tissues to be operated upon, because the circulating blood prevented the proper penetration of the rays. The discomfort, pain, and other objectionable features led Jamieson[1] to employ adrenalin for its vasoconstrictive properties. The simple application of the ordinary 1 : 1000 solution to a patch of lupus was found sufficient. A séance lasting one hour was found possible without compression.

Piffard has recently used the same substance, driving it into the tissues by means of cataphoresis. One minute suffices to produce dehæmatization of unbroken, sound skin, lasting from one-half to one hour. We may venture the prophecy that this method will supersede painful compression in the near future.

The apparatus of Foveau-Trouvé has been used by Du Castle without the employment of compression, and good results have been secured.

Finsen, however, condemns attempts to do away with the compression.

The Way the Ray Acts. In a period of time varying from one to twenty-four hours after an application, redness of the part treated or signs of inflammatory reaction set in. This reaction, according to Leredde and Pautrier, is late in occurring, and lasts a length of time in direct proportion to the length of exposure and depth of effect. Usually there is œdema and serous exudation, producing crusts; at times bullous formation. In about eight days all signs of inflam-

[1] British Medical Journal, June 21, 1902.

mation have usually subsided, and are never followed by destructive action other than erosion. The effects upon deeper-seated disease processes becomes apparent as the redness disappears.

The superiority of this over former methods is the power of the ray to penetrate to the depths of lupous infiltrations.

To secure good results it is not necessary to produce pronounced blistering. A certain idiosyncrasy exists for this as for other forms of light treatment, some patients requiring longer exposures and some reacting scarcely at all.

Weir[1] says the effects must be obtained primarily through stimulation of the vasomotors. There is dilatation of blood-vessels and increased flow of blood.

This incites the production of new cells, and new tissue is formed.

Freund, among others, believes that the ultraviolet rays are largely absorbed in the epithelial layers, and that the more penetrating rays, the longer red, may also have a value. Blue and green also have their effect.

As usually administered the rays from the blue to the ultraviolet are made use of, including the indigo and violet. This is also true when the light is derived from a low-tension arc.

There seems to exist, at the present time, some doubt as to the exact nature of the action of the ultraviolet rays. Some contend that the effect on the granuloma in lupus is entirely a destructive one, and that this destructive action is indirectly produced and is simply the result of an ordinary inflammatory reaction; these further assert that the action of the ray is confined to the affected area only and that the doubtful tissue in the neighborhood of the lupous patch may be exposed with impunity, and that if it is affected it will react, but not otherwise. They also hold that the inflammatory reaction is capable, by judicious application, of being rendered so mild that the regeneration of the tissue is rather stimulated than retarded; so that the lupoid granuloma is replaced by a healthy tissue scar. Other authorities hold that the action of the ray is purely bactericidal, and

[1] Scientific American, November 22, 1903.

that the cure of lupus directly follows the destruction of the tubercle bacilli in the skin. A few go so far as to imagine that the action on all tissue is exerted to so stimulate it that it grows up in greater strength, destroying the morbid condition in some mysterious manner, and transforming it into normal tissue.

The effects are undoubtedly partly bactericidal and partly inflammatory, but the microscope indicates that the photochemical action is of greater importance than the bactericidal.

MacLeod[1] found the destructive process the result of an ordinary inflammatory reaction, and the repair is similar to that after inflammation.

So concisely scientific has Finsen been in all of his work that his utterances of the early days of the method can stand to-day unchallenged.

What has been most striking is his attention to the minute details and the great caution displayed. The superiority of the method lies solely in our ability to effect a radical cure in a large number of instances of rebellious lupus, which resists all of the older methods. Its recognized worth led to a widespread effort to simplify apparatus, reduce expense of application, and at the same time to perfect a lamp which would give chemical rays in great abundance. In this effort electrodes were introduced, giving an almost cold light, and producing with a low electric intensity an enormous quantity of ultraviolet rays. Leredde[2] thought at first that the Lortet and Genoud lamp would produce in fifteen minutes as great effect as the original Finsen apparatus in one hour. He has recently informed me, however, that he has discarded this lamp in favor of the new Finsen-Reyn model. (See Fig. 97.)

Histological Effect of Ray. Photoelectric erythema has been studied by Leredde and Pautrier[3] in two sittings of seventeen minutes each. The arm of one of the observers was exposed to the rays of the Lortet-Genoud lamp. A portion of skin was excised in the first instance one-quarter hour after the sitting, and a dilatation of some bloodvessels was the only change noted. In the second test, a portion excised

[1] British Medical Journal, October, 1902.

[2] Ann. d. derm. et de syph., December, 1902.

[3] Loc. cit.

twenty-four hours afterward, the epiderm showed evidence of vesiculation. There was œdema of the derma separating slightly the connective-tissue bundles; there was here likewise a dilatation of the bloodvessels, also of the perivascular spaces and a moderate cellular infiltration. The important change seems to be a slight proliferation of the fixed cells, or, rather, a tumefaction which made their smaller protoplasm more apparent. All these changes, the authors say, correspond to those found by them in the histology of sunburn. The horny layer was partially exfoliated in spots and some cells were seen which had preserved their nucleus. Vascular dilatation with the endothelial cells, showing some figures of karyokinesis; the connective-tissue cells are swollen and here and there karyokinetic. Lymphocytes forming little masses seemed to occupy lymphatic fissures. Mast-cells more numerous than normally. A uniform condition of sclerogenous inflammation existed. In lupous tissue there is found the same dilatation of vessels and a generalized sclerous change.

Under high power there is seen slight hyperkeratosis in the corneous layer, and marked thickening of the granular layer.

In a word, there is a fibrosclerous change of great regularity without atrophy. New connective tissue invades the lupous areas.

The microscopic changes are found to include the deeper structures, substantiating the claim of penetration. The resulting cicatrices are characteristically soft and white.

The Bactericidal Working of the Ultraviolet Ray. The bactericidal has been looked upon as one of the chief influences to which radiotherapy owes its utility in lupus. Many have regarded it indeed as secondary to the changes produced in the tissues. Nagelschmidt,[1] working in Lesser's clinic, found that light does kill bacilli, and that it is because of the cessation of the irritation they produce in the tissues that the absorption of morbid products becomes possible.

With all due precautions he rubbed into the shaved, scarified backs of guinea-pigs living cultures of tubercle

[1] Arch. f. Derm. u. Syph., No. 63, 1902.

bacilli in two symmetrical places. After the produced wounds were healed, there were noticed local changes in the skin, and portions on one side were excised after having been exposed to the action of light for one hour, while portions on the other symmetrical side of the back were excised, without having been previously exposed to light. The excised portions were inoculated into two series of guinea-pigs; one series was inoculated with the tissues upon which the light acted for an hour; the other series was inoculated with the tissues not acted upon by light. Eight guinea-pigs out of nine of the first series remained free, while all of the second series were affected with tuberculosis. The ninth guinea-pig of the first series showed tuberculosis of both testes, bladder, and kidneys.

The clinical observations were abundantly confirmed in all instances by exact laboratory findings.

Improved apparatus is capable of producing a ray which will destroy the vitality of the bacillus prodigiosus in the short space of two seconds, and by intensifying the light we find that the length of time necessary to kill bacteria is very much shortened. In fact, in testing a new apparatus we can expose cultures to their rays and judge the intensity of the light by the length of time it takes to destroy the various germs. Jansen has demonstrated that chemical rays may kill bacteria at a depth of two millimetres in the skin. The ultraviolet rays have been demonstrated by Dieudonné to have decided bactericidal effect. Tubercle bacilli have been shown to be destroyed by sunlight (Koch), and also the plague bacillus (Kitsato), while the germs of tetanus are said to be killed more quickly than by some strong germicides.

The bacillus prodigiosus, unaffected by a five-minute exposure to a Dermo lamp, was killed in less than a second by a 70-ampère carbon lamp.[1]

Tests for Violet and Ultraviolet Rays. The ultraviolet rays can be reflected, refracted, and polarized. They will not pass through some substances that are perfectly pervious to luminous rays—for instance, glass. They will have no influence on deep and even on superficial tissue unless the

[1] Busck, Dermat. Zeitsch., 1903, Bd. x.

latter are first dehæmatized. They may be stopped by a sheet of paper. They will rapidly destroy the vitality of bacteria. They have the power to pass through rock-salt and quartz, and will discharge a negatively electrified body. Rock-salt, it will be remembered, is opaque to x-rays and likewise to radium emanations.

In testing for the presence of ultraviolet rays in any given luminous field, certain substances which are known to fluoresce in the presence of these rays are employed.

Such substances are willemite, or the silicate of zinc, which gives a bright-green fluorescence; the polysulphide of calcium giving a blue phosphorescence in the presence of ultraviolet, while the x-ray causes only a white phosphorescence, etc.

The x-ray as well as the ultraviolet will produce fluorescence of willemite. To distinguish Roentgen rays from ultraviolet the polysulphide of calcium should be employed.

To distinguish violet from ultraviolet rays it suffices to interpose glass between the test object and the luminous source. If the effect persists it is due to violet rays, since the glass is impervious to the ultraviolet.

Much confusion has occurred in testing various lights for the presence of ultraviolet rays.

Willemite exposed to the condenser spark gives brilliant fluorescence; exposed to ordinary low-tension arc light, moderate fluorescence; exposed to a condenser spark with quartz interposed, there will be no appreciable diminution of fluorescence; with glass interposed, instant disappearance. It fluoresces when exposed to low tension-arc light, even when glass is interposed, showing that the fluorescence is not due to ultraviolet, but to luminous rays. In the presence of ultraviolet rays fluorescent solutions change color: orange eosin becomes gamboge, straw-colored æsculin changes to pale blue, the surface of a solution of quinine takes on a characteristic blue, and paraffin oil becomes likewise blue; yellow fluorescence changes to green.

All these various changes may be utilized in testing for the presence of ultraviolet rays, but no one test should be depended upon, and it is advisable to resort to it at least two or more tests to make the test conclusive.

CHAPTER XXVII.

PHOTOTHERAPEUTIC APPARATUS.

An ideal apparatus for the administration of the ultra-violet rays should embody the following essential features. a source of light, a system of condensing lenses or mirrors, a system of screens for separating the heat from the light rays, and some mechanical means of orienting or accurately adjusting the direction of the beam of light.

The source of light should be available for use at any time and should be under the complete control of the operator at all times. It should give the maximum of chemical rays and the minimum of heat rays. Also the total amount of energy generated should be as great as possible.

The condensing apparatus should be able to collect as much of the energy that is generated in the source of power as possible, and should not in any way interfere with the transmission of the energy.

The cooling system should abstract as much of the heat from the total energy coming from the source as to render the application of the remaining chemical rays absolutely free from any of the injurious effects of heat. It should not interfere with the transmission of the chemical rays.

The whole should be mounted in a stand that will permit the focal point of the light to be placed at any place desired, and it should be oriented with very little physical effort and with very fine adjustments.

This ideal is approached in a greater or less degree by each of the instruments that has been used by the different phototherapists who have proposed or devised apparatus. Mechanical and physical difficulties intervene whenever it is attempted to combine all of the features of an ideal apparatus in one instrument. Where the source of light is very large the amount of heat that accompanies the chemical rays offers grave difficulties; where the heat rays are well eliminated the chemical rays also suffer absorption, and so on; we find that the perfection of one feature of the apparatus usually acts to render another less perfect.

Sources of Light. Sunlight has been practically abandoned as a source of chemical rays for the purpose of phototherapy on account of the uncertainty of obtaining it when required. There are but few places where the direct light from the sun can be depended upon with any degree of certainty; besides, it has been found that the light from the electric arc lamp is much richer in the ultraviolet rays than the direct sunlight. This is due in a measure to the atmosphere of this planet, which is a great absorber of the rays from the ultraviolet region of the continuous spectrum. It is also due to the fact that the sunlight is obliged to pass through numerous strata of gases which surround the sun and exert a powerful absorptive action upon the different rays. These different gaseous strata we recognize by the appearance in the solar spectrum of numerous black lines or absorption bands, called Fraunhofer lines from the name of their first observer. Each line represents a region of the spectrum that has been absorbed or abstracted from the total light of the sun by some matter through which it had to pass on its way into the universe. Over four thousand of these lines have been carefully tabulated and mapped out in the solar spectrum, and there is a great probability that these will be added to when the infrared and ultraviolet regions have been more thoroughly observed. This will, in a measure, serve to make it clear that the light from the sun as it reaches us is not so rich in chemical rays as a study of its chemical composition might lead one to believe. It is known that the light from an electric arc lamp is very much richer in the ultraviolet rays than that of the sun, and that from an electrostatic spark is much richer in the chemical rays than either and possesses less of the heating element. It is for this reason that the light from the arc or the electric spark is much better for our purpose than that from the sun. On the other hand, where the sunlight can be depended upon, it offers advantages which the others, with the possible exception of the electric spark, do not possess. It is cheaper, costing nothing to utilize in any quantity; the far greater intensity, being equivalent to 670,000 candles at the distance of one foot at the earth's surface, is sufficient to overcome in actual intensity the superiority of the artificial light. Arc lights are commercially reckoned to give in a rough way 200-candle power at each 50 watts consumed, or 4000-candle power per kilowatt. This is generally expressed in ampères, since the voltage in all arcs is approximately the same (about 50 volts); it is said that the light will be equal to 200-candle power to the ampère. There have been no authentic measurements of high-power arc lamps, and so we can only estimate the power of large lamps on these insufficient data. Accepting these imperfect results, we have a high-power arc—say, of 80 ampères—which will amount to 16,000-candle power, or about one-forty-second part that of sunlight. In such a vast difference it is more than probable that the amount of chemical rays lies in favor of the sun for quantity. We have at our disposal another factor in the production of artificial light which somewhat modifies the question, and that is the addition to the arc or spark, as the case might be, of some substance whose spectrum is known to be in the ultraviolet. The substances at our disposal which have been tried practically are chiefly iron and magnesium. Lithium has a band in the violet, but no satisfactory results have been obtained with it in phototherapeutic experiments. It is found that the arc in which a small amount of iron is volatilized has a spectrum in which the blue rays are predominant, and the violet and, in a less degree, the ultraviolet rays are more in quantity than in other spectra that are commonly at our disposal. In the spark, if the tips of the oscillators are made of iron, very little difference can be noted in the spectrum than in the case of carbon, perhaps owing to the fact that there is only a very minute quantity of the metal volatilized. The blue color of the arcs in the Kjeldsen and Bang lamps is, perhaps, due to the great absorption of heat rays by water circulating in close proximity to the arc, and not to any of the iron being concerned in the formation of the light. That there is any iron volatile in these lamps is extremely improbable, as the heat of the arc is so low that no other cooling than the internal circulation is necessary to make it tolerable to the skin, and the volatilizing point of iron is placed at over 1700° F.

It is extremely probable that the light waves in an electric disruptive discharge or spark are excited in consonance with the Hertz and other waves with which we have perhaps not as yet become acquainted, and bear a certain ratio to the other waves which places them almost exclusively in the chemical region of the spectrum. In accordance with the accepted theory of light it is probable that these waves of short length are accompanied by others of gradually increasing length which are in all probability exact multiples of them. This is suggested by the fact that the continued disruptive discharge from the static machine or the induction coil rapidly changes from violet to a redder tint, when the difference in potential is lessened and the quantity is proportionately increased, while the Herzian waves, excited by a short, "fat" spark, are said to differ materially from those excited by a longer and thinner spark.

At all events, when the spark from a high potential discharge has been utilized as a source of chemical rays, the results have been very satisfactory.

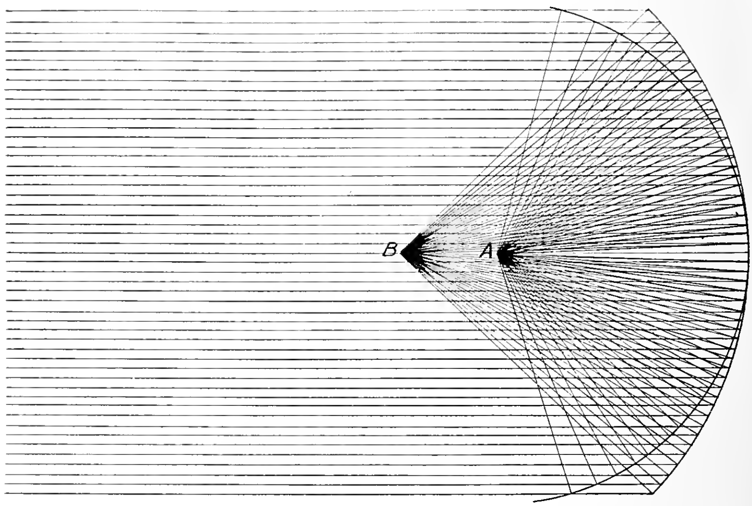
Varieties of Lamps. We will consider first apparatus in which the light comes from an artificial source.

Lamps of the incandescent pattern are not worthy of mention except to condemn them. Any apparatus depending upon incandescent electric lamps for their energy are fundamentally wrong, and if any effect is secured from them, which is extremely doubtful, it must be attributed to the heat rays, of which there are a great many generated. In the first place, an examination of the spectrum of the filament in an incandescent lamp will reveal the fact that it is possessed of a very feeble and short ultraviolet region which stops far below the point where sun or arc light are known to extend. It appears from many observations that the incandescent filament excites in the ether only waves of comparatively short length. This is in a measure corroborated by the yellow color of the light. The largest incandescent lamp is limited to about 100-candle power, consuming about 350 watts, and, as the energy generated in the electric lamp bears a certain ratio to the current consumed, it will be seen that at best these lamps are weak compared with lamps consuming five or more times the power. Even if the lamps could be made very much larger, or could be greatly multiplied in number, the result of the multiplication would be to increase the heat rays, as no number of lamps will render the spectrum any longer than that of one lamp, though it will intensify what there is of the one. Also, there is the fatal condition of the light having to traverse the glass of the globe. There does not exist at the present time in commercial form a glass that will not absorb the greater amount of the chemical rays. All of the observations that have been made on chemical rays have been accomplished by means of rock-crystal prisms or the diffraction spectrum gratings, either ruled upon plane rock-crystal plates or upon a non-absorptive reflecting surface. The substitution of blue glass does not in the least help so far as the result goes, as all of the rays are generated in the filament, and the fact of traversing a colored glass can only effect an absorptive action upon the light and not add anything to it.

The condenser may be a reflector or a lens. A condenser of the reflecting type must be so computed that the rays which are collected will be brought to a focus at a point as near the condenser as conditions will permit. The intensity of any beam of light at the focal point will depend on the angle formed by the extreme rays at the margin of the beam. Thus, if the focal point of the beam be near to the reflector the strength of the light at the focal point will be greater than if it is remote. This is illustrated in Fig. 89. Here the rays, striking the reflecting surface, are represented as parallel or coming from an infinitely distant point. If the rays are brought to a focus at the point A, the angle will be greater than the angle at B if the rays are focused at the more remote point B. The light intensity at the focal point will vary as the square of the angle. The angle may be increased in two ways, viz., by increasing the diameter of the reflector, and by bringing the focal point as near to the surface of the reflector as possible. The light is placed at a point in the axis of the curvature of the reflector and at such a distance that the rays will be brought to a focus as near to the reflector as convenient, as seen in Fig. 90.

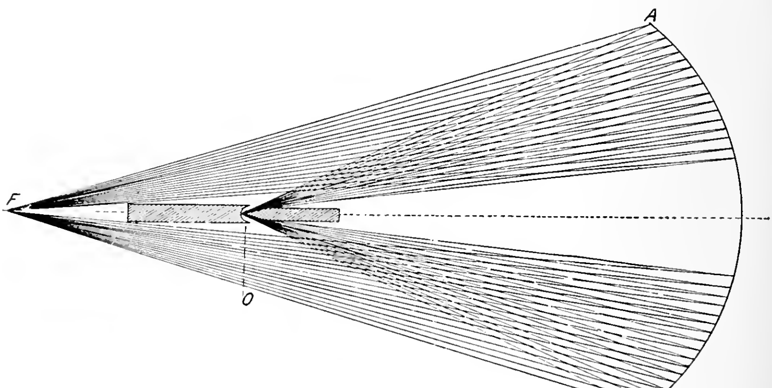
Here the carbons of the lamp are placed with their axes in the same line as that of the condensor, as favoring the transmission of as great a quantity of light from the positive

FIG. 89.



Showing the determination of strength of concentration for reflectors of the same size, but different curvature.

FIG. 90.



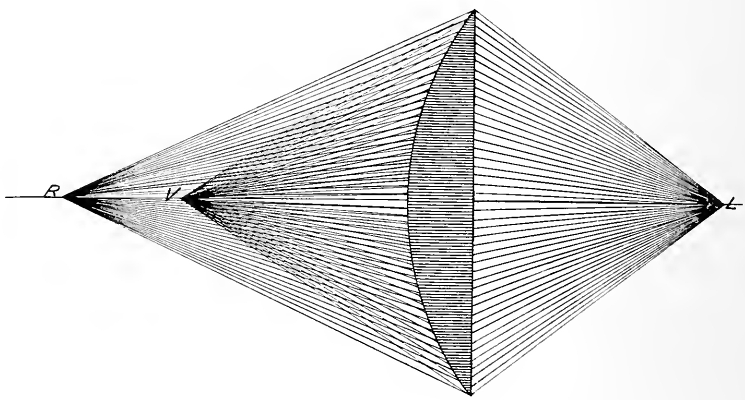
Illustrating loss of light for reflectors by the interposition of the carbons.

pole or crater to the condenser as it is possible under the circumstances. It will be seen from the cut that reflectors have the disadvantage of losing a portion of the light that is reflected by the interposition of the carbons, and that a great quantity of the light from the positive carbon is shut off from the reflector by the interposition of the negative carbon. If the carbons were placed with their axes at right angles to that of the reflector, only a small portion of the light centre would be turned toward the condenser. Another great drawback to the use of reflecting condensers is, that unless the curve is precisely computed the rays will not all meet at one focal point. An optically perfect reflector would cost an enormous sum, and is, therefore, out of the question for general use. If the reflector is made of glass with the silvering on the curved surface, the great heat to which it is subjected would ruin the silvering almost every time that the machine is used, and if the silvering is on the back of the glass the light is made to traverse the thickness of the glass twice before coming to a focus, and glass absorbs almost all of the chemical light, rendering such an apparatus useless. Another very serious objection to the reflector is that the heat rays are focused in identically the same points as the light and chemical rays, and where there is a powerful source of light the amount of heat is considerable and offers untold difficulties in its elimination.

The condenser may be a positive lens, in which case the rays pass from the arc through it and are brought to a focus at a point on the other side of the lens. The advantages of a lens are: that the acromatic error of all uncorrected lenses causes the rays to come to foci at different planes for the heat, the light, and the chemical rays; and that if they are properly proportioned with regard to relative curvatures of the surfaces, the rays of one length are focused in practically one plane. In Fig. 91 it will be seen that there is a space between the focal point of the heat and chemical rays, which renders the process of cooling the beam to the point of tolerance very much simpler than where the heat and chemical rays focus in one plane. In the figure, *L* represents the source of light, *V* the focal point of the chemical rays, which are the most refrangible and come to a focus sooner than the red or heat rays, which are the least refrangible and focus at *R*.

The disadvantages of the lens are that the surfaces reflect a quantity of light that otherwise would enter and be transmitted; owing to the fact that there is constant danger of overheating the glass, the light cannot be placed very near to the lens, and consequently the angle formed by the rays transmitted is very small. Even if the light were approached very close to the lens there is a natural limit to the rays transmitted which is decided by the angle at and beyond which all of the rays are reflected backward and do not enter

FIG. 91.

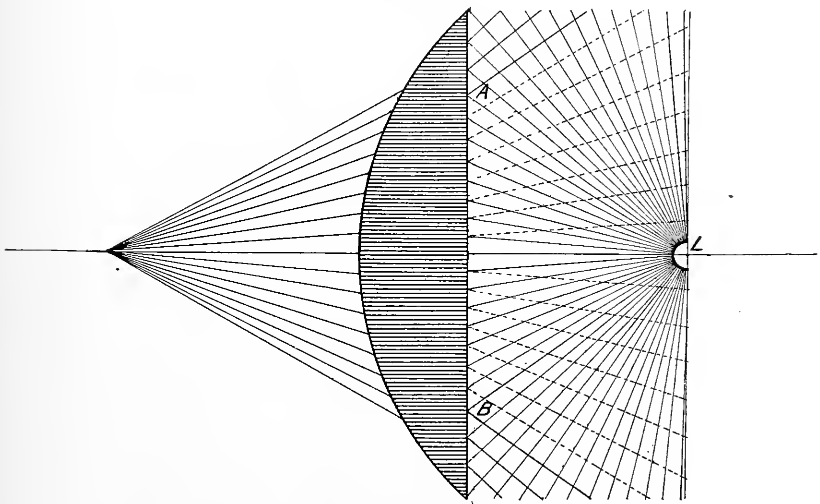


Illustrating the different foci of chemical rays (*V*) and the heat-producing rays (*R*).

the lens; this is called the angle of total reflection, and the angle formed is called the "critical" angle. This is illustrated in Fig. 92, where *L* is the light source and *A* and *B* are the points at which the angle of total reflection has its vertex. It will be seen that there is reflection of light at every point, and that the amount of this increases as we get farther from the centre until the point is reached where the amount of light that enters the lens is smaller than that reflected, and so on until there comes a time when no light enters the lens at all. This limits the available angular aperture of lenses to something under 73 degrees for ordinary glass.

Lamps. Because of the great expense, size, difficulties in maintaining, and in the United States for the further reason that there is comparatively little lupus to treat, there has arisen a demand for inexpensive appliances. Many of the newer lamps have limited actinic possibilities, and some have been used from which little or no actinic rays could be expected. The original arc lamp represented 50 to 60 ampères, and from the light there radiated a number of telescopic tubes cooled by their containing water.

Fig. 92.



Illustrating critical angle of lenses.

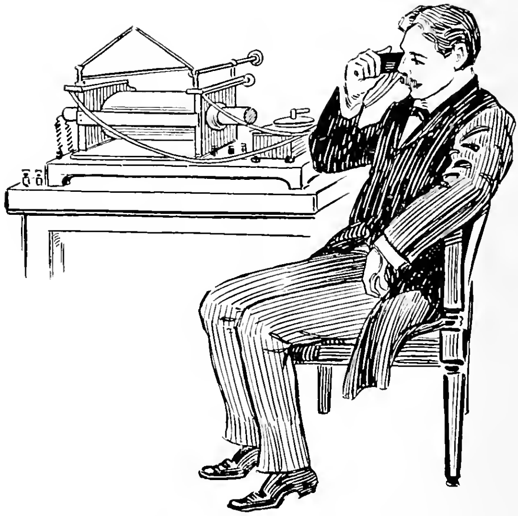
Illustrations of the smaller varieties of lamp and methods of easy or self application are shown in Figs. 93 and 94.

The modified Görl, of flat model, might be bound on, as shown, or the regular oblong form can be held with or without a handle by the patient.

The limited success attending the use of various apparatus is largely due to attempts to shorten the sittings.

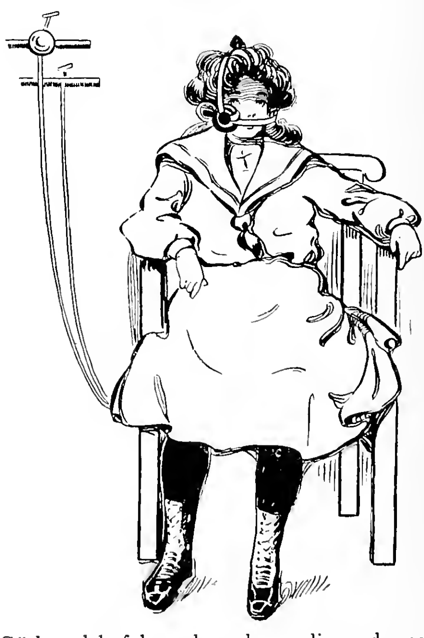
Finsen finds that to obtain the best results lamps require a current of 60 to 80 ampères. With such lamps the same effects will be accomplished in twenty to twenty-five seconds, which with a 40-ampère lamp require four to five minutes.

FIG. 93.



Patient holding Piffard lamp (condenser interposed between coil and patient).

FIG. 94.



Görl model of lamp bound over diseased area.

The solar apparatus consisted of a large, hollow lens, having a diameter of 20 to 40 centimetres, mounted on a stand, and movable in all directions. It contained a solution of ammoniated sulphate of copper to absorb and filter out the caloric or heat rays. Uncolored water can also be used, and has, in fact, largely superseded the colored solutions.

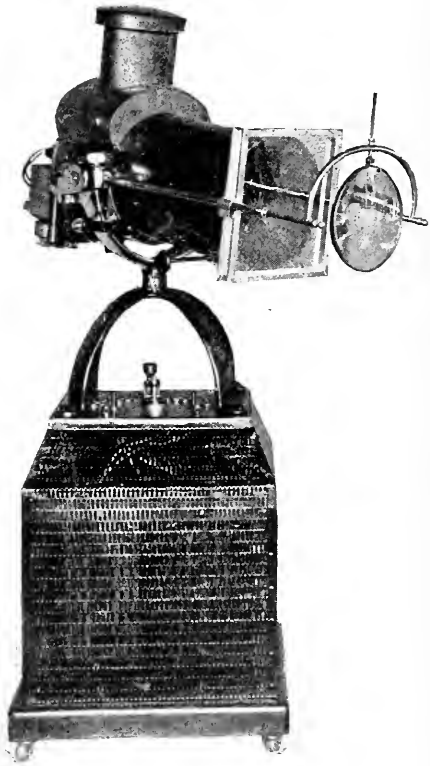
FIG. 95.

Arc lamp (compressor held to focus rays).

FINSEN ARC-LIGHT LAMP. The lamp proper consists of an upper positive and a lower negative carbon. This constitutes a 60- to 80-ampère lamp of about 35,000-candle power. When the current passes, a crater-like excavation forms in the upper carbon, from which the rays are directed downward and outward, striking the upper lens in the copper tubes, which pass off in various directions; the rays are rendered parallel so that they pass to the farther extremity of the tubes, where a concentrating lens converges them upon the area to be treated, as the patient lies or sits beneath the tube. A coil carries water to circulate in metallic sheaths about the lenses at the tube's extremity.

In the Finsen arc-light bath a lamp of 100 ampères' strength is suspended six feet above the floor, and beneath it patients lie naked upon couches. Here, as in the direct sun-bath, heat may be decreased by frequent showers.

Fig. 96.



Actinolite.

Finsen's experiments upon the skin of his own arm led to two important changes in apparatus: the substitution of crystal for glass in the compressors and the substitution of arc for sunlight, the latter, when run under high amperage, showing greater activity.

In Fig. 95 is shown an arc lamp in operation, a compressor, with tubes attached for circulating water, being applied by an assistant to a lesion of the cheek.

The rays being insufficiently cooled by the distilled water at the lower end of the copper tube, a supplementary cooler is combined with a compressing apparatus, to be applied over the skin lesion.

Actinolite. This apparatus consists of a large iron base on which are mounted the collecting and condensing lenses and the cooling arrangement, having back of them an extra large arc light. The lenses are made of some peculiar form of glass, which the manufacturers claim is pervious to the chemical rays. There is no evidence that this is true, and we are informed by physicists that no glass exists at the present time capable of doing this. The cooling arrangement consists of a brass frame enclosed with glass walls, open at the top and arranged with inlet and outlet so that water may be kept circulating. Distilled water is used (Fig. 96). It may be run on from 55 to 100 ampères.

There are several smaller-size apparatus made of this same type, run on much smaller amperage, for office use where such a strong concentrated light is not required. The lenses being of glass, render this a theoretically incorrect model possessing very little chemical efficiency.

Broca and Chatin Lamp. Here we have an arc from metallic electrodes, but devoid of cooling apparatus. The positive electrode is carbon with metallic base, the negative plain carbon. There is a regulator working automatically or by hand. The arc is surrounded by a high stovepipe-like metallic chimney. This protects the patient and operator. There are four openings in the circumference of this upright pipe; patients may sit opposite three, while the fourth permits inspection of the light and carbons. The apparatus runs on 15 to 30 ampères.

The patient is ten to fifteen centimetres from the arc. The time of exposure is from twenty minutes to one hour. While vigorous compression is supposed to be necessary, I saw patients being treated, at the St. Louis Hospital in Paris, without compression or dehæmatization, and with seeming benefit. It has, however, been too short a time in use to report definitely upon its merits.

Schall Lamp. This was devised in 1901 to supply the needs of those having only an alternating current, and is constructed to work on either current.

The alternating current produces a pointing of the carbons in use dispersing light. A mirror capable of withstanding the heat is thus necessary.

There is a disk of pipe-clay mixed with oxide of magnesium. One of the faces of the disk is hollowed into a cylindrical cavity into which the two carbons are pushed by a spring arrangement. A replaceable protuberance of refractory material prevents contact of the carbon points. It consumes 8 to 10 ampères with 50 to 60 volts.

Lortet-Genoud Lamp. Here the rays are not concentrated, but the patient is placed as close as possible to the electric source. The lamp permits of an intensity of 10 to 15 ampères. In front of the arc is placed an elongated, metallic basin (curette), having double walls, with a central opening for the rays to pass. In this water circulates. Behind the arc is a concave mirror to concentrate the rays at the opening. Fitted to the opening is a crystal against which the patient presses the part to be treated.

This lamp has given satisfaction, especially to those operators who did not attempt to secure equal benefit from short sittings.

A continuous current of electricity is necessary just as for the Finsen lamp.

Advantages are: saving in the cost and expense of running; low amperage (10 to 15) instead of 50 to 80, with tension of 50 to 60 volts.

Disadvantages: sittings, to be effective, must be as long as with other lamps; the carbons need frequent renewal; there is a lack of uniformity in the mass of radiant energy, depending upon the quality of the carbons.

The Marshall and Woods Lamp. This is a modification of the Lortet-Genoud lamp. It has a water chamber through which the light passes which is cooled in a metal case. The area of skin treated by this lamp is four times that of the Finsen, and the exposure is from ten to fifteen minutes. The ampères required is only 10 to 15, instead of 60 to 80 necessary for the Finsen lamp.

The Leslie-Miller Lamp. This is the same as that described as the St. Bartholomew lamp. Here, as in the Bangs, iron electrodes are used, run on a high potential secondary. The exposure is very short, from fifteen to twenty minutes, and a superficial erythema may be rapidly produced, the same as with the Görl and Piffard lamps. Here compression is applied with ice, or parts are frozen with chloride of ethyl or liquid air. It must be remembered that freezing with chloride of ethyl or liquid air has been at times found curative in lupus without any other treatment. The reaction may be painful.

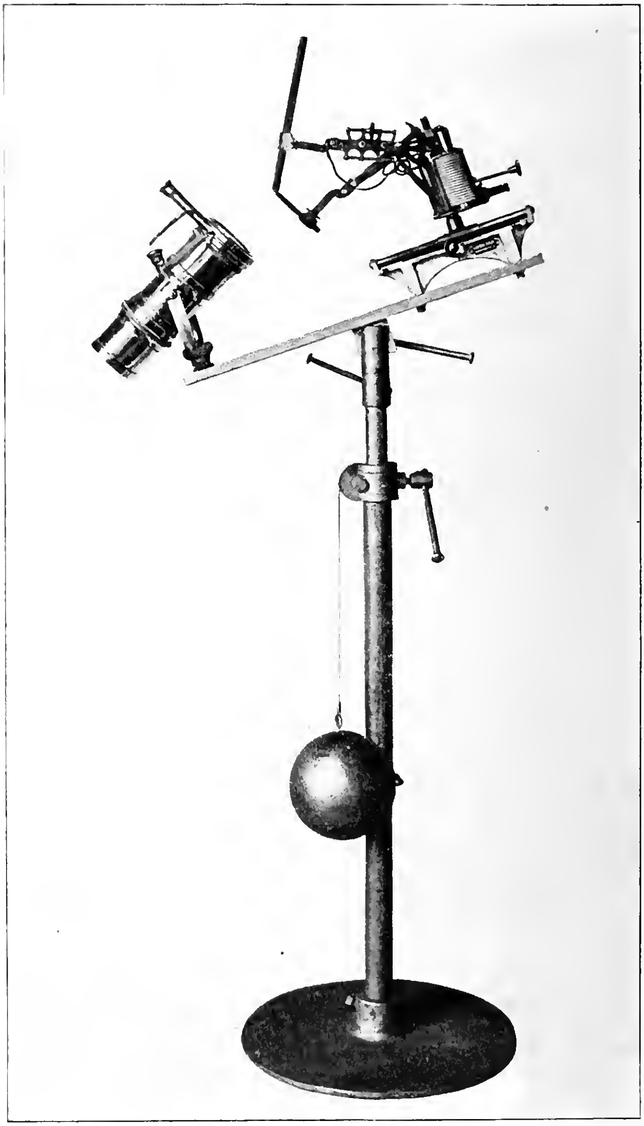
There is an American modification of this lamp which is smaller, but more powerful.

The Finsen-Reyn Lamp. At the Lysinstitut in Copenhagen, while they are still using the larger forms of apparatus originally installed, Finsen and many of his followers, both here and elsewhere, think favorably of this smaller lamp, known as the Finsen-Reyn lamp. The object sought is to produce chemical rays in very great abundance. It is also necessary that the light should be almost cold. According to Finsen's recent researches, some form of concentrating apparatus is requisite, and some of the newer lamps are gradually being abandoned, since it is found in practice that the short sittings it was claimed were sufficient for these smaller forms of apparatus are really not sufficient to secure efficacious results.

The apparatus, as modified by Reyn, consists in a stand with a transverse arm, holding the lamp and the concentration apparatus. The lamp itself is self-regulating, having a force of 55 volts and 20 ampères, arranged to be run on a direct continuous current of 100 volts. It is movable forward and backward on a sliding bar. It can be made to rotate about its vertical axis, on which it may be also fastened in a vise. The concentration apparatus is arranged upon the same principle as that of the larger Finsen lamps. It is composed of two disks of rock-crystal, the space between which is filled with distilled water.

The arc light can be placed very near the concentrator without danger of breaking the quartz lens nearest the light. In order to keep the distilled water cold there is a jacket

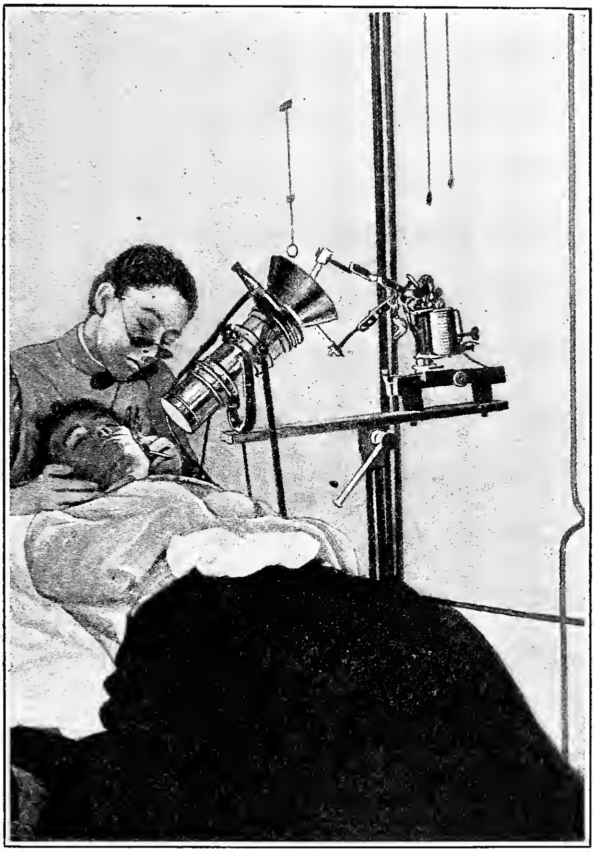
FIG. 97.



Finsen-Reyn lamp. (From photograph furnished by Waite and Bartlett.)

of metal outside in which a stream of water constantly circulates. The water can be taken direct from the supply pipes if a stop-cock is inserted to regulate the consumption. Beyond this layer of water is a Fresnel lens, and entirely

FIG. 98.



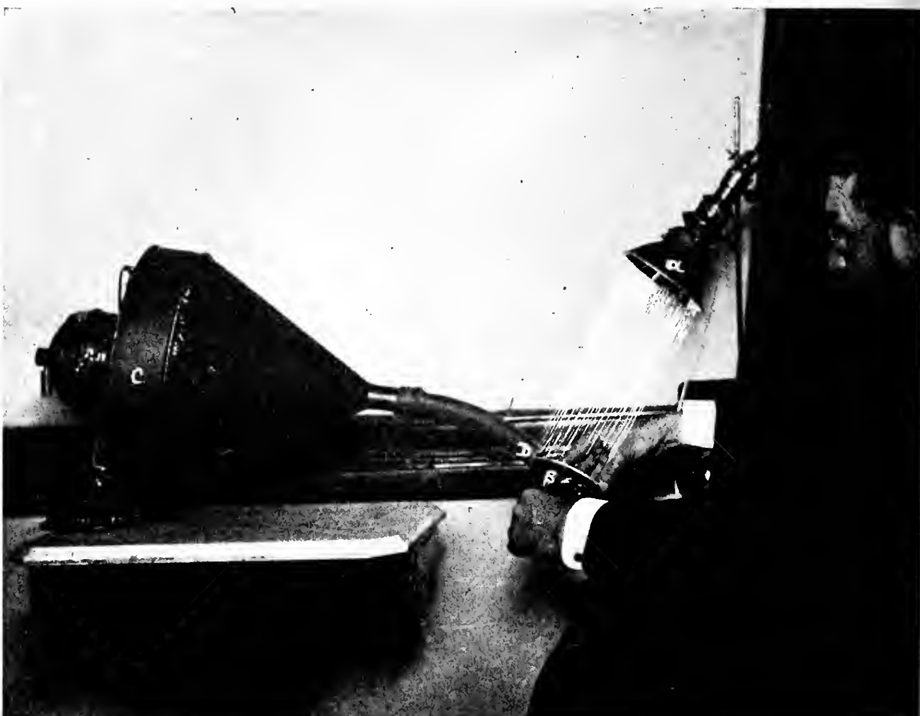
Finsen-Reyn lamp in operation.

below the apparatus are still two more lenses, between which is a space which should also be filled with distilled water to absorb the heat rays. The exposures are of about an hour's duration.

This apparatus I have seen in operation in Leredde's clinic, where good results were being obtained. Only one patient can, however, be treated at a time.

The lamp gives the same intensity of light power as the older apparatus with 20 to 25 ampères. The photograph from which the illustration was made was loaned by Dr. Piffard, who has made modifications of smaller hand lamps.

Fig. 99.



Arnold's phototherapeutic apparatus.

Believing as Finsen does, most thoroughly, that it is an error to strive to reduce amperage of apparatus and length of séances, results of the method should be judged only from the standpoint of a luminous source as powerful as he himself employs. He finds the iron light too little penetrating. To meet the requirements of diminished expense, he and his assistant have devised a lamp simulating in some particulars that of the Lortet-Genoud. Finsen's concentrating appliance enters into its make-up.

Experimentally it has been found that ultraviolet rays of greatest wave length and also the blue-violet penetrate most.

Arnold's phototherapeutic apparatus[1] consists of a lamp with a reflector attached (see upper part of Fig. 99), a parabaloid concentrator for concentrating the light to the parts affected, and a powerful bellows for bringing currents of fresh air to remove undesirable heat. By cutting off the concentrators beyond their foci subcutaneous concentration of light rays may be effected. The apparatus is portable, and is said to be twice as effective as any device for similar purposes.

Dermo Lamp. The Dermo lamp, of English manufacture, is favored on account of its portability. It is a modification of the Bang, the arc being struck between two iron electrodes, hollowed out to permit of circulation of water for cooling. It is said to be rich in violet and ultraviolet rays.

The Triplet Lamp. This is Kromayer's modification of the Dermo lamp. It is made to be used with either iron or carbon points, or a combination of both, with a blue fluid in the compressor on the skin.

Kromayer[2] has experimented with iron electrodes to take the place of carbon in the Lortet-Genoud model of lamp. Though a lamp so fitted possesses greater bactericidal power, it is less efficacious in treatment. This he attributes to the iron light having forty times as many erythema producing rays as the carbon, and therefore does not penetrate as deeply into the tissues, it being a law that the more a ray of light produces irritation of the tissues the less deeply will it penetrate. The iron light is much richer in ultraviolet rays than is the carbon light, and it is possible that if in some way its irritating quality can be lessened it will penetrate much deeper. At close contact the erythema produced

[1] Journal of Cutaneous Diseases, January, 1904.

[2] Eisenlicht, Dermatologisches Zeitschrift, Bd. x.

in a few minutes is so great that its application has to be suspended before the penetrating quality of the ray has been exerted. He obviates this by passing a solution of 8:100,000 methyl blue through the quartz chamber of the lamp.

In the original Finsen apparatus, besides the effect of the water filter, the distance from the concentrating lens to the skin (about a yard) suffices to eliminate the short-waved ultraviolet rays which cause surface erythema.

The great richness in ultraviolet rays with iron electrodes necessitates short exposures. The chief deep action lies in the visible rays of the actinic end of the spectrum. Besides the blue solutions in the compressor he paints the skin at times with methylene blue, to effect the same purpose of exclusion of such rays as cause the surface reaction.

The suggestion to paint the skin was made by myself several years ago as a protection against so-called *x*-ray burn, and, as stated elsewhere, I have practised it with seeming success.

He finds that in carrying out this simple procedure a much longer exposure can be given.

Busck[1] refutes Kromayer's statement that the Dermo lamp is thirty to forty times as powerful as the Finsen in bringing on skin reaction.

The object aimed at is the deep effect, and in this he finds Kromayer's apparatus works with about one-sixtieth of the blue-violet rays possessed by the Finsen.

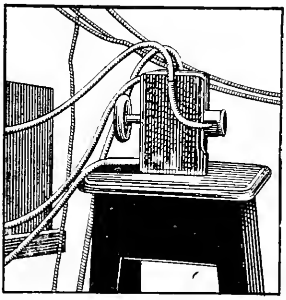
THE WILLS LAMP. Dr. W. Kenneth Wills[2] has constructed a lamp with both carbon and iron electrodes (Fig. 100). The iron is arranged so as to give up vapor in the burning of the carbons, resulting in a light very rich in ultraviolet rays and in rays of great penetration. This lamp has a chamber for running water, the whole fulfilling the conditions essential for a lamp, namely, intensity of light, richness in chemical rays, sufficiently cool, and of penetrating quality. The alternating current can be used as a supply when the lamp has a step-up transformer and

[1] Dermatologisches Zeitschrift, Bd. x. p. 178.

[2] Bristol Medico-Chirurgical Journal, June, 1903.

condenser attached. A current of about one-half ampère is used. This lamp in operation is illustrated in Fig. 101, the weight of the lamp as it rests upon the tissues making the required pressure.

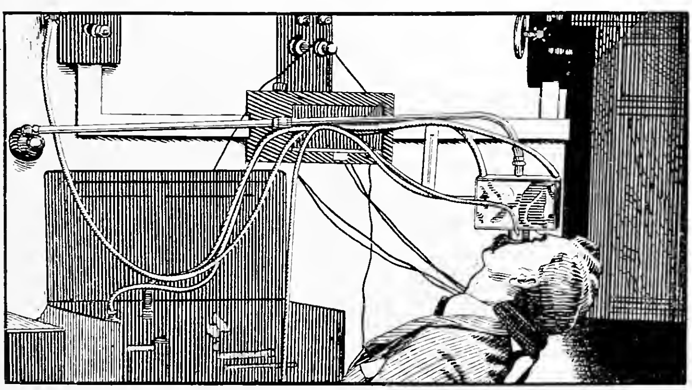
Fig. 100.



The Wills lamp.

In tests made by the author the reaction produced compared favorably with that of the Marshall-Woods and St. Bartholomew lamps, the latter giving a fluorescent affect

Fig. 101.



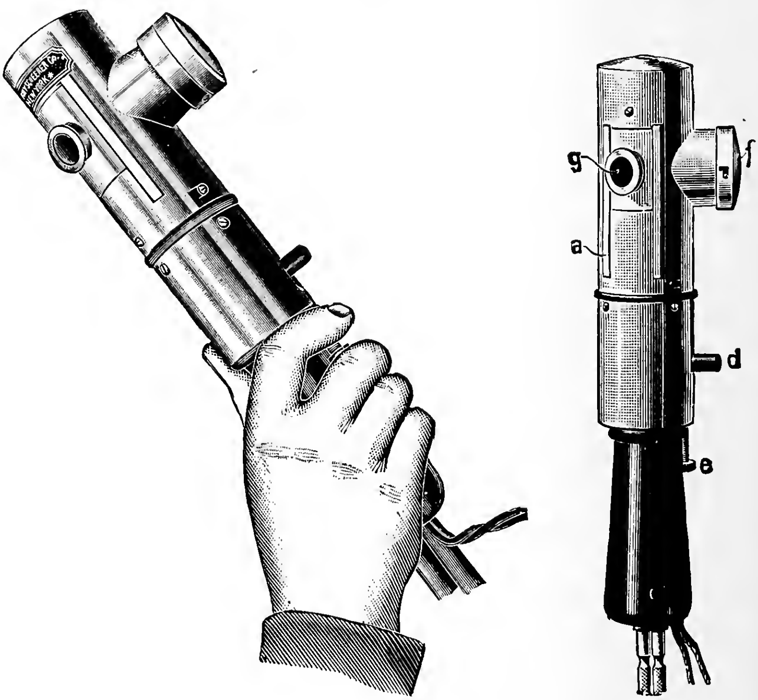
The Wills lamp in operation.

at three feet, while the new lamp increases this distance to nine. The iron in the Wills lamp is introduced as a thin wire running through the core of the carbons.

The Bang Lamp. This is an apparatus devised by Dr. Sophus Bang while an assistant to Finsen.

The object of this device is to produce a cool light with a maximum of active rays. Iron electrodes cooled by water flowing through their hollow interior, or in larger apparatus the electrodes are placed in a receptacle filled with water.

Fig. 102.



Dermo lamps on Bang model.

The arc in the small lamp is at a distance of only one centimetre and a half at most from the skin when in use.

In practice it has been found that the light does not penetrate sufficiently for lupus, but may be used in superficial affections. Experimentally it has been shown by Jansen that rays of short wave length are least penetrating, and since the iron arc produces such short waves its lack of deep penetration is explained.

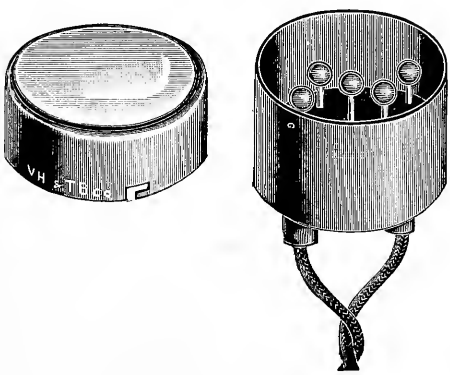
A modified Bang lamp is shown in Fig. 102. Iron electrodes replace the carbon. They are enclosed in a metal chamber having two side openings.

A water-cooling chamber is attached to one, a colored window to the other. The lenses are quartz. Any intensity of light from 750- to 1500-candle power can be utilized.

THE GORL[1] AND LEDUC LAMP. This was conjointly suggested in 1901 by those whose names it bears after experimentally observing that an electric spark, whether produced by a coil or a static machine, was rich in ultraviolet rays, and Leduc[2] suggested the use of the spark as a source of ultraviolet light.

FIG. 103.

a



b

Görl model spark lamp.

MODIFIED GORL LAMPS. The modified Görl is a small hand lamp with iron electrodes. It may be used upon a static machine or coil.

There are five metallic rods an inch in length in a cup-shaped container (*b*) of hard rubber or mica. These are capped with balls of the same metal. In the cap (*a*) is a condensing lens which should be of quartz.

The violet end of the spectrum given is found to be very rich, but less so than the violet end of the spectrum of the iron-electrode arc.

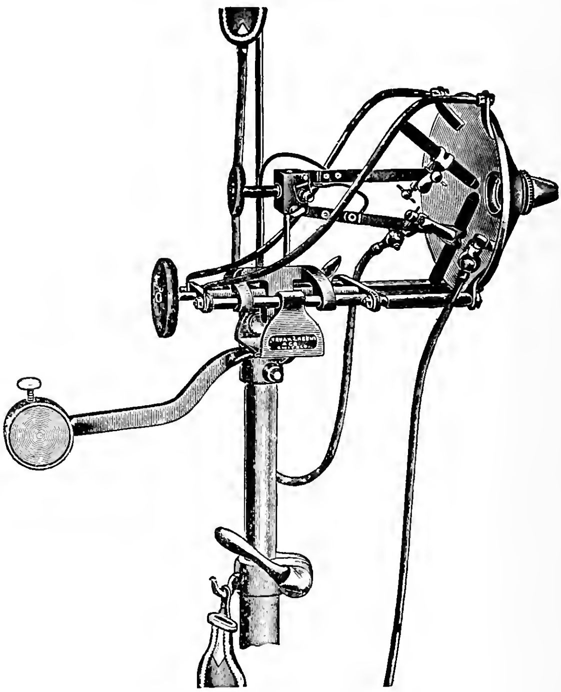
[1] Münchener med. Wochenschrift, 1901, No. 10.

[2] Comptes-rendus, March 3, 1901.

The photographic test proves marked actinic power. The therapeutic effects are soothing to nerve pains.

Either pressure or the dehæmatizing effect of adrenalin with catophoresis should be applied to secure good results in pathological tissue.

FIG. 104.



London Hospital Finsen lamp

LONDON HOSPITAL FINSEN LAMP.[1] The type of lamp illustrated herewith is the one designed by Finsen for use in the London Hospital, where so much good work has been carried on. It comprises a powerful arc light, which may be placed in circuit with either a 104-volt alternating or a 110-volt continuous current. A rheostat is employed with the lamp, so that further control apparatus is practically done away with. A tube and a reservoir provide for a continuous flow of water, either violet or uncolored, and

[1] Cut loaned by Detroit Medical Journal, January, 1903.

this assists in keeping the whole lamp cool. A screw device provides for the proper focusing of the light on the lenses, and another screw provides for the proper approximation of the two carbons in the arc-light. The lamp has a capacity not to exceed 10 ampères, as suggested by Monell. It provides for a maximum amount of violet rays, with limited amount of heat and small radiation of light.

KJELDSEN LAMP. This has iron electrodes, rich in chemical and poor in heat rays. It has the advantage of costing about one-tenth that of a Finsen lamp.

Kattenveracker[1] in experimenting with this lamp found that the growth of cocci was inhibited in about five seconds, and that the bacillus of anthrax was killed in thirty seconds.

The Cox (Heathcote) lamp belongs to the variety of water-cooled carbon devices.

A new method of generating ultraviolet rays has recently been announced by J. Mount Bleyer, of New York. He uses a Crookes tube of a vacuum lower than is necessary for the production of *x*-ray, giving a dark-purple fluorescence. It is said to differ only from the *x*-ray bulb in the quantity of gases exhausted and in the placing of the poles, and can be used on either coil or static.

It is difficult to understand how ultraviolet rays generated within the tube should have any utility in treatment, since glass is opaque to them.

There is a lamp manufactured in this country which is attached to a condenser, so that when the current enters the lamp it is of a high-tension, high-frequency variety. It has no water connection, and it is claimed to be very rich in violet rays.

Dr. Piffard,[2] of New York, has devised a hand lamp with iron electrodes, whose salient points are that it is self-cooling, without water circulating, and can be attached to an electric-light plug without additional wiring or apparatus aside from the rheostat which comes with the lamp.

Static Source of Rays. Prof. Leduc, of Nantes, France,[3] found that a metallic point connected with one pole of a

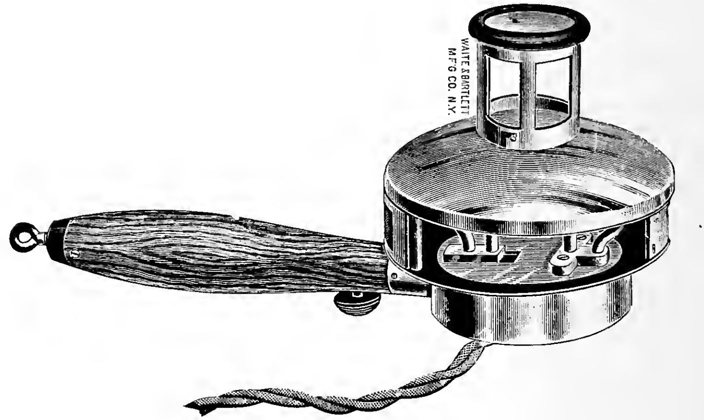
[1] Allgemeine Wiener med. Zeitung, 1902, p. 26.

[2] Medical Record, January 23, 1904.

[3] Compt.-rend. de l'Acad. des Sciences, June 12, 1899.

static machine, the other pole being isolated, furnished an active centre for the production of ultraviolet rays. The negative pole produces the most intense ray. He also found

Fig. 105.

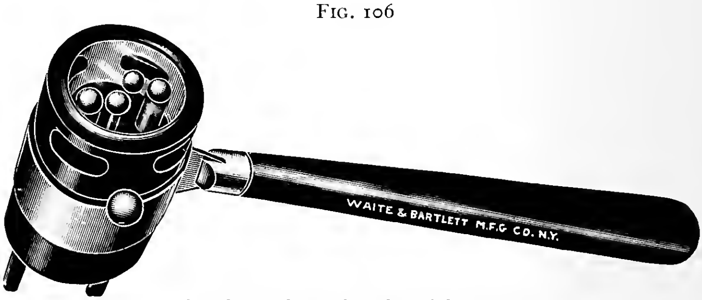


Piffard self-cooling hand arc.

the electric "effluve" the source of the purest chemical rays, and also the most economical, intense, and practical.

Schall and Strebel made observations upon the same subject. The latter observed that the spark from a powerful

Fig. 106



Spark-gap lamp for ultraviolet rays.

coil in conjunction with the Leyden jar produces ultraviolet rays. The rays are made parallel by a quartz lens and caused to pass through a prism, and concentrated by another quartz lens.

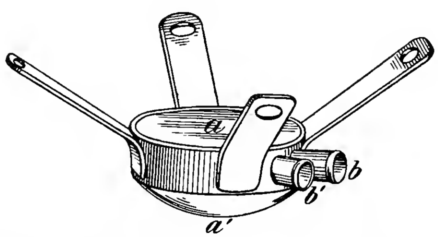
Since then several investigators, including Görl and Piffard, have followed up this new source of ultraviolet rays in constructing apparatus.

In Fig. 106 is shown the Piffard lamp,[1] which can be used with the coil or static machine. Experiments recently carried out by Piffard[2] show that the quartz absorbs 90 per cent. of the radiations capable of affecting a negatively charged electroscope.

Compressors. The compressor used in Copenhagen consists of two plates of rock-crystal set in a metallic frame so as to form a chamber in which a flow of water is maintained through openings for inflow and outflow tubes.

This is bound upon the parts to be treated, so as to keep up sufficient pressure to expel the blood and permit the rays to exert their full power unimpeded by the blood in the tissues.

FIG. 107.



a. Rock-crystal lens. The projections *b* and *b′* are for attaching water-cooling tube and outflow.

In connection with the Broca-Chatin lamp new compressors have been introduced by the inventors to paste upon the skin. While flat-surfaced, round compressing crystals suffice for even surfaces, it became necessary to invent those of different form for such locations as the region of the eye and nose, mucous membranes, gums, ear and nose cavities. Leredde and Pautrier have had made by Werlein cone-shaped, hollow, water-cooled crystal compressors in metallic sheaths. These have been found useful in the conditions indicated.

[1] Medical Record, January 23, 1904

Journal of Cutaneous Diseases, June, 1904

CHAPTER XXVIII.

THERAPY.

The value of blue, violet, and ultraviolet rays has been proven, but rays of greater wave length also have their therapeutic value. The beneficial effects of Finsen's method of treatment are not entirely due to the ultraviolet rays, which are largely absorbed by the skin, but to the violet and more deeply penetrating rays which are also produced. These rays, like the *x*-rays, besides destroying morbid cell elements, also stimulate the production of connective tissue and the formation of non-disfiguring cicatrices.

The original plan of concentrating the sun's rays by the use of large lenses containing a solution of copper sulphate has been largely abandoned in Copenhagen as elsewhere, the electric light proving more efficient and being more constantly available.

Among the conditions which interfere with treatment are dark pigmentations, swarthy complexion, thickness of integument, the presence of cicatrices, great vascularity of the part, depth of penetration of the pathological process and infiltration of tissues.

The cicatrices obtained are usually white, more supple than those produced by other treatment, and compare favorably with those left by the *x*-ray. Contractions in the scar and resultant deformities can often be decreased by the method itself.

In lupus when one lesion is treated, untreated parts of the body often participate in the improvement. This phenomenon, not always easy to explain, has been seen in psoriasis when one part has been treated by chrysarobin or pyrogallol, and in lupus erythematosus when only one patch was medicated.

There is a general concurrence of view, that there is produced by the application of concentrated chemical rays a specific form of irritation of the skin which has a definite power over certain skin diseases.

Preparing Parts for Treatment. All detachable crusts, scales, secretions, ointments, etc., should be removed with the aid of green soap and ether, as they impede the ray's passage. Finsen employs pyrogallic acid solution. Some advise painting parts with carbolic acid or pyrogallol to intensify or to secure more prompt reaction in those who react poorly.

Protection of the surrounding skin can be carried out by applying a square piece of adhesive plaster with a round opening in its centre opposite the lens, or by covering neighboring parts with thin tin-foil or similar substance. Red silk has been used by Leredde.

Compression. The necessity of compression was demonstrated by Finsen, who showed that the light influenced sensitive paper through a rabbit's ear in twenty seconds when the blood was pressed out, but only in five minutes, without compression. Darbois showed by placing in the mouth two watch-glasses enclosing a piece of sensitized paper, that the ray penetrates the lip in one minute when the latter is compressed.

After-treatment. The inflammatory zone may be dressed with cold cream. When crusts follow vesiculation, soda solutions, boric lotions, etc., may be applied and tepid boric acid water used as a wash. After crusts have fallen Lassar paste or zinc oxide ointments can be kept on.

After-treatment in the various skin diseases once clinically cured needs the knowledge of the experienced dermatologist or one versed in skin diseases to guard against recurrence.

Acne. Twenty-five cases have been reported from the Finsen Institute, with cure in 13.

Acne Rosacea. In rosacea the seborrhœic condition usually present would suggest one of the older methods of treatment with solutions of resorcin or corrosive sublimate in alcohol, or occasional *x*-raying to affect the overactive and often enlarged glands.

Loeb treated 8 cases of acne rosacea with the Finsen method and had 8 cures. He gave half-hour exposures without producing any scars. The length of treatment required was from two to three weeks.

Long-lasting redness of the nose and cheeks which our exfoliating methods, scarification (puncturing), electrolysis, etc., have failed to relieve may often be brought back to a normal color with disappearance of vascular dilatations and varicosities by persistent phototherapy. Best results will, however, probably follow a combined plan. I usually employ electrolysis coincidently. In the good results reported by Finsen and his followers, and especially those in France, rosacea stands almost second to lupus. Leredde has had 6 good results. Burgsdorff saw 3 patients greatly improved. Personally I have seen decided benefit in several patients.

The rays must often be continued until deep sclerosis has been produced.

Contraindications. Too dense fibrous cicatricial masses, too great vascularization, sclerous bridles and bridges of tissue offer resistance to the rays.

Alopecia Areata. Noiré, of Paris, has treated 50 cases, and finds the method most useful when the plaques are limited, the skin thin and atrophic, and on which for a long time no hairs have grown. In other forms of alopecia he finds it no better than older methods. Kromayer cured all of his 3 patients on whom he tried his all-iron electrode lamp.

Twenty-nine cases have been treated at the Finsen Institute. In 6 of these there was no result. The remaining 23 were all benefited. It is more than possible that there are two varieties of alopecia areata, one of parasitic origin, the other trophoneurotic. It would therefore not be surprising if those of the parasitic variety were beneficially influenced, while the condition persisted in cases of the other class or even grew worse under the ray, as in Schmidt's case.

Jersild reports great success in all of his cases (6). As a rule, the bald spots were covered with hair in a few weeks.

Forchhammer treated 29 cases, with 6 failures.

Gottheil reports 1 successful case.

Local Anæsthesia. Minin, of Russia, uses the violet ray for the production of local anæsthesia. His lamp was described in the section on apparatus. (See Fig. 88.)

Tracy[1] reports 3 cases, demonstrating the use of the actinic ray in minor surgery. In the first a sebaceous cyst was removed from the scalp without pain, no other anæsthetic being employed than the rays. The lamp employed was a No. 3 Minin, and the exposure was for fifteen minutes at ten inches. In the second case, a subcutaneous abscess, the size of a marble, was removed from the thumb under actinic-ray anæsthesia, and the rays were also applied later in place of all other antiseptic treatment. In the third case a skin slough an inch square was removed from the palm of the hand. It is extremely probable that in the cases reported there was a strong element of suggestion in the attainment of the results, as it is scarcely within reason to suppose that a lamp of the type used can have much effect of this nature. These lamps do not produce any of the ultraviolet rays, and transmit a very small amount of violet and blue-violet rays, and of the total energy produced in the lamp, minute at best, only a small amount traverses the glass of the globe. The heat waves are not sufficient to produce any effect, and the anæsthetic action of light waves of any length has never been demonstrated per se.

In minor surgery, Brockbank[2] has, in 2 cases, found ultraviolet-ray anæsthesia practical. Fifteen minutes' exposure with a No. 4 Minin lamp enabled him to take sutures in an incised wound of the forearm which had exposed the tendons. A fatty tumor was removed from below the breast without pain after a twenty-minute exposure at a distance of eight inches, nor did suturing cause complaint. This suggested that a strong mental effect may have had much to do with these results.

Diseases of the Eyes. At the present time there is no literature upon the subject of the treatment of diseases of the eye by means of chemical rays. Owing to the nature of this agent it is not improbable that these rays will ulti-

[1] Boston Medical and Surgical Journal, November 6, 1902.

[2] American Medicine, 1903, vol. v.

mately find a broad field in this branch of medicine. Slow-growing, non-inflammatory conditions of the conjunctiva, iris, and retina are easily approachable by the rays, and on account of the peculiar action of the latter ought to yield to their influence. It has been already suggested that, on account of the powerful physiological action of light, contractions and adhesions of the iris might be remedied by its means.

It has been found that yellow-light waves have the greatest effect in causing dilatation of the pupil.

Caution. The effects upon the eye are at times detrimental and conjunctivitis of the operator must be prevented by the use of glasses.

Epithelioma. When we compare the number of patients treated for lupus by actinotherapy with those treated for epithelioma, the reports so far available seem insignificant as compared with those reported upon from radiotherapy.

Among the reported results are Forchhammer's 24 cases from the Finsen Institute, with 11 cures; Sequeira's 3 successful cases; Burgdorff's 8 cases, with 3 reported cured and 4 improved.

My personal experience with exclusive actinotherapy in cancer has been slight. In several instances actinic rays have been tried for a time, but given up in favor of the *x*-ray, whose effects seemed more satisfactory.

Malcolm Morris[1] reports 27 cases of rodent ulcer in which the *x*-rays were also employed. In 12 there were favorable results, but it is difficult to assign to the Finsen method its exact share in the cures.

Bollaud reports an epithelioma of the nose cured in twenty-one sittings.

Sjögren had 10 cases of rodent ulcer, with 5 cures.

In carcinoma Finsen's statistics show 17 patients, with 8 good and 2 fair results.

Leredde, von Ziemssen, Petersen, Helm, all report cases.

Cancer of the Breast. In advanced carcinoma of the breast, as well as in two instances of Paget's disease, Harrison and Wills gave the method a trial. The final report is not yet made.

[1] The Practitioner, April, 1903.

Cancer of Uterus. Dr. Margaret Cleaves reports relief of pain and hemorrhage in uterine cancer, using the modified Bang lamp.

In an inoperable case after fifty treatments, covering a period of six months, in conjunction with *x*-rays, there was amelioration in the local condition.

Tuberculosis Cutis. In 6 cases treated at the St. Louis Hospital, 1 only is reported cured, the rest being partially cured.

Follicles and other tuberculides, such as agminated, deeply seated nodules, may give way to the light.

Ichthyosis Hystrix. Goler reports the cure of a boy with a harsh, scaly, wart-like condition of the skin, by daily applications for twenty minutes of the light from a 20-ampère arc lamp, passed through two eight-inch plano-convex lenses mounted in pairs. By the third day the skin of the arms had lost its warty appearance, and at the end of seven days was soft and normal.

The light was then applied to the legs, and after twenty exposures of about thirty minutes each there was complete recovery, which, when reported, had persisted for three months.

Keloid. In this condition and in hypertrophic cicatrix, in which the *x*-ray has proven so satisfactory, Morris finds that the actinic ray exerts no influence whatever.

Lupus Vulgaris. At first it was believed that the beneficial action of the chemical light in lupus was mainly due to the direct destruction of the tubercular bacilli by this light, and that the light reaction was only of minor consideration.

But careful investigation seems to show that the destruction of the tubercular bacilli is mainly due to the reactive inflammation of the tissues, the increased blood flow, or to the eventual chemical changes taking place, and not to the direct action of the light.

Nagelschmidt believes that the destruction or weakening of the tubercular bacilli through the direct action of light is the first result, and that only after this is accomplished the light reaction becomes an issue by facilitating absorption and assisting in the regeneration of the tissues.

The Finsen treatment is not always applicable to lupus of the mucous membranes or to ulcerating or vegetating lesions. For the most successful results it is necessary that the patch should be dry, and the lens be pressed hard against it.

If by the use of the x-rays or with the aid of applications of various medicines an ulcerating lupus can be dried up, then treatment can be continued with the Finsen light. Its greatest value comes in treating lupus of the face, on account of its good cosmetic effect; in lesions on the other parts of the body where we are not so particular about leaving a scar, surgical measures are much more rapid and therefore at times more advantageous.

The pronounced effects are well shown in the pictures to be seen in Finsen's latest work.[1]

Statistics. From November, 1895, to January, 1902 (7 years), 804 cases were treated in the Finsen Institute; 412 were cured, of which number 124 showed no recurrence in from two to six years, and of which 288 had been free from recurrence for a period of less than two years. Of the remainder, 192 were nearly cured and 117 remained under treatment. In 67 the treatment was interrupted by death, illness, or other cause, leaving 737 for study. Of these the result was favorable in 695, unfavorable in 42, or 6 per cent., against 94 per cent. of good results. At the St. Louis Hospital in Paris Gastou, Baudouin, and Chatin[2] report 30 cases with 7 failures, 12 partial cures, and 11 complete cures. Leredde and Pautrier[3] give 43 cases, 8 of which were cured, 7 almost cured, with 28 still under treatment. In a recent visit to Paris I had the privilege of seeing the work being done by Gastou and Leredde among others. At the Broca Hospital I found my friend Prof. Brocq operating by the well-known methods of ante-Finsen days upon a number of lupous patients in whom the light had been successful up to a certain point, but beyond which it seemed incapable of producing further benefit.

Such instances illustrate the point upon which I have previously dwelt in these pages as well as in former publica-

[1] Die Bekämpfung des Lupus Vulgaris, Jena, 1903.

[2] Annales de dermat. et de syph., April, 1902.

[3] Phototherapie, Paris, 1903.

tions, that these methods are not to be relied upon exclusively, but must often be fortified by other measures.

Malcolm Morris reports upon 65 cases, 11 of which were cured, no relapse taking place in from six months to two years. In 15 cases slight remnants have remained or relapses have occurred; 15 are still under treatment. All patients remaining sufficiently long under treatment were improved.

Forchhammer found that out of 456 patients treated, 130 showed no recurrence during an observation of from one to five years. These are undoubtedly included in the larger statistics of Finsen.

Harrison and Wills report on 42 cases being treated by the Lortet-Genoud lamp. Almost all were improving at the time of report.

In the London Hospital 398 patients have been treated, with 149 discharged as cured, up to 1903.

At the St. Louis Hospital in Paris up to May, 1903, when I visited the laboratory of Professor Gastou, 250 patients had been treated, 100 of them regularly and several for two years or more.

While nearly the whole number showed improvement, about 20, I am told, had been discharged as definitely cured, having been seen for the most part some six months afterward and the persistency of the benefit verified.

The length of exposure was in most cases one hour, no matter which model of lamp was employed.

At the time mentioned the Broca-Chatin lamp was being used to treat three patients at a time. Prof. Gastou reported good results without the use of compression, though most patients were using the compressor.

Histological Changes. In the investigation of Schmidt and Moscuse,[1] Sack[2] and McLeod[3] the inflammatory reaction is put down as the essential feature. All of these observers believe the effect to be largely the result of inflammation, which may reach even a necrotic stage. When

[1] Archiv für Dermat. und Syph., March, 1903.

[2] Münchener med. Wochenschrift, April, 1902.

[3] British Medical Journal, October 25, 1902.

repair begins new connective-tissue spindles are noted, and their multiplication culminates in the production of a scar which leaves nothing to be desired so far as appearances go.

PROGNOSIS. In any given case an opinion can be formed of the ultimate outcome by taking into consideration the extent, duration, age of patient, preceding operations, and treatment, the amount of cicatricial tissue present, pigmentation, secondary infiltrations, etc.

The more uncomplicated, accessible, and free from secondary effects, the better the chance of complete removal.

Lupus Erythematosus. In the Paris Congress (July, 1900), Forchhammer reported on 38 cases treated by Finsen; 12 were cured, 13 were being treated, and 13 had ceased treatment. Morris thinks these results less pronounced than in lupus vulgaris.

In the Breslau Congress 44 cases were reported, 14 cures and 15 improvements, the results being always good in recent cases, doubtful in old.

Sequeira reports 14 cases, of which half were rebellious to the method.

Leredde and Pautrier report 33 cases, with 23 remaining and available for observation. Of these 11 were cured, 3 improved, 3 were complete failures, and in 6 cases there were cures of isolated patches.

We must remember a peculiar tendency to spontaneous improvement going to the point of complete disappearance for a time. I have seen disappearance of lesions after an intercurrent attack of erysipelas; also at a considerable time after *x*-ray had been stopped, little improvement having occurred while the patient was under treatment.

For the inveterate, persistent, stationary plaques, long sittings to secure deep effects and the formation of sclerous and scar tissue are required.

Gastou, Baudouin, and Chatin, out of 10 cases treated had 3 cures and improvement in the balance.

Malcolm Morris treated 11 cases with no cures, improvement in 7.

Du Castle reports a case of five years' standing cured after eight sittings.

Leredde and Pautrier say that this treatment is contraindicated when the lesion is not situated on the face, and also in aberrant lupus curable by other methods. I have seen patches, however, disappear from the scalp.

On the whole the results here, though in the main satisfactory, are less certain than in lupus vulgaris, giving approximately 50 per cent. of cures while the figures in lupus vulgaris are placed above 90 per cent. by some observers.

Kromayer has cured a patient by the use of the iron-electrode lamp bearing his name. (See under Apparatus.) I have had decided improvement in several instances, including the case in which the lip was involved.

The patient maintained that the lamp did much more good than the *x*-ray which had been previously used.

In another case involving both lips, the affection was of five years' standing; *x*-ray treatment had been previously given without much benefit. I therefore curetted extensive lesions upon the cheek, and employed actinic rays with the Görl-Piffard lamp. Upon the lip I made daily applications of aromatic sulphuric acid. After a week there was decided improvement in all the patches, which has gone on progressing. Statistics gathered from literature so far show 103 cases treated, with 35 recoveries.

Nævus. Telangiectatic nævi have been treated with some success by various operators, including Heidingsfeld. While vascular nævus may be bleached to a certain extent, as in a case of my own, instances of complete disappearance are rare.

In nævus vascularis of the flat variety some success has followed the Finsen plan, he having removed one entirely and improved nine out of ten in which trial was made. My own best results have followed a combined plan of destroying first the largest vessels by electrolysis and immediately following with the ultraviolet lamp, keeping up all the compression possible upon the dehæmatized areas.

Vitiligo. Montgomery, of San Francisco, has recorded a case much benefited.

Other Diseases. Among other affections in which benefit has been reported are to be enumerated *localized eczemas*, *chronic ulcerations*, *actinomycosis* (late stage), *adenoma* *sebaceum*, and *acne pustulata*, one case each of the latter being reported by Harrison and Wills. Rhinophyma was benefited in a case of Leredde.

In my own practice sycosis, alopecia, eczema, acne, psoriasis, dermatitis, pruritus, rosacea, epithelioma, lupus, lupus erythematosus have received benefit, and localized areas have been at times cured.

BIBLIOGRAPHY—H. Krukenberg, Münchener med. Wochenschrift, April 1, 1902. H. Lebon, La Phototherapie, Paris, 1901. Duclaux, Compt.-rend. de la Soc. de Biol., 1885, p. 395. Arloing, Influence de la lumière sur la végétation et les propriéties pathogénés du bacillus anthracis, La semaine médicale, 1885, pp. 46, 293, 309. N. R. Finsen, La semaine médicale, December 21, 1887

CHAPTER XXIX.

RADIOCHEMICAL THERAPY.

By this term Dr. Bevan, of Chicago, and some of his colleagues designate the procedure of administering drugs, such as iodine preparations, usually in large doses, after which *x*-rays are applied up to the full tolerance of the patient. The idea is that while the drug circulates in the diseased tissues the ray will act more effectually.

They have applied the method with success in actinomycosis. We must remember that in this disease the iodide of potassium acts surprisingly well at times without the ray.

In occasional instances there comes a time in the treatment of lupus, and, in fact, in carcinoma too, when no progress seems to be made. The healing process which has started well comes to a standstill, and, despite our efforts to force treatment, no improvement takes place. In this class of cases we must resort to other measures. Before discarding radiotherapy wholly, it will often be found advantageous to make a trial of actinotherapy. I have seen the advantage of alternating these two methods in epithelioma, carcinoma, lupus, lupus erythematosus, and other lesions.

In cancerous peritonitis as well as in tuberculous peritonitis a combination of *x*-rays, ultraviolet light, and oxygen baths have, according to Watson and Cattell,[1] proven beneficial.

Besides the various methods of combining other procedures with the *x*-ray, we must not lose sight of the probable advantage of employing this method in association with surgical procedures. Thus, certain manipulations, such as partial excision or excision without going wide of the apparent limits of the disease, or even a partial curettage

[1] International Clinics, 1903, vol. i., 13th series, p. 214.

without attempting to remove the entire tissue involved, may be undertaken with deliberation and assurance if the ray can be simultaneously and subsequently employed until cure or marked benefit is effected. This opens up quite an extended field of surgery which before the ray could not be too severely condemned. This applies also to extensive deep-seated growths, as cancer of the breast. Cases which hitherto have always been classed among the inoperable, and patients who have been considered incurable, can now have some slight hope held out to them from partial operation and irradiation as soon afterward as is possible.

Varney reports a patient clinically cured, in whom the field of operation was irradiated for two weeks before operation, and again as soon as the wound was solid enough to permit.

Byrne, of Brooklyn, advises the use of the cautery knife in connection with the *x*-ray.

According to Hopkins,[1] the most successful method of treatment of uterine cancer consists in the combined use of the ultraviolet and the *x*-rays. A great deal of care is required in the application of this combined method, as their effect is quite different. In the case of the Finsen light only external protection is needed, and this may be adequately obtained with a fabric of a color impervious to the rays, but in the case of the *x*-rays, however, metallic protection is necessary. The patient is placed in the dorsal position and the rays are so directed that they will impinge upon the diseased portion. The application of the Finsen rays may last an hour or more, but the application of the *x*-rays must be carefully limited.

A report by Margaret Cleaves on the combined treatment will be found under "Cancer of Uterus," page 193.

In treating with the *x*-ray malignant growths in which there is a glandular involvement, we find that we get more satisfactory results by excising the glands and applying the ray to the wound.

In connection with the *x*-ray we have found some good results from applying the high-frequency current for a general stimulating effect, in patients who have been in a

[1] Philadelphia Medical Journal, February 21, 1903.

generally weakened condition. In colitis Tousey speaks of a beneficial and stimulating effect of the ray combined with high-tension discharges from the tube.

Walker and others use adrenalin chloride in solutions of $\frac{1}{4000}$ to $\frac{1}{1000}$ as a dehæmatizing agent before the application of the Finsen light. When doing this we must keep in mind that adrenalin itself has proven to have a curative effect at times.

In alopecia areata, freezing with ethyl chloride spray or applications of carbolic acid to aid the light treatment has been found of great value, but here we must also not forget that these applications alone have very often brought about a cure.

We have often found that to get rapid and satisfactory results it was necessary to combine a number of different methods, especially when the lesion is a somewhat complicated one.

In the case of Mr. M., who has been suffering from a number of different lesions about the face, we applied simultaneously electrolysis for the destruction of a vascular nævus and a network of telangiectatic bloodvessels, the x-ray for a severe acne pustulosa, hydrarg. ammoniat. for an acne varioliformis, and the ultraviolet light for acne rosacea of the nose. The recovery was very prompt and satisfactory, and illustrated the value of analyzing lesions and combining methods of treatment to reinforce one another.

In lupus, when the disease is extensive, or there is much infiltration, scraping followed by x-rays may usefully be employed as a preliminary to the application of ultraviolet light treatment, or x-rays alone at first and then the Finsen method.

Morris states that these methods may be reinforced by such caustic remedies as pyrogallic and salicylic acids. The x-rays appear to increase the reaction caused by the actinic, when the latter is applied subsequently.

Pyrogallic acid, acid nitrate of mercury, silver nitrate, or pure carbolic acid may be used to remove the horny layer before Finsen treatment. To make the horny layer transparent strong carbolic, anilin oil, or clove oil can be used to increase reaction.

I am pleased to note that De Forest Willard has taken up a suggestion made by me two years ago—*i. e.*, of covering parts with a methylene-blue solution, his object being to secure easier passage of ultraviolet actinic rays.

It must be remembered that these alone are curative. One objection to their use is, that the hyperæmia thus produced requires more pressure to dehæmatize. Doré applies several layers of acid nitrate of mercury and MacLeod iodine (potassium iodide, 2 parts; glacial acetic acid, 2 parts; water, 100 parts). Wills and others find that a preceding *x*-ray exposure increases reaction from the light treatment. The *x*-ray is almost a necessary adjunct in treating mucous membranes and cavities. The *x*-ray, as it would seem at times, has a more selective affinity for lupous tissue than the ultraviolet ray. This is well illustrated in the case of Mrs. J., in whom a very decided reaction occurred after the third *x*-ray exposure, and these few treatments would seem to have effected a cure.

Malcolm Morris, as early as August, 1901, advocated the simultaneous or the combined method, especially for lupus about the eye and mucous membranes of the nose and mouth. This has been carried out by various workers and recently is reported upon by Hopkins.

Although he considers the results obtained in Finsen's clinic better than anything that had been previously obtained, Brookes strongly recommends the combined use of the Finsen method and the *x*-ray.

Leredde and Pautrier advise that phototherapy should not be combined with other methods, but should be used alone. They claim that it is the chemical rays traversing the region which produce the benefit; scarification and cauterization or other methods employed may make this penetration more difficult.

In a recent visit to the hospitals in Paris I observed that in a large number of lupous patients who had been improved up to a certain point by actinotherapy, minor surgical procedures were being carried out upon those portions of diseased tissue which had refused to yield to the ray treatment.

In tuberculosis the ray should prove more beneficial in a dry, warm climate. Much time is necessary to achieve improvement beyond that of alleviation of symptoms.

Mixed infections require longest treatment, including anti-streptococcic injections. In joint tuberculosis, supporting treatment or immobilization is necessary. In general tuberculosis, besides climate, the use of general exercise or calisthenics is advised.

Hubbert and Gibson believe that many patients can be cured if the stomach and digestion can be controlled. We must always remember that we are treating a human being, and that the ray is only one factor in the cure. The co-operation of the patient aids materially.

COMPARISON OF THE TWO METHODS.

In making a study of the relative merits of radio- and phototherapy it seems at the present time necessary to consider only a few diseases as they are influenced by the Roentgen ray and by the actinic rays, as applied by Finsen and his followers.

First, we must appreciate the wider range of usefulness of the Roentgen ray, which is not restricted wholly to surface influence, as seems to be the case with the ultraviolet light. To be sure, the results have so far not been brilliant in many internal or deep-seated affections, but that the *x*-ray produces a pronounced action upon deeper tissues cannot be doubted.

In the treatment of lupus much stands in the way of definite conclusion at the present time concerning the relative merits of *x*-ray and actinic light. There is the personal equation with individual preference, greater experience and greater skill with the one than with the other. The phototherapy has been perhaps more profoundly studied and more cases have been treated to a point of cure.

That the Roentgen ray has a great influence upon lupous tissue there can be no doubt. Many have been cured. The proportion of failures, so far, has been greater than in the other method. We must remember, however, that the greatest success has been achieved by the originator in Copenhagen. If we compare lupus treated by the two methods the world over, the difference in end results is not so marked.

When we consider the difficulties and tediousness of the most effective methods previously employed, the pain attending their application and the small percentage of actual permanent cures, we have to confess that up to the present the newer methods by actinic and Roentgen rays is an advance of decided importance. The brutality of curettage and boring in with caustics is great and the results are unsatisfactory.

Ablation can be practised but rarely, especially about the face.

Scarification, galvanocautery, and electrolysis or cautery by pastes are the only other available methods.

The chemical light penetrates deeply, homogeneously, and pains less; herein lies its advantages, granting that end results may be equal. In point of time this method has the advantage over the older when we calculate the period over which the others exclusive of ablation must extend.

The expense for the private patient is not much greater by comparison, and while institutions may find it much more expensive to install apparatus than to have the physician's time the only item, still, if results are more satisfactory it is cheaper in the end for the community, so far as public service is concerned.

A careful computation of statistics points to phototherapy as the method offering the largest percentage of actual cures.

The advantages of the x-ray as compared to the actinic method in the treatment of lupus are that (1) we can treat larger areas; (2) it is much more effective in ulcerating lesions; (3) we can treat lesions of the mucous membranes; (4) the treatment is much shorter in duration.

The x-ray is more uncertain; the dosage is not so well established or controlled; the limitations are not so well mapped out, and harm can more readily be done.

Reports, although numerous, represent too large a proportion of cases which have "improved." Naturally, we can consider only those discharged or reported by competent observers as being clinically cured. In this country at least, where lupus is rare, and presumably in others as well, statistics must be based upon the competency of the observer from the diagnostic side. Reports have been made of lupus treated by these methods which was not lupus at all, but syphilis or something else.

There is one feature of radiotherapy to make it of decided advantage, and that is entire absence of pain or discomfort, and the much restricted number of applications required.

Among other advantages of the Finsen method are that it is not very dangerous to the operator, while the *x*-ray has been known to produce serious results. While the Finsen is the more tedious treatment it has the advantage that it can be carried out by trained or semiskilled persons—nurses, etc. This is not practical with the *x*-ray, which should be under the direct supervision of the physician.

Morris and Doré[1] say that Finsen does prevent recurrences by his method of treatment. The apparatus used by Finsen himself is superior to that of Lortet and Genoud, it having better penetration and being more intense. The latter lamp is useful only in superficial lesions. The *x*-ray is better than the ultraviolet rays in ulcerating lesions, and where the mucous membranes are affected. In epithelioma, curettage should be employed coincidently with either of these methods.

The actinic-ray reaction is apt to come on, if at all, in from four to five hours, and the resulting slight dermatitis, resembling that produced by the sun's rays, is usually readily controlled by some simple ointment.

The dermatitis following the *x*-ray comes on only after some days or even weeks, and the extent and ultimate results are very uncertain. The condition when severe is not controlled by ordinary methods of treatment.

The actinic treatment is less likely to produce burn than the *x*-rays.

The resulting cicatrix after the actinic-ray treatment is softer, whiter, and generally better, as a rule, though most excellent scars often follow the *x*-ray.

The effect of the chemical rays is very irritating upon the conjunctiva and the retina, while the *x*-rays exert very

[1] British Medical Journal, May 31, 1902.

little effect. The use of amber- and red-colored glasses and the application of dark-red shades to the windows will lessen the irritation in case of inflamed eyes. Blue glasses, however dark, are found unsuccessful.

Leredde and Pautrier[1] make a comparison of the results obtained by phototherapy in lupus vulgaris and lupus erythematosus with those following other methods of treatment. They conclude that phototherapy is the one method which gives the best results in tuberculous lupus, giving deepest action, although radiotherapy may in the future be found just as useful. While a cure cannot always be promised, the number of failures is small. In lupus erythematosus this method of treatment is superior to all others, although the results are much less constant than in tuberculous lupus. It is necessary to produce complete sclerosis, and the phototherapy should be continued until a cicatrix is formed. The indications and contraindications for the employment of this method of treatment are as follows: It is indicated in every case of tuberculous lupus which has resisted other methods of treatment. The results are uncertain in cases with much thickening of the tissues and in those in which a deep sclerosis has been produced by other treatment. In vegetating lupus the volume of the tissues should first be reduced by scarification or caustics, such as potassium permanganate; phototherapy may then be able to exert its curative effects. In elephantiasic lupus this method of treatment generally fails. It is contraindicated in recent lupus which can be cured by ablation with union by first intention, and in lupus of the trunk and extremities which can be cured more rapidly by other methods. In tuberculosis of the extremities it is likewise inapplicable because the hyperkeratosis and acanthosis prevent the penetration of the chemical rays. In lupus erythematosus it is contraindicated in the superficial wandering forms curable by other methods. It can be applied only in those cases in which the disease reappears in the same places, and in which other methods have failed. In the fixed forms, with or without a tendency to atrophic regression, it may be

[1] Annales de dermat. et de syph., 1902, No. 8.

employed after the failure of other remedies. Every case ought to be treated energetically from the beginning, since the longer it lasts the deeper and more rebellious it becomes. In those cases which have resisted phototherapy, properly carried out, radiotherapy or radioactinic therapy may be tried.

In skin diseases in general the field of usefulness for x-rays is much broader than for Finsen's method. Here the lesions must be few and localized, while the ray can be so applied as to take in extensive surfaces.

Lupus. In two lupous cases with marked ulceration treated by Morris,[1] Finsen's method was found useless, but in both the ulcers healed rapidly under x-rays. When the mucous membranes are involved the x-ray gives good results. That of the nose is attacked with difficulty by the ultraviolet rays, but very easily with the x-rays. Many cases of lupus under treatment by the Finsen method or the x-ray improve up to a certain point, but stop short of a complete cure; so that whichever method is used it must be supplemented by subsequent treatment with some of the older methods.

In comparing the value of the different methods of treatment we must naturally be guided by the result achieved by different observers.

Scholtz, who has had a very extensive experience covering a number of years, with the x-rays in all varieties of lupus, in his report of 55 cases published, claims to have brought about a complete cure in the majority in a very few months with very satisfactory cosmetic effects. This seems to compare very favorably with Finsen's method, which requires a much longer time for many of the cases, with a great deal more inconvenience to the patient as regards the comparative length and frequency of exposures.

Freund says much the same length of time is required in the two methods; the resulting scar is equally good. He advises raying large surfaces and applying actinotherapy to the remaining foci.

Heidingsfeld[2] speaks of 3 cases in which the ray had

[1] Practitioner, April, 1903.

[2] Cincinnati Lancet-Clinic, 1903, vol. lxxxix.

failed, but under the London Hospital or Sequeira lamp the nodules disappeared. Rockwell, on the other hand, saw an extensive lupus of the chest cured by fifty-five exposures to the ray after prolonged treatment by the Finsen method had failed.

Harrison and Wills[1] found that while 2 out of 3 lupus erythematosus cases improved under actinotherapy, they made more rapid progress under the x-rays.

Sequeira, of the London Hospital, believed from a trial of both methods that the Finsen gave better results. Out of 154 cases treated by the latter, 42 were successful.

Burgsdorf, of Kasam, treated 24 cases, with 3 cures and 16 much benefited.

Leredde and Pautrier report on 40 cases up to November, 1901. Of these 37 remained under treatment sufficiently long for conclusions to be drawn; 8 were cured, 7 nearly cured, in 10 definite areas were cured, and final cure was seemingly sure. They expect 34 cures in time, and in 5 the results are doubtful.

In picked cases ablation can be done, or scarification, galvanocauterization, or electrolysis can be attempted as the most favorable methods when phototherapy and radiotherapy are not available. If recurrences are prompt and persistent, efforts should be made to resort to one or the other of these newer methods, as too prolonged attempts result in a too abundant production of dense sclerous tissue, which ultimately makes the success of rays less sure.

Lupus Erythematosus. In lupus erythematosus the x-ray gives at least as good results as phototherapy. Compared with high frequency and radium therapy, too few data are available. It looks, however, as though radium promises little, but high frequency, even perhaps more than either of the others, and may become the method of choice.

As between phototherapy and radiotherapy and high frequency on the one hand, and older methods (application of iodine, pyrogallol, caustic potash, strong carbolic acid, chloride of zinc, scarification, galvanocautery) on the other, the newer methods have the decided advantage.

[1] Bristol Medico-Chirurgical Journal, 1903, vol. xxi.

Alopecia Areata. Here the time element must not be ignored in forming final conclusions. The well-known tendency for many cases to make spontaneous recovery should not confuse the observation.

When a recent case responds promptly to chemical light we may credit the method with the result.

The conditions of control have been complied with in a number of instances, including Finsen's own cases (49, with 30 cures). Sabouraud believes, and we must lean to his way of thinking, that the irritation produces the equivalent of that we aim at in our older methods. In my own practice I have experienced little difficulty in the non-universal cases in securing renewed hair growth within comparatively short time limits with pure carbolic applications at long intervals (three or four treatments in six or eight weeks). This is surely much simpler, more time-saving, and inexpensive.

Localized chronic plaques which resist this and similar measures will sometimes give way under chemical light or *x*-raying. Comparing the latter it would seem that more patients have so far recovered under radiotherapy.

Epithelioma. Here the *x*-ray is unquestionably superior, though the arc lamp will cure lesions of the cancroid and rodent-ulcer type.

Sycosis. While violet rays have been tried with some success, as in long-standing sycosis of the upper lip (Leredde, 2 cases), the method falls far short of the brilliant results following radiotherapy.

PART VI.

RADIOACTIVITY.

CHAPTER XXX.

RADIOACTIVITY.

WHAT have come to be known as the Becquerel rays owe their name, not less than we owe our knowledge of their existence, to the French physicist who surprised the world by his announcement from the Natural History Museum of Paris early in 1896.

While experimenting with the salts of uranium and the heavy metal uranium itself he found that peculiar rays were given off. These radiations are not visible to the unaided human eye; still, they penetrate substances which are wholly opaque to ordinary light, or, while making no impression upon our retina, pass through metals just as do the *x*-rays.

Two other scientific investigators, working also in Paris, shortly after this discovered other radioactive minerals in pitchblende, a mineral compound of uranium found in Cornwall, Bohemia, and in small amounts elsewhere, as in Colorado. They crowned a laborious series of experiments with the demonstration that certain bodies are constantly emitting radiations carrying actual energy, which, while not appreciable by our senses of natural endowment, can still be measured. Their component particles can be counted and weighed; their heat-giving properties can be calculated with precision.

Radium, actinium and polonium are the names given by their discoverers to the chief metals or chemical elements which have to do with the remarkable phenomena recorded.

Radioactivity may be described as the active dissociation of intra-atomical units. The thousands of "ions" composing the radium atom, for example, revolving in their orbits, fly apart and escape into the ether.

When the creator of all things gave that blessed command, "Let there be light," radium and polonium no less than the sun and stars obeyed. Since that great dawn they, too, have possessed a never-failing light, though, through all these ages, it has glowed deep down in what seemed to us pitchy darkness—shut in from our sense of sight by its pitchblende envelope, awaiting that other great dawn, the dawn of science, which would fortify our normal senses with far more delicate means of appreciation than any vouchsafed them by nature.

Radioactivity became a possibility only subsequent to Roentgen's work. The omnipresence of penetrating rays was surmised by Becquerel, no doubt as well by many others whose minds were active in these directions. Still, he worked out the problem, and, thanks to the wonder-working scientists of the day, radioactivity must take its place alongside of light, heat, magnetism, and electricity.

The determination and patient working out of difficult detail on the part of Madame Curie, added to the scientific training and active imagination of Prof. Curie, combined to make possible their brilliant accomplishment.

The Discovery of Becquerel Rays. It may be looked upon, in a measure, as a lucky accident that led Becquerel to his fortunate discovery. Testing on a photographic plate the effects of some salts of uranium which he had exposed to sunlight to cause them to phosphoresce, he found that a better image was secured when the plate was placed in a dark drawer than is usually secured from sunlight. He had, after exposure, put the plate away because the weather was cloudy. After several days he developed it, impulsively, as it were, little dreaming it was going to teach and lead to such brilliant results. Roentgen, it will be remembered, had a somewhat similar experience with accidental image-making which pointed out the way to a new force in nature.

We must go farther back in tracing the discovery and see how working out one problem leads to another, though neither may be fully solved for a long time. Spirit photography was undoubtedly behind the investigations.

It was known long ago that when a metal coin was enclosed in a pasteboard box along with blackened paper, or even a printed sheet, and kept shut up in the dark, an image of the coin might appear upon the paper or interior of the box. This was evidently an effect of luminous emanations from either the metal or the material blackening the paper.

Prof. and Madame Curie had found the source of uranium (pitchblende, or urananite) more radioactive than the metal itself, or, the discarded pitchblende from which urananite had been extracted, more powerful than urananite itself. Searching, then, for the cause of this, they unearthed, so to speak, radium, polonium, and actinium, whose powers are respectively 1,800,000, 1000, and 100,000 greater than those of uranium. Radium has been studied through its known or manifest properties, as until now it has not been isolated. For much that relates to the physical and active properties of radioactive agencies, I am indebted to the excellent work recently published by my friend, Mr. W. J. Hammer, of this city, and to unpublished material placed at my disposal. Let us briefly review the leading characteristics of these new substances.

Qualities of the Becquerel Ray. The peculiar radiations known as Becquerel rays are believed to consist of matter or particles rather than of a new form of ethereal vibration. These emanate from substances possessing permanent and seemingly inherent properties of giving out rays. They bear no relation to light (wave motion capable of refraction). Becquerel rays in common with ultraviolet, *x*-rays, and cathode rays will discharge an electroscope by rendering the air between it and the gold-leaf plates a good conductor of electricity. They are deflected (influenced) by a magnet. Radium rays are not homogeneous, but consist of rays possessing different characteristics and correspond well to a combination of cathode and Roentgen rays; the former being deviable, the latter not.

They appear to differ from cathode rays only in possessing a much greater rapidity of transmission. Some of the rays can be bent out of their course in the magnetic field, and even among these we find rays of different qualities. The effects upon the skin resemble those from x-rays (dermatitis, burn). Becquerel produced an ulceration of the skin of the abdomen by carrying a tube containing a radioactive substance in the vest pocket.

RADIUM.

Of the various radioactive substances recently investigated, radium stands far in the lead in point of importance and prospective utility in medicine.

Its discovery was announced by Prof. and Madame Curie some months after her discovery of polonium. Its rays possess very decided penetrating qualities, a considerable portion of them being capable of penetrating a lead plate of twelve millimetres' thickness, while those of polonium are readily absorbed and their activity decreased by the interposition of a thin sheet of paper.

Radium is self-luminous, possessing a bluish light, and causes phosphorescence on a sensitive screen. It is believed the light given off depends upon its stimulating impurities found in association with it. It has the power to throw out heat without the phenomenon of combustion, without undergoing chemical change, and, seemingly, without loss of weight. It is said also to maintain a temperature of its own, of 2.07° F. above that of its own surroundings, and in liquid air it shows at least no decrease.

In temperature much below this, such as that of liquid hydrogen, the astonishing discovery has been announced to the French Society of Physical Research, that radium gives out an increase of heat in this coldest of all known media.

Prof. Dewar, of the Royal Institution of London, showed, by surrounding radium with liquid hydrogen, that its radiation and heat output were increased, and thus could not be considered as drawing its energy from outside sources. A molecular change in the radium itself is the explanation offered.

If a salt of radium is dissolved in water in a sealed tube the quantity of heat disengaged is at first small. At the end of a month the quantity given off tends to become constant and is the same as that of the salt in the solid state (Curie). This would point to a part of the heat given off being due to a destruction of the emanations.

It emits both visible and invisible rays, as indicated by the persistence of its radiographing qualities after the visible rays have been excluded. There are three kinds of invisible rays. Examined under the microscope, a particle of radium salt suitably arranged before a sulphide of zinc screen gives the appearance of dots of light upon a dark background.

According to Sir William Crookes, the platinocyanide of barium or zinc sulphide fluorescent screen, which glows with a uniform phosphorescence when exposed to the *x*-ray, has superimposed upon this glow a shower of sparks of light when radium is placed near the screen. As the radium is brought nearer the number of sparks increase until there is a perfect rain of fire. If, now, we interpose a plate of glass the bombarding particles are shut off without producing any effect.

What the nature of the energy is, whence it comes, how it is stored, and in what manner it acts to keep up an invariable and continuous supply of motive power permitting radium to emit this never-ending discharge, are questions which the untiring investigations of scientists may some day make clear.

Crookes and others agree with J. J. Thomson's idea that in some, at present inexplicable, manner radium replenishes its energy from the movement of molecules in the surrounding air.

Under certain peculiar conditions it has been thought that particles, or, as Thomson has termed them, corpuscles, may be capable of flying off from the atom. On some such hypothesis alone does it appear that the law of conservation of energy can be brought to harmonize with the facts. The stored-up supply of energy would seem to be practically unalterable, for, while the substance does not materially lessen, it is not acted upon by any known influences which would tend to increase the output, unless it be a degree of cold approaching the absolute zero point.

The belief that the energy given off is not at the expense of weight,[1] furnishes an additional distinction between the active barium preparations consisting mainly of radium and the bismuth preparations containing polonium. While the former will not diminish with use and time, the rays from the latter decrease from the first moments of use, and in a few weeks may entirely disappear. On the contrary, it would appear that the heat activity of fresh preparations increase for a considerable time after they are made.

In this connection it must be noted that Marckwald has lately succeeded in producing, electrically, bismuth-polonium preparations whose activity is said not to diminish with time.

Wide credence has been given to the claims of Heydweiller, that a loss of weight occurs in radium amounting to two-hundredths of a milligram per day; but for what quantity is not stated. Hammer shows in his book, and after extensive correspondence, that the observations have not been confirmed, nor have they seemed to be by Heydweiller's own subsequent work. Others have demonstrated practically no loss in weight.

The point is one of the utmost importance. The atomic weight of radium has been found to be 225; it having been erroneously quoted at 289. Its occurrence in nature is so restricted, that Thomson says there is more gold in sea-water than there are radium, actinium, and polonium combined in pitchblende.

The reason we have no pure metallic radium is that it would be unstable, oxidizing in the air.

The source of radium, as elsewhere explained, is pitchblende or uranium residues, and it requires five thousand tons of the latter to produce a kilo (2.2 lbs.), since it exists in only about $\frac{1}{100000}$ per cent. It is in combination with lead, iron, chalk, silica, etc.

The recent discovery of radioactivity in various mineral waters would point to a wider distribution in the earth than

[1] This has since been disproven by Rutherford.

was first thought to be the case. More recent observations show its presence in slags, slimes, chemical wastes, deep-well waters, and petroleums.

Three classes of rays are designated as α, β, and γ. The α-rays are the largest and represent corpuscles positively electrified, just as the cathode rays are composed of corpuscles negatively charged.

The β-rays are found to be identical in many respects with cathode rays and negative electrons.

The velocity of projection of α-rays Rutherford finds about one-tenth that of light.

Induced Activity. Acquired radioactivity, or the activity which is induced in surrounding bodies by radium or by the Becquerel rays, persists, in distinction from that induced by Roentgen rays, which ceases shortly after removal from the rays' direct influence.

Exposure of objects, as the operator's clothing, walls of the room, the body itself to radium permits them to become secondarily radioactive for a time, so that they will themselves emit Becquerel rays for a short period.

The gas produced by radium, and in which Prof. Ramsey discovered helium, can be conducted through a pipe and cause substances at a distance to become radioactive. Soddy has employed inhalation of this gas in the treatment of phthisis. Hammer has discovered that substances which have received imparted radioactivity, the effect of which is no longer visible to the eye, can be made very apparent by stimulating it even after months by some high rate of vibration, such as that produced by burning a magnesium wire, by ultraviolet light, or by the brush discharge.

Lebon has found that almost all matter is capable of giving out Becquerel rays, due to the action of light alone. A body exposed to sunlight, or, still better, to ultraviolet light, gives off a form of radiation capable of discharging an electroscope which has been positively charged, and of satisfying other tests.

Effects on Animal Life. The most remarkable of the experiments upon animal life and development are those which Danysz carried out upon larvæ, and which might have a bearing upon the arrest in development and multiplication of cells such as those of cancer. A flask containing larvæ exposed to the ray showed, after several weeks, that the few which had escaped death were still living under the form of larvæ. Those in a control flask had changed into moths which had hatched their eggs, producing other larvæ which in turn had produced other moths.

The modifications of species elsewhere mentioned, in speaking of tadpoles whose development had been markedly influenced by exposure, are not more wonderful than this effect upon a still lower form of life, preventing the natural changes and perpetuating existence in a form under natural conditions so transitory.

Caterpillars exposed by Danysz became paralyzed and died. An intense action is noted upon the skin of animals, but the underlying tissues are little affected. The larvæ of meal-worms are promptly paralyzed. Of three fish exposed by Hammer, one died in two hours, one in seven hours, and the third was found dead outside the globe.

Effects of Radioactive Substances. The effects of radium seem to be identical with those obtained from the Roentgen rays. There are hyperæmia and tumefaction, and if the exposure is continued sufficiently long, ulceration. Treatment with radium gives at the end of six weeks the usual white, supple scar, and recovery seems to be quite as perfect as with rays produced by a Crookes tube.

These rays may cause upon living tissues at a distance lesions and changes quite similar to those caused by a too intense Roentgen ray.

London put a number of mice in a glass box with a perforated zinc top and kept the radium box on this from one to three days; the animals all showed symptoms of being affected on the third day, and all died on the fourth to the fifth day.

A few hours of contact of a strong radium with the sagittal suture of a rabbit, after trephining, caused first hemiplegia and then death.

Solutions of radium salts were found by Danysz to produce the same effects upon animals as the dry salts. He ascribes the pathogenic action to the susceptibility of the skin's nerves.

The duration of the effects varies with the intensity of the action and the length of time it is applied. Burns do not show themselves for about a fortnight after exposure. In this they resemble *x*-ray effects. The erythema may, however, be apparent in a much shorter time—according to Exner,[1] from two to forty-eight hours.

In an experiment by Danysz, two parent and six young white mice were exposed to the influence of five centigrams of the chloride for three days, when the young began to lose their fur and in three days later had become quite bare over the back; two days later they became blind; one died two days after this, two others the next day, and two more on the following day.

About ten days later both parent mice became blind and died twenty-three days subsequently. Two other adult mice, exposed for ten days, died at the expiration of the experiment. The time required to produce death appears to be in inverse ratio to the strength of the radium employed. Thus, with half the activity, other conditions remaining the same, death occurred in twenty-two to twenty-six days respectively.

Just as we have noted for the *x*-ray, mild dosage, as by short exposure, increased distance, or low intensity, may produce a stimulation of vital process, the animal thriving and showing increase of hair growth instead of loss.

Chemical and Physical Action of Radium. The photographic plate is the test for all suspected radioactive substances. The discoloration seen in glass receptacles and the burn-like changes in human tissue are due to chemical change. Becquerel noted a loss of germinating power of seeds exposed to the ray.

Hammer's[2] experiment upon the electric fish in the Aquarium at Naples would point to the possibility of producing paralysis by radium, as is suggested by experiments made by several observers.

BURNS. Walkhoff and Giesel were the first to observe the effect of the Becquerel rays upon the skin; they found that it is very similar to that of the Roentgen ray.

[1] Wiener med. Gesellschaft, June, 1903.

[2] Radium and Other Radioactive Substances. New York, I. Van Nostrand & Co., 1903.

Giesel kept for two hours upon his hand a celluloid capsule containing radiferous barium bromide. An erythema appeared in a few days and necrosis and ulceration some weeks after exposure. The lesion healed very slowly, with a thin, smooth, somewhat pigmented cicatrix.

Becquerel and Curie observed the same effects on their own persons from radiferous barium chloride.

Prof. Curie exposed his arm to a weak preparation of radium for ten hours; shortly after an erythema developed, and fifty-two days later the resulting ulceration was still unhealed.

Becquerel had the same result in working with a very active barium radium bromide; a minute quantity of the salt in an hermetically sealed tube worn upon the coat-sleeve for an hour produced an intense inflammation of the skin and an ulcer which did not heal in less than three months.

Aschkinas, after two hours' exposure to a very active preparation, found that the inflammatory symptoms developed only in about thirty days, up to which time there was only a slight redness visible.

To judge from the length of time elapsing from the first reaction to the inflammatory process, it would seem probable that there must be some microscopically visible changes in the tissues long before they become visible to the naked eye; just as the rays are imperceptible, so are their early effects.

London, in experimenting with a preparation of radium enclosed in a metal box, found that on the human skin, even from a distance, it may produce a gangrenous burn of any severity, depending entirely upon the intensity of the ray's action.

The course of this burn is so characteristic that we are justified in speaking of a *dermatitis radiogenes.* He has also found that arterial blood will become dark under the action of the Becquerel rays. This would naturally lead to the supposition of an interference with the proper oxidation of the blood, perhaps as the result of its action upon the vasoconstrictor nerves impeding circulation. This may also possibly be the explanation of the cause of the deep destructive effects similar to the x-ray "burn," as we have suggested in the chapter on this subject.

Hammer met with the same disagreeable effects from inadvertently carrying eight tubes in a box beneath the arm. The entire region was peculiarly sensitive and tender, persisting for two months, though the skin was not ulcerated.

Goldberg[1] applied 75 mg. of radium to his arm and left it in contact for three hours.

On the fourth day a red area corresponding to the disk of the radium-holder appeared. This increased in color, with the formation of a hard, infiltrated zone around it. Next a serous bulla formed, and shortly after the whole epidermis was exfoliated, leaving the corium denuded, which broke up rapidly, forming an ulcer. This still persisted three and a half months later. The reaction produced depends upon the radiant power rather than on the quantity or intensity.

Exner and Holzknecht[2] find that the reaction produced on the skin cannot possibly be due to the fluorescence of radium, as it may be applied enclosed in substances that keep out the light without affecting the reaction following the application.

They divide the reaction produced into three grades characterized by:

1. Reddening, swelling, pain, with final restoration to the normal.

2. Vesicles with or without exfoliation, accompanied by a condition only differing from the normal in a slight atrophy of the skin.

3. Mortification with following ulceration and subsequent scar production.

In studying the intensity of the reaction they find that the latent period is in inverse ratio and the duration and severity of the reaction in direct ratio to the length of exposure.

Effects upon the Eyes. London,[3] experimenting with a preparation of radium enclosed in a metallic box upon its

[1] Dermat. Zeitschr., vol. x. p. 457.

[2] Sitzungsbberichte der Kaiserlichen Akademie der Wissenschaften, July 2, 1903.

[3] Berliner klin. Wochenschrift, 1903, No. 23.

effect in blind people, found that those who can perceive some little light will get the effect of light as soon as the radium is brought near the eyes; but in those who cannot perceive light the result is negative or very contradictory.

Those who can distinguish light from shadow, but cannot recognize objects, can in a dark room differentiate some substances placed on a fluoroscope when lit up with radium. Any person will perceive a light effect in an eye protected from light when radium bromide is brought within 10 to 15 cm. of the eye, or even if it is brought close to the forehead or to the temple, but in varying degree, depending upon the strength of the preparation. This is supposed to be caused by a certain retinal fluorescence, and in the various diseases of the retina we get different characteristic light effects.

The light effect is sufficiently strong to enable us with eyes carefully bandaged to locate the position of the box containing the radium and to recognize its movements in the air.

A number of subjects have this light effect even when the radium is brought near the back of the head, which seems to point toward an irritation of the central nervous system rather than phosphorescence of the retina.

This light effect is present even when the closed and carefully bandaged eyes are still further protected by the thickness of four overlapping bands, or if the radium is enclosed in a metal box.

Prof. Greef,[1] in experimenting upon vision with radium, found that those whose optic nerve has not been destroyed could distinguish objects in front of a screen made fluorescent by radium; but he also has found that they could distinguish objects on a semitransparent screen illuminated by an ordinary lamp. He concludes that the blind cannot hope for the slightest help from radium.

With the assistance of radium we can make microscopic examinations in a dark room. All we need, it is said, is to light up the object field of the microscope with a good fluoroscope.

[1] Medical Record, April 2, 1904

Schwarz and Holzknecht[1] believe that the ability of blind persons to perceive the light of radium and the images of metallic objects is to be explained either (1) that the ray passing through the tissues stimulate in the optic nerve the relics of vision persisting in it, or (2) that it is due to the transformation of the radium energy into objective phosphorescence just as it causes many objects in nature to phosphoresce.

The latter explanation they believe the more probable, the radium rendering the sclera phosphorescent in the area of the retina opposite this phosphorescence.

The sensation of light when a tube is held against the temple or against the closed eye is probably an effect of phosphorescence within the orbit, the liquids within the globe becoming luminous or phosphorescent. There may also be an effect upon the optic nerve.

Caution. In view of the marked and lasting ill effects which might be caused, and bearing in mind the injury to the eye in many instances from x-rays, the operator should protect himself from long exposures. Induced activity can cause interference with sight lasting for several weeks, as Hammer found in his own case in experimenting with his head enclosed in a box whose interior had been rendered secondarily radioactive.

Experiments about the eye cannot be too carefully conducted, especially in slight affections curable in other ways, and in a diseased globe when the other eye has been lost.

Bactericidal Effects. Observations upon the influence of Becquerel rays upon bacterial life are still too few for definite conclusions.

In experiments by Danysz, anthrax bacilli were checked in development. Pfeiffer and Friedberger, of Königsberg, have demonstrated the germicidal action which they claim surpasses that of the x-ray; but since, until now, no great power in this direction is attributed to the latter, their claims are moderate. Aschkinas and Caspari[2] found some bacterial forms could be destroyed.

[1] Wiener klin. Wochenschrift, No. 40.

[2] Arch. f. d. ges. Physiol., 1901, No. 86, pp. 603–618.

Experiments were made on agar-agar cultures of the micrococcus prodigiosus. The culture was exposed for from one to five hours to the action of the rays from barium-radium-bromide crystals. The results showed that those rays which are only slightly absorbed are without effect upon the bacteria, and that those which are absorbed in any great degree have a strongly inhibitive action, so strong in some cases as to entirely stop the growth.

Pathological Effects. Halkin,[1] experimenting with the Becquerel rays on rabbits, found on microscopic examination that the ray affects the capillaries, epithelium, and connective tissue at the same time, and that these effects only become visible to the naked eye when a certain amount of degeneration has taken place. It appears to exert a specific action on cutaneous vessels.

Radium appears, in common with *x*-ray, to possess the power of producing sclerosis. Ulcers exhibit the outline of the radium plaque which has been applied; so there exists no question of their being produced by radium. The depth of the ulcer may implicate the whole thickness of the derma if applied for a long time.

Barthélemy makes the good suggestion as to the therapy in these burn-like ulcers that soothing applications succeed better than others, since it is a general rule that in the seat of all trophic changes irritating substances are badly borne.

Uses in Diagnosis. Radium has been employed as a test in paralysis of the optic nerve. There is a probable phosphorescence produced within the orbit when a small tube of radium salt is held against the temple or in front of the eye. This fact has been utilized in testing for total blindness.

Radiographs have been made by the aid of radium, but until now they have a purely scientific rather than a practical significance.

Dr. Javal, himself a victim of blindness, believes that we may have in radium a means of diagnosticating cataract and of showing whether operation would be likely to succeed. Naturally, if radium indicates that the retina is intact the lens can be removed with the expectation of restoring sight.

[1] Arch. f. Dermat. u. Syph., vol. lxv.

Therapeutic Uses. It was because of the physiological effects accidentally produced in human skin that the suggestion was made that therapeutic results might be obtained.

A combination of chloride of barium and radium giving, as compared with uranium, an activity of 1000 to 2000, kept applied to the skin for twenty-four to forty-eight hours, produces little more than a slight redness, which persists for perhaps five or six days. This is followed by a flat bulla, or, perhaps, excoriation without evidence of vesiculation. The lesion takes longer to cicatrize than similar lesions from ordinary burn or injury. If the activity is greater the lesion is correspondingly deep and obstinate, but the length of exposure need be much less.

In applying radium to such a disease as *lupus* or *lupus erythematosus*, the sulphide is diluted with chloride of barium. This is placed in a small caoutchouc bag and fastened upon the area to be affected for the required time, which varies according to the case from twenty-four to forty-eight hours.

Since it is possible to obtain specimens whose radioactivity is said to go into the millions, the time of therapeutic application may come to be materially shortened; still, as no pain or discomfort attends the treatment, the time element *per se* seems unimportant; the danger is, however, great.

Danlos[1] has subjected four patients to a comparative test by radium and other forms of treatment. Three of these were affected with *lupus*, and one with *cutaneous tuberculosis;* although the time was too brief for definite conclusions, the comparisons rather favored the newer method. He employed plaques of radium having an activity of from 2500 to 19,000, leaving them *in situ* twenty-four to thirty-six hours. The results were such as to cause a prediction of a brilliant future in dermotherapy, provided the price can be reduced by advances in chemistry. According to Curie, the activity could be carried to 1,500,000. Since this statement preparations of 1,800,000 activity have come into use. This increased radioactivity would seemingly permit of

[1] Annales de derm. et de syph., July, 1902

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results from the employment of radium far superior to those now obtained. The rays emanating from the plaques seem to be a mixture of the cathode and x-rays, and since pains have been known to be caused by the x-rays the author believes the painful crises reported as following the application of radium may be due to x-rays emanating from the latter. He suggests, as a guard against secondary effects, to multiply the number of sittings and diminish their length.

There is a strong analogy between the lesions due to radium and those due to the x-ray. The objections to the treatment are, first of all, the high price, and, secondly, that no two samples are exactly alike, and each one would, as it were, have to be experimentally tested to determine its burning curative or destructive power. Its advantages are simplicity, innocuity, and generally absence of painful reaction.

The cicatrices left after radium compare well with those after other forms of ray treatment, and at times seem to surpass in softness those following other methods.

Oudin is said to have had good results in *lupus*. Mr. Hartigan[1] reports four cases of lupus vulgaris treated with good results.

The effect upon vegetating tissue is found to be quite feeble. Thus, in a *vegetating cancroid* which had developed upon the cicatrix following lupus, despite prolonged application, the result was *nil*.

Dr. A. Blandamour, in a Paris dissertation, reports upon several patients with *lupus* who were cured in from three to six weeks, the scar being white and smooth. Scholtz[2] reports five cases of lupus cured by the application of radium.

MacIntyre has seen very satisfactory results in several cases of lupus recorded by him.

A patch of *lupus hypertrophicus* was cured by Holzknecht in two applications of seven minutes each at an interval of one month.

Einhorn[3] has devised various methods for applying radium to the digestive tract. For the stomach he uses a glass capsule which may be unscrewed (Fig. 108). The

[1] British Journal of Dermatology, March, 1904.

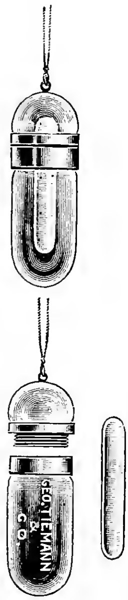
[2] Deutsche med. Wochenschrift, 1904, No. 3.

[3] Medical Record, March 5, 1904.

upper part is provided with an opening for the attachment of a silk thread. This is marked with knots at 40, 50, and 63 cm. The method for introducing the radium capsule is the same as that for the introduction of the stomach bucket.

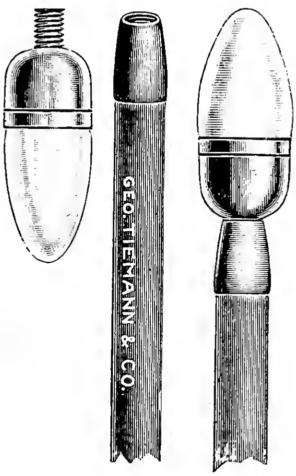
The receptacles for the œsophagus and rectum are somewhat similar (Fig. 109). They may be made of any material which does not markedly obstruct the emanations from the

FIG. 108.



Radium receptacle for the stomach.

FIG. 109.



Radium receptacle for the œsophagus and rectum.

radium. On the cover is an elevation provided with a screw-thread to be attached to a bougie. The instrument is introduced far enough to enable the capsule to come in contact with the affected parts, and is permitted to remain there for a variable time, depending upon the radioactivity of the specimen used. He reports one case in which the stomach receptacle was used for three weeks with apparent good result. The tumor seemed to have diminished in size and the pains considerably lessened.

Exner,[1] preceding Einhorn, devised and described the identical apparatus for the application of radium to the œsophagus, using a hard-rubber capsule. He reports five cases in which he applied it with a resulting diminution of the stenosis and other accompanying beneficial results.

Lupus erythematosus, as well as *lupus vulgaris*, may receive radium treatment when persistent phototherapy and Roentgen therapy have failed. Danlos employed, in this affection, a white powder made of chloride of barium containing a small quantity of chloride of radium, and whose radioactivity varied from 1000 to 5200.

In one case wherever the radium was applied, smooth, white islands were left which contrasted with the surrounding red areas not treated. A receptacle containing the 5200 radioactive powder was left in contact with five different areas from twenty-four to sixty-three hours. The contrast with untreated areas was manifest. The opposite side of the face received one hundred and ten treatments by phototherapy. That under radium was much more improved than the side treated by light.

Cancer. Plimmer[2] analyzes 17 cases treated with radium bromide, and concludes that emanations from this substance can only act on young and rapidly growing cells, and that the older cells, especially if surrounded by fibrous tissue, are less and less easily affected, and, if there is an excess of fibrous tissue, hardly affected at all. The therapeutic test was negative.

Epithelioma. Mackenzie Davidson reports a case of epithelioma of the nose treated with the *x*-ray unsuccessfully which was cured by exposing it to radium. There were four exposures given at intervals of a few days, aggregating an hour; in three weeks the ulcer was healing, and in six weeks, with two further exposures, it had entirely disappeared without leaving any scar whatever.

Radium should prove its greatest worth in cancer of the smaller cavities, so difficult of access by usual means.

Mr. Hartigan[3] reports three cases of epithelioma that resisted all other forms of treatment cured by radium.

[1] Wiener klinische Wochenschrift, January 28, 1904.

[2] The Lancet, April 16, 1904.

[3] Loc. cit.

Holzknecht secured rapid disappearance with only a trace of infiltration left around the edge in three sittings of five minutes each.

Scholtz[1] reports cure in two cases of epithelioma treated by him.

Exner treated an ulcerating epithelioma of the corner of the mouth showing deep infiltration. Radium was applied for from fifteen to twenty minutes six times over a period of a month. In a month's time the tumor has apparently vanished. Trial in a second case seemed equally successful.

In the clinic of the late Professor Gussenbauer, of Vienna, some twenty tumors have been seen to grow smaller, and even to disappear in from two to six weeks.

Melanosarcoma has been successfully treated by the bromide of radium in the same clinic.

The practically invariable return and fatal outcome in this form of sarcoma makes radium rays after surgical intervention of much importance, if the cure in this instance proves permanent.

Exner, of Vienna, saw a disappearance of rapidly growing melanosarcomatous nodules of the skin when emanations from three milligrams of bromide of radium were applied for upward of twenty-five minutes.

In a subject of *osteosarcoma* whom I subsequently treated by the *x*-ray, I saw no benefit from radium of 3000 activity employed for some time.

Deleterious Effects. The deleterious effects seem to be identical with those of the *x*-ray, the action being, however, more intense; in consequence of degeneration, perhaps beginning in the intima, there is rapid dilatation of the capillary and precapillary vessels.

Hallopeau and Gadoud[2] report a case of verrucous lupus which had persisted for several years despite vigorous curettage and a variety of other painful procedures. The verrucous condition disappeared and was replaced by a smooth cicatrix. There were two ulcerations on the dorsal surface of the hand due to the radium which persisted for

[1] Loc. cit.

[2] Compt.-rend. de l'Acad des Sciences, July, 1898.

about six months after the lesions for which it was applied were cured.

The radium had been left on from seventy-two to one hundred and twenty hours. A persistent coloration remained, and fifteen days later an ulceration appeared. There was an impairment in the flexion of the last two phalanges which the patient attributed to the radium. This was the result of a sclerosis of the skin which impeded the motion and was similar to those at times following x-ray.

Caution. The authors warn against the use of plaques having too great radioactivity, as they are liable to produce more harm than good.

Among other supposed injurious effects the eye has come in for a share just as with x-rays. The fact that Holzknecht and Schwartz have shown that the crystalline lens and the vitreous body become fluorescent under radium might add strength to the supposition of some that an ill effect might be produced in these tissues.

These same observers do not find ground for this view, nor for that of injury to the retina.

Telangiectasia. Holzknecht operated in a very satisfactory manner upon an extensive flat birthmark covering the entire left arm. Applications of ten minutes' duration were made at eight different points; the result at these points was the production of patches, one-half centimetre in diameter, of perfectly normal appearing skin scattered over the nævus.

In *neuralgia* radioactive substances have been tried with some good results.

Psoriasis. Holzknecht finds that an application of one minute's duration is amply sufficient, and that radium cures psoriatic patches as well as do the x-rays.

Radium is now offered in the American market having an activity of 300,000 at $3200 per gram, while a radium salt of 1000 radioactivity can be had for $35 per gram.

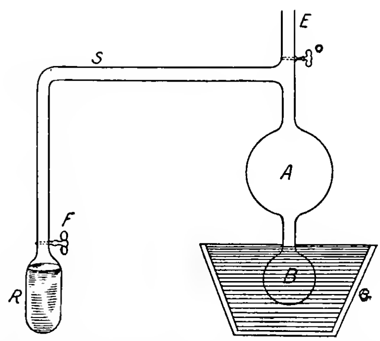
Spinthariscope. This is an instrument devised by Crookes for observing emanations of a minute quantity of radium and their radioactive properties.

In placing upon a microscopic slide a small quantity of radium, in front of a fluorescent screen under the microscope, scintillations can be observed. The screen transforms the invisible emanations into waves which the eye can perceive, the radiations emitted being longer than those absorbed by the screen; a tube having a screen at one end and a movable pointer carrying the radium and a powerful lens in a sliding tube make it possible to dispense with the microscope.

Radium Emanations. Radiations or products of apparently gaseous nature are continually given off as an invisible vapor, so to speak, capable of depositing upon surfaces and causing acquired radioactivity in various substances.

To demonstrate their existence, Prof. Curie employs a simple apparatus, as shown in Fig. 110. The bulb *R* contains a solution of salts of radium. In the angular tube connecting with the larger bulb *A* and the smaller *B*, which are filled

FIG. 110.



Apparatus for demonstrating radium emanations

with sulphide of zinc, is a tight stopcock; another shut off in the tube *E* permits of the exhaustion of the bulbs *A* and *B*. In a darkened room the bulbs *A* and *B*, after exhaustion, glow brilliantly when the stopcock *F* is opened. Since there was no glow previously, it proves that the radiance has not passed directly over from the radium through the glass walls, but must have gone around through the bent glass tube.

It is also known that radium rays are capable of passing through glass, but have no power of affecting zinc sulphide. If now the tube *B* be plunged in a basin (*G*) containing liquid air the intensity of the glow is increased at the expense of the brilliancy of the light within the bulb *A*. Just what occurs by this outside cold effect is not known, but it has been suggested that the gas may be changed into a liquid possessed of some power of attracting other gases to itself. These emanations have been found to be of very great attenuation, and have the power of rendering all substances radioactive for a longer or shorter time, according to the way they are protected.

Sir W. Ramsey and Mr. Soddy have found the spectrum of helium in a vacuum tube which contained nothing but the radiations and "emanations" from radium. In other words, radium develops helium by a spontaneous change.

Tuberculosis. In phthisis radium emanations can be inhaled into the lungs, according to Soddy, and are there capable of giving off rays similar to those from radium itself. When dissolved in water the stored-up activity of a solid radium compound is given off.

Once the emanations have been inhaled the solution must be left tightly closed, in order that it may recover its emanation before it can again be used. It is supposed that an induced radioactivity is excited and remains in the air cells after the emanations themselves have been exhaled.

Thorium acts in the same manner, but is but feebly radioactive. The nitrate is very soluble and most suitable for this purpose, but the free nitric acid should be neutralized by cautious addition of ammonia with stirring.

An hour's daily inhalation of emanations from 100 grams of thorium nitrate dissolved in a bottle could be safely employed and gradually increased. Radium emanations mixed with air glow brightly in a dark room and exert a powerful oxidizing action on carbonaceous matter.

Radiofluorescence. It has been suggested that solutions of radioactive substances might be administered internally in various affections, especially those of the gastrointestinal tract.

Since it has recently been found that many mineral waters of known efficiency in disease possess a natural radioactive quality, it may be possible that the greater efficacy which these waters possess over those artificially made in conformity with other chemical analyses is due to this hitherto undiscovered property.

POLONIUM.

This name was given by Madame Curie to a substance found by her and her husband, Prof. Curie, and announced in 1898.

Experimenting with pitchblende residues from which the uranium had been extracted, they noted more powerful radiations than from any uranium with which they were familiar.

It is associated with bismuth and chemically resembles the latter closely, though its color is more that of lead.

It has been shown by Markwald to be a primary element, though it is more sparsely distributed in uranium than xenon, the most rarefied gas, is in the atmosphere.

Polonium gives up power, it would seem, with greater ease than does radium. Giesel claims to have produced a polonium some of whose rays are deviable and others not. Crookes finds that the rays do not penetrate glass, and, while those of radium penetrate not only glass, but quartz and mica, polonium rays are absorbed by them as well as by minerals, although they pass more readily through aluminium than do the uranium rays. It is not used in therapy.

ACTINIUM.

This is the name given by Debierne to another substance found in pitchblende in 1899, which is a compound mineral containing 81.5 per cent. of uranium, 4 per cent. of lead, and 0.5 per cent. of iron, besides traces of barium and many other elements. It has the characteristics of thorium, and, according to Crookes, is identical with uranium X, a substance he isolated from uranium.

Actinium rays are deviable. While supposed to be a new element, it has not been found in a sufficiently pure state and in sufficient quantity to give a spectrum.

URANIUM.

To Klaproth chemistry owes the discovery in 1789 of the metal named for Uranus.

In 1840 Peligot isolated metallic uranium from the chloride.

This metal, which has been adopted as the unit of measure for radioactive substances, while comparatively common, occurs most largely in pitchblende or uraninite, which is a compound oxide. The supply of this ore has been until now limited, and some specimens do not contain a large quantity of radioactive metal.

Two classes of rays were found to exist by Rutherford, who named them alpha and beta. The alpha is the most important and numerous. They are deviable in a powerful magnetic field. The beta rays have the characteristics of the cathode ray and are readily deflected.

This, like polonium, does not possess the power of exciting radioactivity, the emanations characteristic of radium and thorium being absent.

Rutherford and Soddy, comparing uranium with thorium, find that uranium in certain respects is much simpler than thorium. The important distinction consists in the photographic and the electric effects. The uranium radiation consists of two types: (1) rays that are readily observed, and (2) penetrating rays which may be readily deviated in a magnetic field.

The photographic effects are probably due to the penetrating rays, while the easily absorbed rays produce the electric effects. In the radiation of what is called uranium X there appears to be no rays which are easily absorbed, while in thorium there exists a non-separable activity consisting entirely of easily absorbed rays.

Uranium nitrate may be obtained at about $5 per pound.

If a piece of the nitrate be held before an arc lamp so as to be acted upon by the invisible rays, it becomes beautifully fluorescent.

In doses of 10 to 20 grains three times daily, uranium has been used internally with benefit in diabetes, interstitial nephritis, and bronchitis.

THORIUM.

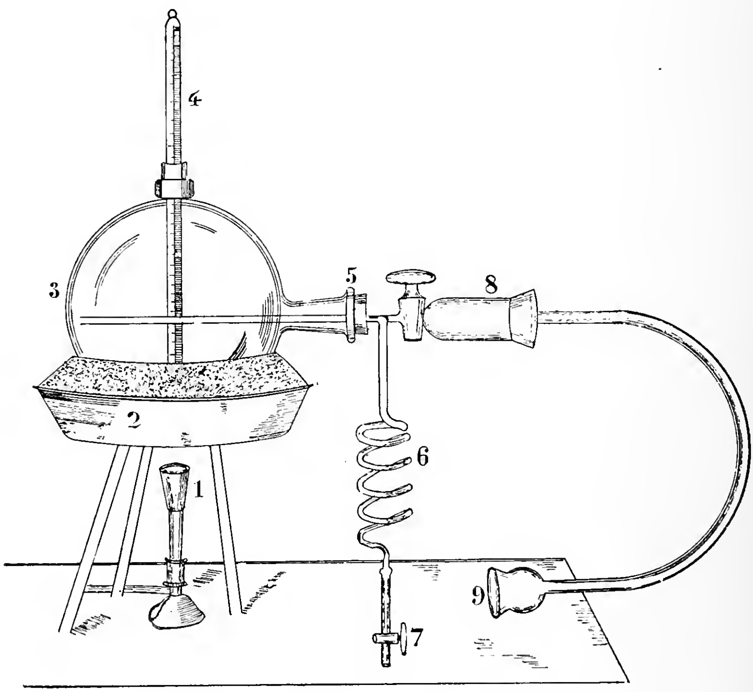
The radioactivity of the oxide of thorium was discovered independently by Schmitt and Curie. It stands next to radium in its radioactive qualities. Its chief use has been in the making of Welsbach mantles. Professor Rutherford, of McGill University, announces important discoveries relating to "thorium emanations." Thorium is one of the metals which has the power of emitting rays similar to those of radium. They reduce the silver salts of a photographic plate. These rays when passed over red-hot lead chromate and through boiling nitric acid are unaffected, there being no chemical reaction. This fact led to the supposition that the emanations might be of the nature of gases similar to those which have been recently discovered in the atmosphere, and which it is almost impossible to combine chemically.

Upon cooling the tube through which these rays passed with liquid air it was found that the emanations were condensed in the tube. The emanations were discharged in such a way that they made a circuit between two electrically charged plates, the current being registered by a delicate galvanometer. As soon as the tube was cooled by liquid air the current ceased, showing that whatever had been passing through the tube was condensed. Afterward the tube was removed from the liquid air and allowed to get warm. When the temperature had risen to a certain point the galvanometer suddenly registered a stronger discharge than any previously obtained.

The emanations were condensed inside the sealed tube and kept for almost a week. These experiments seem to prove that these emanations or corpuscles have some of the characteristics of ordinary gases. Possibly they constitute a new form of matter having properties different from any with which we are acquainted (Fig. 111).

The experiments seem to settle the question that the emanations from radioactive substances are "corpuscular." It is assumed that radioactivity is a manifestation of subatomic chemical change. Such change is evidently of a different order from that which has been commonly dealt with in chemistry.[1] Radioactivity is not a specific property of certain so-called elements such as radium and polonium, since bismuth and barium emit seemingly identical radiations. It may also be communicated from a radioactive substance to one which has no such inherent property. Sir William Crookes assumed the existence of matter in a gas-

FIG. 111.



Apparatus for the inhalation of the emanations of thorium.

eous state which he called radiant matter. In some of its properties radiant matter appeared to be as material as a block of wood, while in other properties it assumed the character of radiant heat. He said: "We have actually touched the border-land where matter and force seem to merge in one another."

Prof. J. J. Thomson calls the emanations of radioactive

[1] The Lancet, December 27, 1902.

substances electrons. An electron is about the $\frac{1}{700}$ part the mass of the hydrogen atom, and these masses start from the negative pole in a vacuum tube with a velocity of 10,000 miles per second. Electrons emanating from radioactive bodies behave like particles of matter, partaking of the properties of a fog or mist, and are capable of being diffused away in the free air like odoriferous substances.

Uranium radiations or Becquerel rays (β) travel at about 100,000 miles per second, still less swiftly than light.

It would seem as if Professor Rutherford had captured the radiant matter of Crookes and the electrons of Thomson.

Just as thorium became much more plentiful after a demand arose for it in the manufacture of incandescent bulb mantles, it is probable that some new sources of radium will be found. Still, at best, it does not seem as though the latter could ever be anything less than the rarest and most precious metal.

NIEWENGLOWSKI'S RAYS.

These rays emanate from substances which have been previously exposed to the sun.

Thus calcium sulphide gives out in the dark, so that a photographic plate shows its presence, energy which it has absorbed on exposure to sunlight.

That these rays are similar to light and differ from Becquerel rays is shown by evidences of refraction when passed through glass (a line at margin of glass).

GOODSPEED RAY.

Secondary Radiations. Evidences of secondary action have been from time to time noted, as in the accidental-image found upon the plate when metallic bodies have been in a position behind the latter, or on the opposite side from which a shadow picture was being made. In the experiments of Prof. Goodspeed the tube was enclosed in a box, which prevented any optical fluorescence from entering the room; while the x-ray could penetrate the sides of the box, heavy lead plates placed upon the top of this box supported radiographic films, and upon the latter were placed objects of metal and wood; in spite of direct radiation to the plate being prevented by the leaden plates, a picture of these images was obtained. While some admit this secondary radiation, they do not admit its phosphorescent character.

Dr. Lebon failed to reproduce the experiment. De Rochais found that by filling a glove with sand and heating it to the body temperature, the same effect was produced upon a sensitive plate as from the alleged luminous radiations emitted by the human body. It was inferred that the marks upon the plate were caused by the heat alone.

Dr. Milton Franklin has observed the same effect, and explains it on the theory of fluorescence. It is well known that the x-ray causes glass to fluoresce, and the emitted rays passing from the back of the plate strike the coin or other object, and, unlike the x-ray, are reflected by it into the plate again and cause an impression of its image.

GOLDSTEIN RAYS (CANALSTRAHLEN).

What have been called s-rays are produced when x-rays encounter some resistance. When x-rays pass through some transparent medium another set called s'-prime are formed; these are named the Goldstein rays.

So-called channel rays, produced by a perforated cathode, are thought by Wehnelt to be ions. Berg[1] has, however, shown them to be anodal rays.

Wien demonstrated them to consist of positively charged particles moving with a great velocity.

BLONDELOT'S N-RAYS.

In a volume where scope includes the whole subject of radiation as applied to medical practice, the omission of

[1] Wiedemann's Ann., Bd. lxviii. p. 688.

at least a brief mention of that form of radiation first observed by M. Blondelot,[1] of the University of Nancy, and by him named the *n*-ray, would be an error. While it is true that at the present time there is not the slightest application of these rays in medicine, the fact that they are radiated by the human body under certain circumstances and that they have already been shown to possess the ability to produce certain physiological effects, added to the circumstance that they are being widely investigated by many eminent medical authorities, lead to the hope that they may eventually prove of considerable therapeutic interest.

The *n*-rays were discovered by Blondelot during an experimental endeavor to polarize the *x*-rays, and were for a long time supposed to emanate from a vacuum tube only. Subsequent investigations have demonstrated that these rays are given off by a variety of substances, among which may be mentioned tempered steel, sulphur, and many rolled metals. Under the influence of torsion or tensile strain, wood, paper, and several other organic substances have also been found to possess this property.

To Charpentier is due the discovery that the human body is capable of giving off rays which have been identified as *n*-rays. This discovery was followed by a belief on many sides that the effects were due to heat, but the further experiments of D'Arsonval and Charpentier, who surrounded themselves with all possible precautions, have amply demonstrated that this is not the case.

In addition to the substances that are known to emit the rays spontaneously a still larger class are at present known, including gold, silver, platinum, zinc, iron, and a host of others which, when they have been previously exposed to some powerful light-source, are capable of emitting the rays in the dark.

The *n*-rays are capable of reflection, refraction, and polarization in very much the same way as light, thus differing from the *x*-rays; they pass freely through several substances, such as paper, wood, and aluminium, which are

[1] Comptes-rendus de l'Acad. des Sciences, March 23, 1903.

opaque to light, and are somewhat absorbed by glass, the degree depending upon the nature and thickness of the latter. These numerous, apparently contradictory conditions render the exact location of these rays in the scale of wave lengths extremely difficult and uncertain, but recent investigations on the part of Blondelot seem to definitely assign them to that region of the spectrum between the highest limit of the electromagnetic waves and the lowest known infrared rays, a region which has until the present existed as an unexplored vacant gap in the spectrum.

It has been suggested that these rays may be of value in determining whether or not life had actually ceased in obscure and puzzling cases, but in the present condition of our knowledge the determination would hardly be a safe one, as there may exist some conditions of the body not as yet recognized in which these rays are in abeyance. Further than this, some slight observations have been made in the emission of the rays in certain nervous conditions, with the result that it has been fairly established that in such conditions as paralysis or atrophy resulting from myopathy, neuritis, or poliomyelitis, where the peripheral motor neuron is affected, there is a diminution of the emitted *n*-ray. Beyond this there has been practically nothing done in a line of any interest to medical science.

The *n*-rays may be conveniently observed in the following manner: Two screens are prepared by painting on a couple of similar sheets of black cardboard small disks of the polysulphide of calcium about 1 cm. in diameter. These screens are placed close together and moderately illuminated for the same length of time by the same source of light. One of the screens is then protected by being turned face down and the other is applied to the tip of the finger or tip of the nose, to the forehead, or to the palm. On comparing this screen with the other it will be readily seen that that which has been exposed to the body has gained in brightness. By attaching one end of a thin copper wire to the screen and applying the other to the body, it may be shown that the rays traverse the wire.

These and similar experiments must be performed in darkness, as the relatively feeble luminosity of the *n*-ray may be perceived only when the eye has been accustomed to the absence of light.

The presence of the *n*-rays in other substances than the human body may be proven by their ability to increase the luminous intensity of a gas or electric light when they are focused upon it.

Blondelot[1] claims, in his eighth paper, that when the rays fall upon the retina they increase its visual acuteness, so that objects viewed in a very dim light become clearer and brighter.

[1] Comptes-rendus de l'Acad des Sciences, November 23, 1903.

PART VII.

HIGH-FREQUENCY CURRENTS.

CHAPTER XXXI.

INTRODUCTION—HISTORY.

A WORK on treatment by light, radiotherapy, and actinotherapy must to-day be considered as incomplete which does not take cognizance of what has been done during recent years in a comparatively new field of electrotherapeutics—viz., *high-frequency currents.* The local effects of these currents being obtained largely by the aid of sparks, or visible currents which have been demonstrated to contain actinic and other rays of recognized utility in treatment, cause many observers to believe that the latter have much to do with the good results obtained from high-frequency currents. There exists an additional reason for introducing a chapter on high-frequency currents, besides the possibility that some at least of the therapeutic results obtained are caused by rays which are emitted in some of the forms of application. The method has been proven of decided value when employed in conjunction with other methods described in these pages.

We might add, as a further reason, that the apparatus necessary for the production of *x*-rays serves equally for generating these newer electric currents, with the addition of some accessories. In the preparation of the following account we are indebted largely to the works of Denoyés,[1] Freund,[2] Chisholm Williams;[3] to the experimental investiga-

[1] Les courants de haute frèquence, Paris, 1902.

[2] Radiotherapie, Berlin, 1903.

[3] High-frequency Currents in the Treatment of Some Diseases, London, 1903.

tions and writings of D'Arsonval, Oudin, Piffard,[1] and others.

We have utilized, so far as possible, extant literature in connection with a personal experience covering a fair range of pathological conditions. One feature which high-frequency currents is said by some to have in common with radiotherapy is the presence of the cathode ray.

Louis Jones[2] says, in this connection, that perhaps in the future one may come to speak of treatment by "cathode rays." Since, however, this can only apply to the one restricted application by means of glass electrodes, and as D'Arsonvalization forms a most important part of the method, we must consider the results as due to other electric phenomena.

In approaching the historical side of the question, a distinction should be made between high-frequency currents and high-frequency treatment—*i. e.*, between the origin and development of these currents and their practical application to the cure of disease.

The first may be claimed as essentially American; the second may be said to belong to France, by right of perfection, introduction, and popularization of methods in use at the present time. Morton became a pioneer by the introduction of his static-induced current in 1881, which was a newly recognized form of current, although its claim to being a high-frequency current, in the present sense of the term, has been disputed.

Most important pioneer work was unwittingly executed in 1842, by another American, Joseph Henry, in his demonstration that the discharge from a Leyden jar is not continuous as had been thought, but oscillatory in nature. It was only, however, when Tesla's brilliant genius was brought to bear upon an arrangement of step-up transformers, multiple-pole alternators, and other ingenious devices by which currents were produced on this side of the Atlantic, whose potential extended into the tens and hundreds of thousands of volts, that their application to therapy began to make headway.

[1] Medical Record, October 31, 1903.

[2] Practitioner, 1903, vol. lxx. p. 361.

Historical. It is to D'Arsonval that we owe the most of what is known to-day of these peculiar currents. It was he who studied the physiology of their action and the mechanism of the excitation they caused in muscles and nerves. He constructed a machine furnishing an alternating current of sinusoidal variations.

In this form of current the electric wave is defined by two factors: first, the frequency (the number of alternations per second); second, the greatest ordinates which represent the greatest potential at the point excited. He demonstrated that alternating currents of very slow period did not cause pain or muscular contractions.

By increasing gradually the frequency, the phenomena of neuromuscular excitations increased up to 2500 or 3000 per second; they rest stationary between 3000 and 5000 and then decrease up to 10,000. In this way a current having 3000 alternations is more painful than a current of 10,000 and much less than a current of 150 only.

Ward and Spottiswoode found in 1881 that sparks from an induction coil connected with a rotary interrupter of great rapidity, producing 6000 interruptions a second, was painless when applied to the surface of the body. In 1890, after various experiments, D'Arsonval adopted the Hertz apparatus. This consists of two parts: the one called exciter, vibrator, or oscillator; the second called a resonator.

In the first is utilized the discharge of condensers so as to obtain, according to Thomson's formula, electric discharges of very short period. The resonator is constituted by a simple copper wire twisted upon itself in circles or squares and ending in two balls close to each other.

This resonator was constructed in such a way that its own period coincided with that of the vibrator. Under these conditions the vibrator developed in the resonator an oscillating current whose existence is made known by the sparks produced. This apparatus could give as many as 100,000,000 vibrations per second.

In February, 1891, Tesla communicated to the American Institute of Electrical Engineers his brilliant experiments which led to the same physiological conclusions as those D'Arsonval had announced. He employed, however, much more powerful means, using a special alternator capable of giving up to 2000 alternations per second. The current of this alternator passed into the primary circuit of a small induction coil which was perfectly insulated.

He raised the potential to a voltage calculated in thousands and showed that the high-frequency currents generated could be made to traverse the human body harmlessly and without sensation.

There could be collected, from the two extremities of the secondary current, electricity under strong tension and of very rapid alternations. At about the same time Thomson published his method of producing currents of high frequency, which simplified the subject. D'Arsonval, however, went a step farther in simplification. His new apparatus consisted of two Leyden jars, or other form of condenser, connected with a source of high potential, static, coil, or transformer; a solenoid formed by fifteen or twenty spiral coils of coarse copper wire connected the external armatures. From the internal armatures go out two branches, terminating in round balls. Each time that a spark flashes between these balls a very energetic oscillating current develops in the solenoid, and can be gathered at its two extremities.

It is to D'Arsonval as well that we owe the introduction of these currents into therapy. This savant, member of the Institute of France, combined the rare skill for devising new, delicate, and complicated instruments for the production of what may be termed a new force; the genius for the extensive physiological experimentation with this force, and the utilitarian, humanitarian, and scientific instinct to apply these discoveries to the actual cure of disease.

Among the names of the many workers who have contributed to the development of this new method stand out prominently those of Oudin, Apostoli, Berlioz, Leduc, Bissérié. To Morton, of New York, is due the credit of introducing to practical medicine a current of high frequency as early as 1881 which he called the static induced. Manders,[1] however, claims that the Morton device causes an interrupted unidirectional and not an alternating or an oscillating

[1] Medical Electrology and Radiology, July, 1903.

current, though the frequency and potential are higher than can be obtained from any medical coil provided with a mechanical break.

In 1900 H. G. Piffard, of this city, introduced still another high-frequency current to which he gave the name "hyper-static," to indicate that he had raised or increased the potential of the current devised from the static machine or from a similar current taken from an *x*-ray coil.

What are High-Frequency Currents? While we recognize the existence of only one kind of electricity or, perhaps, one divided into negative and positive, still the phenomena elicited and the work accomplished is so modified by the conditions under which its discharges are produced, that the impression is conveyed of electricity of distinctive qualities. The principle underlying these particular currents now claiming our attention is the oscillatory character of the original spark and the great rapidity of the vibrations, which may extend into the millions per second; according to Hertz into hundreds of millions.

These currents, which are produced only with the aid of particular forms of apparatus; which possess physical properties differing from those of other known currents; and which seem to act differently upon the human system, were themselves unrecognized until within comparatively recent times. To understand their production it is well to recall the fact that if a condenser, such as exists in the well-known Leyden jar, has its internal and external armatures connected by a good conductor forming an arc, the internal terminating in a metallic ball, we can excite in the two coatings a gradually increasing difference in potential up to a point at which the condenser will discharge upon itself. If we wish to maintain this discharge continuously we must supply to the condenser, at intervals of the smallest fraction of a second, the electric charge which it originally had. To supply this an interrupter giving thousands of alternations per second is necessary. The best mechanical devices for this purpose were inadequate, and it was only by the introduction of the electric spark as a substitute for the mechanical break that high-frequency currents became a possibility, enabling D'Arsonval in 1890 to devise an instrument capable of 10,000 alternations per second. This alternator brought at once the therapeutic application of these currents into prominence, and started investigations in many quarters. The oscillations which occur at each discharge of the condenser are of enormous frequency when the proper difference of potential has been reached.

High-frequency currents originate in the external armatures of the condensers whenever they are stimulated by any efficient source of electricity conveyed to their inner armatures. For their utilization in practice they must pass through a solenoid (D'Arsonval) or a spiral (Piffard) whenever an electric discharge jumps from one of the internal armatures of the condenser to the other, the solenoid acting as an impedance to the direct flow of the current between the outer coats of the jars.

If we connect two Leyden jars to the sliding bars of a static machine with open spark-gap, the positive stream will enter one jar, the negative the other, while a negative current will flow from the external armatures of the positive jar and a positive current from the outer surface of the negative jar. A moment will arrive when the potential having increased to a point at which the accumulated electricity is strong enough to overcome the resistance of the spark-gap between the metallic balls of the sliding bars, a sudden discharge will take place and the whole process begins over again. The rapidity of these discharges will depend upon the electromotive force, the size of the ball terminals, and the length of spark-gap. In other terms, a high-frequency current comes into existence, when a highly charged condenser discharges through a conductor possessing slight resistance and some self-induction. It is the result of a disruptive discharge through a condenser.

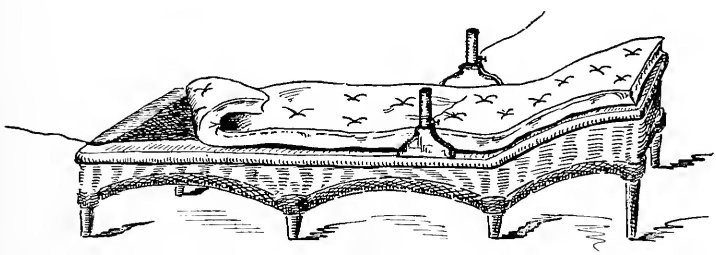
These currents differ from others by their great frequency and the high tension called into play. They cause intense phenomena of induction and circulate not only in closed circuits, but also in open circuits, provided there be a ground connection, so that a current can be obtained from contact with a single pole, and some effects can be secured in a subject placed simply in the electromagnetic field when some grounding is secured.

This effect, however, is almost inappreciable (when the condenser couch is used), unless the patient be directly connected with the other pole of the machine or coil.

There exist several varieties of these currents, depending upon the arrangement of producing apparatus, voltage, amperage, rate of interruption, etc. The variety of effects produced by currents generated in different ways indicates that they are not all identical.

The most important therapeutic current so far studied is that bearing the name of D'Arsonval, who devised the apparatus for its production. This is a current of high frequency, but of a comparatively low voltage, generated in connection with a helix of thick wire to which the patient

FIG. 112.



Condenser couch. (Willyoung model.)

is placed in shunt, or through the medium of D'Arsonval's condenser couch (Fig. 112) or large solenoid cage (Fig. 117).

Currents generated in connection with the resonator of Oudin and the hyperstatic transformer of Piffard are of higher voltage, the Oudin being generated through a helix of fine wire connected with the D'Arsonval small solenoid, or that of Piffard, which is obtained by passing the current of a static machine or coil through a step-up transformer.[1] The Oudin current is by so-called resonance and the other by induction. A current which may be compared with that from D'Arsonval's small solenoid has been obtained in connection with a single spiral of thick wire, having the form of a watch-spring as devised by Piffard.

[1] This is similar to the D'Arsonval so-called bipolar resonator, introduced at about the same date (1900).

CHAPTER XXXII.

HOW THE CURRENT IS PRODUCED.

FOR the production of efficient therapeutic currents a static machine capable of giving a 15-inch spark, or a coil rated at not less than 8 inches, should be employed; a coil rated at 12 inches is, however, preferable. The same apparatus as used for efficient *x*-ray work is ample.

D'Arsonval has suggested for currents of great power, instead of the "Ruhmkorff coil," another transformer with closed magnetic circuit energized by an alternating current. For producing efficient currents we must have: (1) condensers so constructed as to produce and to give off oscillating discharges; (2) a source of electricity; (3) such accessories as will secure proper regulation and obviate the drawbacks incidental to different installations. D'Arsonval's apparatus has the internal armatures of its jars connected with a source of high potential, and its external are connected to the coils of wire in the form of a helix known as his smaller solenoid.

The mode of action in therapy is that the patient is in shunt to an impedance, this impedance being the small solenoid referred to. The rationale of the action of the apparatus is, that when the difference of potential at the armatures reaches the point corresponding to the separation of the balls of the discharger (several thousand volts), the spark jumps the spark-gap, which forms, as it were, a conductor of feeble resistance, by which the charge of the condenser escapes. Now the current of high frequency is that current which passes through the solenoid when the discharge jumps from one ball to the other, being given off from the external armatures of the condensers.

The fact that any of the current will shunt through the patient when the conductivity of the solenoid so far transcends that of the patient is probably accounted for by the "choke" action of the solenoid, which develops an inductance between the successive coils when the current is interrupted or alternating.

If we take as two poles the extremities (opposite points) of the solenoid, the current thus collected is capable of lighting one or more incandescent lamps held between two persons in the circuit. Every discharge of the condensers occurring under the conditions above mentioned gives rise to a series of oscillations of rapidly decreasing amplitude.

In order to bring about a continuity of the phenomena, new discharges as close to one another as possible must be secured. In other words, we must recharge the condensers themselves, and for this we need a source of electricity of high potential.

If we wish to maintain the oscillating discharge at a satisfactory degree of continuity the number of breaks of the wave per second must be sufficient, and for this we must have an interrupter of extra rapidity. The differences of the potential in the solenoid are due to the oscillations alone of the discharge of the condensers.

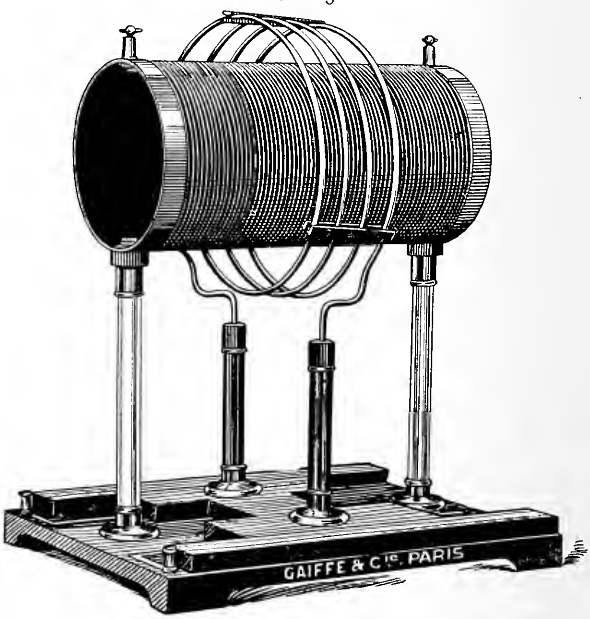
D'Arsonval and Ducretet have each introduced interrupting oscillators, and there are many other models available. A number will be found mentioned in the chapter devoted to interrupters. The static machine gives much less powerful effects when used to charge the condensers. It seems that there should be a definite relationship between the size of the jar and the coil or static, the amount of external coating, the solenoid, and if a resonator is used the length of wire employed in it.

Perhaps a better understanding of the reinforced potential is to dwell for a moment upon the reinforcement of resonance as it exists in the hollow tubes of a church organ. To produce the oscillating current in the lower helix of the resonator, one or two Leyden jars are connected in the circuit, and a flexible wire connects the solenoid with the resonator's coils. The other end of the solenoid is grounded.

Near the base is a movable contact by which the resonator is, so to speak, "tuned" to correspond to the rate of interruption in the primary. The function of the upper portion is to increase the potential.

The electromotive force induced in a single spiral of a solenoid, either by self or mutual induction, is sufficient to make incandescent an electric-light bulb. In order to raise the tension, D'Arsonval constructed a solenoid of thick wire, as shown in Fig. 113. Around an ebonite cylinder of large diameter thin copper wire is wound and attached to two terminals, the two coils being separated from each other

Fig. 113.



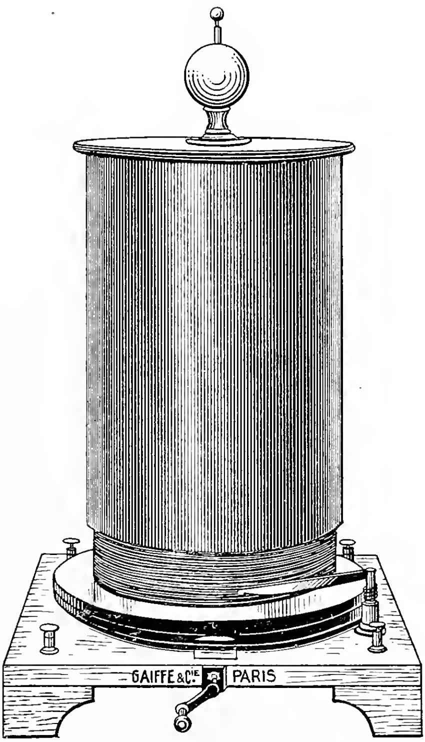
D'Arsonval solenoid.

by an air space acting as a dielectric. The inductor solenoid is attached to a movable base so that it can be placed at either extremity or other portion of the induced solenoid. This gives an equal power to the current at each extremity when the external (inductor) solenoid occupies the middle position.[1] The apparatus is then bipolar. The stronger current goes off from the extremity opposite that at which the external solenoid is placed.

[1] This is essentially the construction of the Piffard apparatus, introduced at about the same time.

Bordier[1] points out that the term resonator as applied to such apparatus is not strictly proper, since it has nothing in common with electric resonance as it is known from the experiments of Hertz. He prefers the term high-tension solenoid.

FIG. 114.



New-model regulating Oudin resonator.

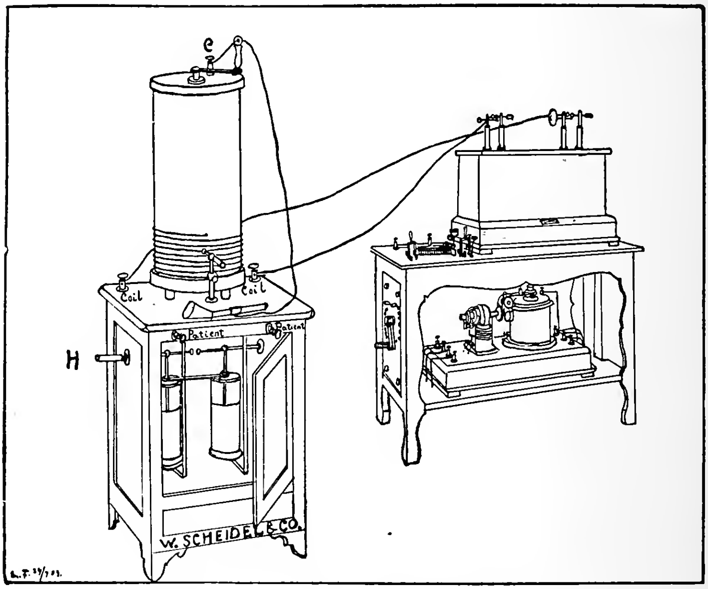
In Oudin's resonator heavy copper wire wound helically about a wooden cylinder forms the lower part of a tall cylinder. The upper part wound with finer wire (about fifty yards) is not traversed by the currents directly, but is thrown into vibration in resonance with that of the oscillating current passing through the larger wire at the base. Attached to one point is the fine wire which encircles the

[1] Traité de radiologie médicale, Paris, 1904.

drum, and it is here that the potential is increased and the resonance which led Oudin to name it resonator is produced (Figs. 114 and 115).

This form of harmonious vibration has its counterpart in music, the coils of the resonator vibrating more rapidly in their remote portion than where stimulated by the current, just as the string of an instrument has a greater vibration at the extremities than at the part which receives the primary

Fig. 115.



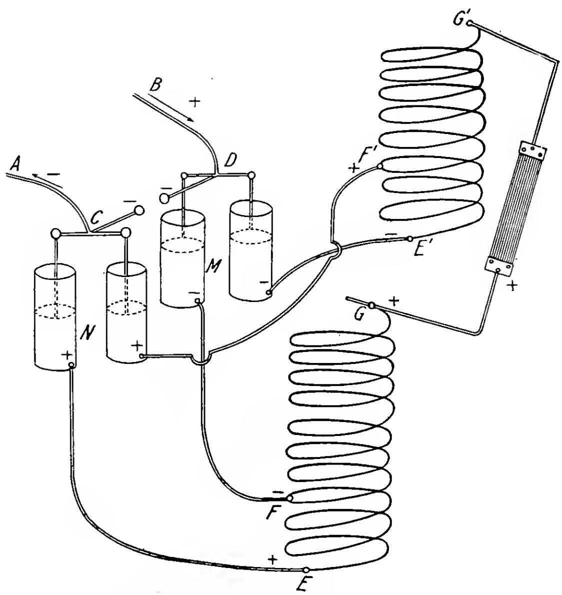
Oudin type of resonator operated by coil.

impact or impression. In other words, it is necessary to harmonize the vibrations. Rochefort constructed a double or bipolar resonator (Fig. 116) which Oudin has used therapeutically with satisfaction, and found that greater intensity and quicker effect could be produced in conditions requiring more energetic treatment than with the single apparatus.

There are various-sized solenoids of this type available, the smaller giving up to 200 milliampères, being sufficient for most methods of application, excepting that with the large cage solenoid, as shown in Fig. 117, or with the auto-condensation couch.

Rochefort recently showed me in his Paris laboratory the extensive magnetic electrostatic field which could be produced by this bipolar apparatus. The limits of this field of action of the currents were beautifully illustrated in a darkened room by the incandescence of a long Geissler

Fig. 116.



Scheme of Rochefort's double resonator.

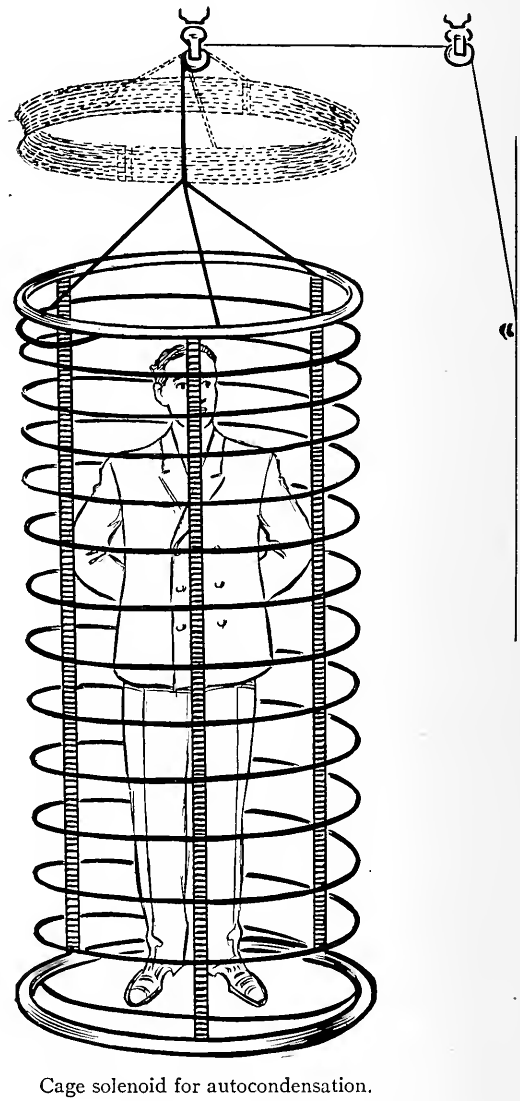
tube held like a wand in the hand at a distance of several feet from the apparatus.

Dean, of London, has produced a new model of double resonator of which Williams speaks highly. McIntyre has designed an arrangement for utilizing a static machine instead of a coil, for this purpose a small D'Arsonval apparatus, Leyden jars, or oil condensers being used. To this is added a special device for reversing the current as it comes from the condensers. Cunningham Bowie[1] intro-

[1] Lancet, May 2, 1903.

duced an apparatus in which he can regulate the frequency of oscillations within the limits of fifty (50) to eighty thousand (80,000) per second, and at the same time provide

FIG. 117.



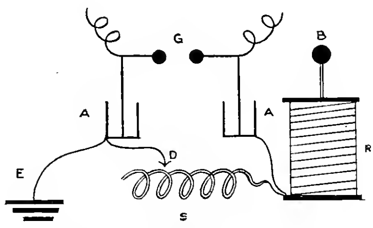
Cage solenoid for autocondensation.

currents of high frequency and low potential (40 to 100 volts). He claims that by this method he gets a higher magnitude of current.

The weak runs up to 100 milliampères, the medium to 1000 milliampères, and the strong to 2 and 3 ampères. The apparatus consists of a step-up transformer, an oil-immersed condenser, and a spark-gap. The condenser armatures are connected by a flat helix arranged on an adjustable slide. The patient is placed in a circuit connected with this secondary helix, and obtains greater or less voltage, depending upon the distance of the secondary helix from the primary.

The frequency rate is varied by alternating the capacity of the condenser, by sliding the condenser plates to or from

FIG. 118.



Showing connections for resonator.

one another. The advantage claimed for this apparatus is, that by lessening the voltage large amperage at high frequency can be administered without pain. According to Piffard's description of a high-frequency current, those derived from this apparatus can hardly be regarded as such, as even at the maximum they do not possess a sufficient number of oscillations in a unit of time.

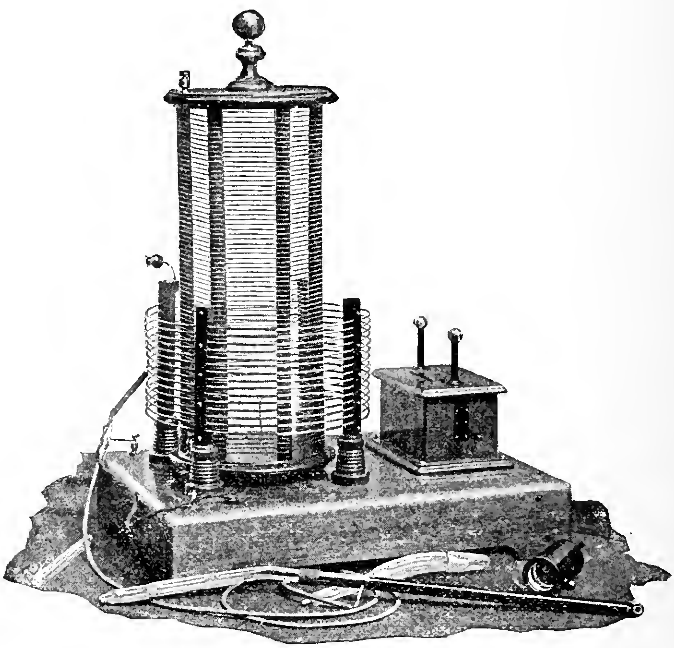
The connections for the resonator are shown in Fig. 118, borrowed from Manders.[1] By shifting the movable arm of connection (*D*) along the solenoid (*S*), a point is reached which gives the maximum brush at *B*, at the summit of the resonator *R*, the maximum syntony remaining on that particular point, no matter to what extent the spark-gap at *G* is increased or diminished. *E* represents grounding.

[1] Proceedings of the British Electrotherapeutic Society, May 22, 1903.

Another form of apparatus is the oscilloresonator seen in Fig. 119. This is of American manufacture, based on the same principle as that of Oudin's resonator.

Piffard's Transformer. The transformer which I have employed since 1901 is the Piffard model, as shown in Fig. 120. It consists of two condensers whose external armatures extend almost to the top of the glass, the

FIG. 119.



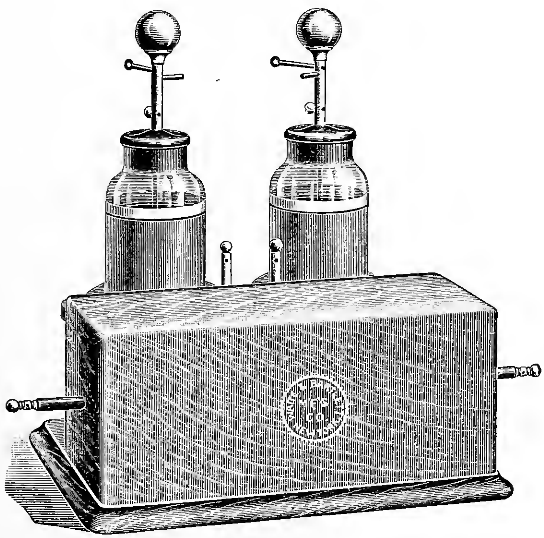
Oscilloresonator. (Willyoung.)

internal armatures being connected with the sliding bars of the static machine or coil and terminating in metallic balls of small size.

Originally there was a sliding bar spark-gap attachment covered with a glass tube to muffle the sound. This, however, was found to impair the greatest working efficiency, and has been done away with, being replaced by projections on either side an inch in length to act as a discharging safety valve, so to speak, when the resistance of the spark-gap on the sliding bars of the machine becomes greater than the resistance between these two points, and thus to prevent damage to the apparatus.

The strength of current employed is regulated wholly by the sliding bar of the static machine, one inch being usually sufficient. When used on a coil it is connected to the terminals of the secondary winding, the spark-gap being regulated so as not to exceed one inch, preferably a half-

Fig. 120.



Piffard's transformer.

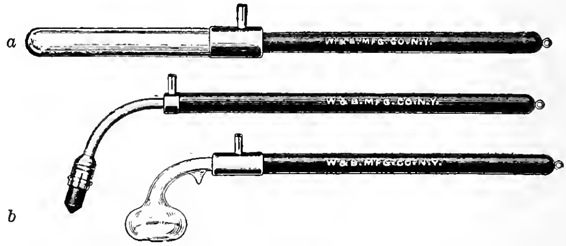
inch. The resulting current is somewhat different from that secured from the static, whose amperage is lower and the voltage higher.

My experience agrees with that of Piffard, that the connection with the static gives the more satisfactory result. This apparatus has recently been modified, by having binding posts attached and connected with the terminals of the primary coil.

A patient introduced into this current, by holding the ball electrodes attached to conducting wires passing from these binding posts, will receive a mild form of D'Arsonval high-frequency current effect.

The original hyperstatic effect is not influenced in its efficiency by this modification, and these two distinct forms of high-frequency currents may be administered simultaneously.

FIG. 121.

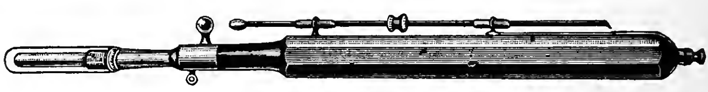


Vacuum electrodes: *a*, glass cone filled with metal filings coated with silver upon the inner surface; *b*, carbon point for single spark.

The case enclosing the solenoids contains a helix of thick wire surrounding a coil of fine wire, the two being insulated by glass and air.

Electrodes. Electrodes may be of metal, carbon, or glass. An efficient metal electrode for a brush discharge to large areas consists of metallic points projecting from a base set into a rim of vulcanite.

FIG 122.



Bissérié's regulating electrode.

Most of the glass electrodes used in this country consist of low-vacuum tubes of various shapes and sizes designed for the various accessible cavities as well as for surface effects (Fig. 121).

Some have been made with metallic internal attachments and insulated in all except the part from which the discharge is desired. While in Paris recently, Dr. Bissérié showed me his ingenious regulating glass electrode with a sliding bar and spark-gap attachment for regulating the strength of application in a very convenient way at the handle (Fig. 122). He also has a metallic brush enclosed within a glass cylinder, arranged to slide back and forth (Fig. 123). This has not proven highly successful.

FIG. 123.

Regulating electrode in sleeve.

Caution. If glass electrodes are made with a very high vacuum, as has recently been suggested by an English writer, unless the glass be especially thick, the danger of collapse in use must be borne in mind, especially when employed within the orifices of the body.

Williams suggests a condenser electrode made by filling a large flat-bottomed flask with salt-water, a wire passing through a rubber cork with its free end connected to the solenoid. Lead-foil may be employed to cover any region of the body, with wet flannel interposed between it and the skin.

A plate of metal may be suspended above the patient in the air, in which case he is in an electrostatic field.

The ordinary incandescent lamp bulb may be utilized by attaching it to a handle with a metallic band, the sparks jumping from the filament to the glass and thence to the patient.

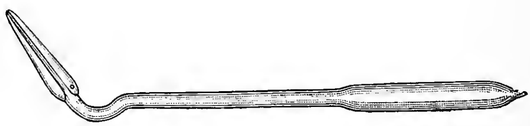
Caution. With strong currents the spark is very apt to perforate the glass, which is made apparent by the delicate bluish glow within the bulb changing suddenly to a pink, and, perhaps, by the larger spark producing a painful effect upon the patient.

The extent of this field can be tested in a darkened room by approaching the generator with a Geissler tube. On reaching the confines of the field, the tube will be seen to effloresce. In the smaller high-frequency form of apparatus, such as the Piffard hyperstatic, such a phenomenon is apparent only at a short distance from the terminals of the solenoid. In using these bulbs it becomes quite apparent that the whole mass of sparks passing from the glass to the patient are not derived from the outer surface alone, since

FIG. 124.

Vaginal electrode.

FIG. 125.

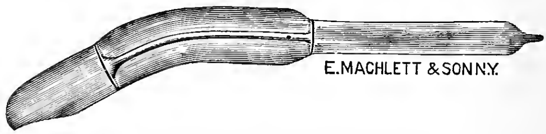


Ear electrode.

FIG. 126.

Doumer's hemorrhoidal electrode.

FIG. 127.



Type of insulated electrode.

some can be seen to pass from the filament to the inner surface of the glass and to be continued as an individual spark from the outer surface to the patient's body.

A globule of mercury is sometimes inserted within the vacuum electrodes to secure a more pronounced glow.

Special electrodes for eye, ear, nose, throat, bladder, urethra, rectum, vagina, uterus are now on the market. Some of the forms are shown in Figs. 124, 125, and 126.

FIG. 128.

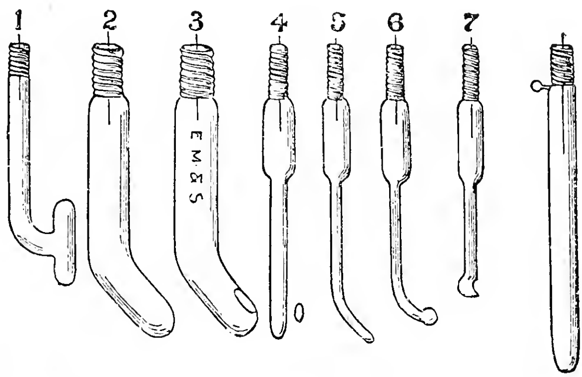
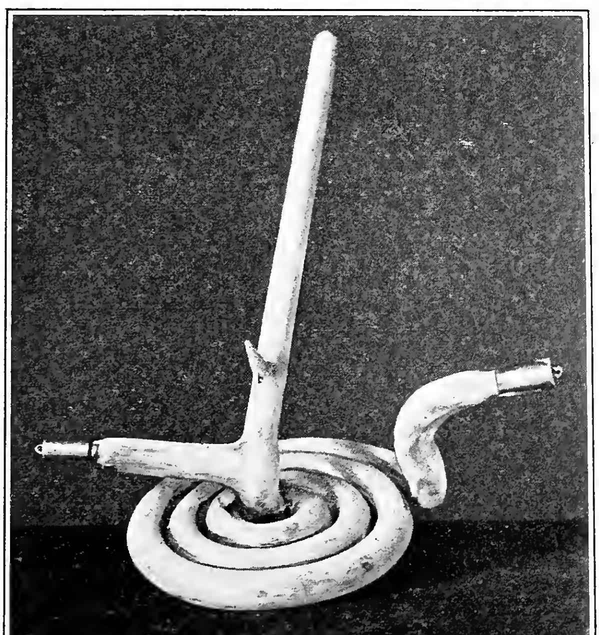


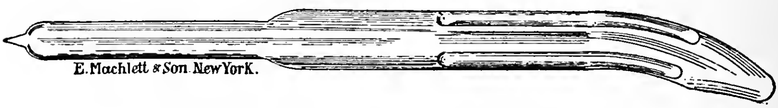
FIG. 129.



Large surface glass electrode.

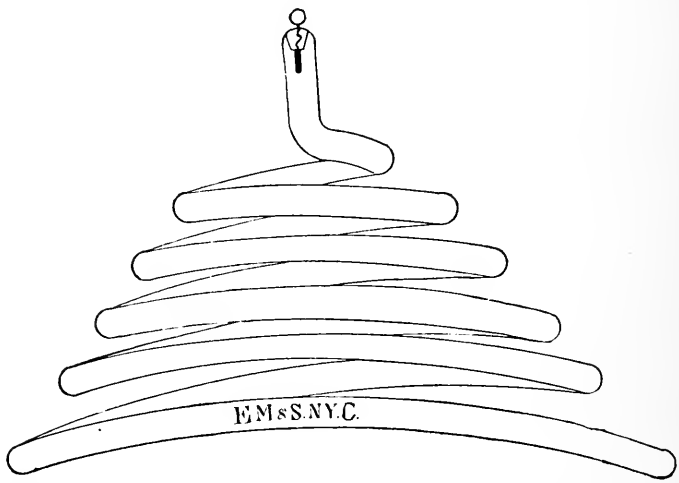
Electrodes with fused-in wire have recently been introduced in this city (Fig. 128).

FIG. 130.



Dieffenbach's electrode for the treatment of constipation.

FIG. 131.



New electrode for the application of high-frequency currents to the head.

Other forms of electrodes for special purposes are shown in Figs. 129, 130, and 131.

CHAPTER XXXIII.

PHYSIOLOGICAL EFFECTS OF THE CURRENTS.

As to the physiological effects, we can say only at the present time that a marked influence upon the nervous system and upon the circulatory apparatus is evident. When the feathery discharge is sufficiently rich to produce tiny sparks, a decided vasoconstriction of the skin follows. Succeeding this almost at once is a vasodilatation.

However, if it becomes a demonstrated fact that the effects are in part due to rays and not wholly to electricity, and we find in this vasoconstriction an almost necessary accompaniment, it will make possible, by this very effect of dehæmatization upon the deeper tissues, the therapeutic influence of the ultraviolet rays given off, if any are so given off.

The equivalent of the compression used in the Finsen method can be secured by allowing a spark to jump to the skin, and if we hope for deep effects from the actinic rays present in the spark, this anæmia of the tissues offers just the condition requisite for its penetration. When the glass electrode is in close contact with the skin, we have none of those vasoconstricting effects.

It would seem rational, therefore, to hold the electrode at some distance from the skin or to keep it in contact, according as we desire or not to cause a condition of local anæmia.

Bordier and Lecomte[1] relate the results of some experiments on animals which go to prove that the effect is not wholly a surface effect, but that the current penetrates deeply, since they succeeded in killing rabbits, guinea-pigs, and rats by applying the current directly or through metallic coils placed about the neck and abdomen.

[1] La tribune médicale, 1903, No. 6.

Death occurred after several days, attended with the phenomena of paralysis. By placing one electrode in the mouth and the other in the rectum, a rabbit was killed in fifteen minutes and a rat in forty seconds with a current of 3 ampères.

These results, which we can possibly attribute to an inhibitory effect upon the nervous centres, confirm the experiences of D'Arsonval; similar experiments made by him show that the effect is a deep one.

The physiological effects of D'Arsonvalization are due to the discharges of sparks, as the result of the following: The mechanical force exerted on the tissues, the effect of heat produced,[1] the result of chemical combinations (formation of ozone), and the formation of ultraviolet rays. The effects of the sparks vary according to their intensity, being stimulating or the reverse.

On the skin it acts on the vasomotor system and tends to produce necrosis of the superficial epithelium. The local action is accompanied by general reaction, arterial tension is lowered, and respiratory combustion is increased. The nerves seem incapable of responding to vibrations exceeding a certain limit, hence high-potential currents may be made to traverse the human body in strength of three hundred or more milliampères without the production of pain.

The physiological effects are thought by Freund to be due solely to the spark discharges. He regards the action of D'Arsonval's apparatus as superficial. He describes a simple spark apparatus. A test-tube is filled with water and connected with the negative pole of a coil, the positive pole being grounded. With this simple electrode, brush discharges, he says, can be obtained equal to those from Oudin's apparatus. The effect upon the muscles appears to be one of permanent tetanization; that is, the individual contractions which would be occasioned by the electric waves, were they sufficiently infrequent, tend by reason of their enormous frequency (millions per second) to fuse these contractions into a condition of insensible contraction.

[1] Frequently a rise of one or two degrees in temperature is noted. Bokenham has seen as much as a rise of six degrees.

The nerves as well as the muscles appear incapable of responding either in a motory or sensory manner to vibrations beyond a certain limit. It is distinctive, therefore, of these currents, that the patient is unconscious of their passage, all neuromuscular reaction being arrested. Passing a fair-sized spark into the tissues does, however, cause a certain shock, pain, and muscular contraction. An inhibitory action is also admitted by D'Arsonval with phenomena of decrease of excitability to other stimulation, local anæsthesia, lessening of the skin sensibility to galvanism, faradization and decrease of arterial tension.

Effects on Bacteria. D'Arsonval and Charrin have found that pyogenic bacilli were rendered innocuous by a half-hour's application of the current. Lagriffoul and Denoyés, experimenting on guinea-pigs by autoconduction, found that the bacilli were destroyed.

Dimitriewsky says that toxins can be made to lose their power.

Foulerton and Kellar[1] experimented with these currents on cultures of bacilli of typhus, coli, dysentery, pyocyaneus, prodigiosus, staphylococcus pyogenes aureus, streptococcus pyogenes, etc.

They found that all the cultures could be destroyed in from ten to twenty minutes, the time depending upon the intensity of the current used. They employed a current of 24 to 35 volts with 2½ to 5 ampères. When these experiments were repeated in an atmosphere of hydrogen instead of air, it was found that even exposures of one and a half hours did not destroy the germs.

[1] Klinische therapeutische Wochenschrift, May 24, 1903

CHAPTER XXXIV.

PHYSICAL PROPERTIES OF HIGH-FREQUENCY CURRENTS.

THESE consist in electrostatic phenomena:

Phenomena of Induction.

Phenomena of Dynamic Electricity.

Phenomena of Resonance.

Among the extreme electrostatic manifestations obtained with a Tesla apparatus are the production of sparks of extreme length in the air. Tesla has produced an almost perfect imitation of the discharging spark of a static machine. In order to establish an electrostatic field, one pole of the apparatus is fastened to a metallic plaque.

If a vacuum tube is held in the hand in this electrostatic field it becomes illuminated on moving it about. Among the phenomena of induction is that of the illumination of an incandescent lamp by suspending it in derivation or shunt upon the solenoid, the current passing from one pole to the other through the longer lamp route than through the more direct solenoid, although the latter would seem less resistant.

If the lamp is connected with a spiral, suspended between the coils of the solenoid, it becomes white hot. This phenomenon is due to mutual induction produced between the solenoid and the spiral.

Among the phenomena of dynamic electricity is the experiment made by Tesla with his motors of "magnetic retard." The primary of the coil is attached to one of the extremities of the apparatus; the secondary is rolled upon an iron base and closed on itself.

A very movable metallic plaque is placed within the field of action of the whole. Under these conditions rotation is obtained. This property of monopolar propagation is very important, aside from its practical application, for it explains very well the sparks and unipolar currents obtained when a single point of the solenoid is touched.

The phenomena of resonance in electricity are the counterpart of those of acoustics. It is well known how the strings of a musical instrument will resound spontaneously in unison with the vibrations of the same tone. It is also well known how a vibrating body which gives out the identical sound produced by a similar body near it may reinforce this sound.

The resonator, which is the name given by Oudin to an appliance first perfected by him in 1892, is thus designated after those acoustic instruments constructed to vibrate spontaneously. The phenomena in both cases are identical. The first instrument of the kind consisted in a solenoid of copper wire which bore a definite relation in its number of coilings to those of the exciting apparatus.

When placed under the proper conditions the two solenoids vibrated in absolute unison, giving out electric manifestations just as similarly arranged acoustic instruments would give out an identity of sound.

Unipolar currents and sparks drawn from a single point of the solenoid are explained by the extremely frequent repetition of the charge and discharge under a raised potential. The patient's body forms a conductor which becomes charged at each oscillation, the quantity being almost constant for a certain distance from the solenoid.

Employing a large solenoid, an incandescent bulb held in the hand by its metallic fixing and made to touch one of the loops, is sufficient to produce incandescence of the filament within the bulb.

Penetration of the Spark. That these currents have a penetrating power and are thus capable of entering the tissues and affecting the system is shown by several experiments. Bishop placed a starch solution between two glass plates. A solution of iodide of potassium in glycerin was placed in the centre of the upper plate; the lower plate was placed on a metallic surface and connected with the earth.

The spark was directed on the iodide solution and in a few minutes iodide of starch was formed. Dr. I. H. Burch, of Baldensville, N. Y., connected a metallic plate to the lower strand of the resonator. Upon this he placed two glass plates having between them blotting paper saturated with potassium iodide. Upon the upper glass he placed blotting paper saturated with starch solution, upon which sparks from an electrode were allowed to fall. In a few seconds iodide of starch was formed. The same experiment was repeated with the iodized paper within a leather mitten with starch solution outside. A stream of sparks let fall upon the mitten produced iodide of starch. To make the conditions approximate more those of a human integument, the iodides were enclosed within the skin of a chicken, this being enclosed within the leather; the result though slower was the same. By using bichloride of mercury, red mercuric iodide is formed in the same way. We have repeated these experiments with the iodide and starch, using test-tubes, and have produced a bluish discoloration of the starch.

A control experiment with the starch alone showed no discoloration. A securely corked tube of iodine solution is decomposed by the spark, fumes of iodine being given off and crystals of potassium forming. It was at first thought, that since these currents tend to flow from the superficial portions of the conductors and electrodes, rather than penetrate their interiors, that it acted in the same way upon the body's surface, and it was to this that the absence of subjective sensations and of muscular contractions was attributed.

The human body, however, it must be remembered, is not a good conductor, and the penetration has been found inversely proportional to the square root of the specific resistance and proportional to the square root of the frequency. Tesla's explanation of the lack of appreciable effect is, that the currents do not penetrate the organism by the point in contact with the electrode, but perpendicularly to the integuments, equally over the whole surface of the body.

CHAPTER XXXV.

THERAPEUTIC APPLICATION OF HIGH-FREQUENCY CURRENTS.

Methods of Application. Currents of high frequency are susceptible of a variety of methods of administration, based upon their physical properties.

First: Local Application. Although we may obtain a current taken directly from the solenoid, these currents are usually painful, and unless modified or given with care produce shocks and unpleasant sensations which interfere with the therapeutic results.

It is for this reason that we resort to apparatus which raise the tension of the high-frequency currents. This is accomplished in one of two ways: either by employing the induced current of a coil of fine wire attached to the solenoid and immersed in oil or simply isolated, or by making use of the properties of resonance of the high-frequency currents.

The latter is the course mostly employed, and we owe it to Oudin's continued experimental work that we can to-day utilize a perfected resonator instead of attaching the exciter to the high-frequency solenoid. In a recent visit to his laboratory, M. Rochefort demonstrated to me his recently constructed bipolar resonator, which is in reality a combination of two resonators, from between which jet forth effluvia of great power and of contrary sign at the same moment at symmetrical points of the two parts of the apparatus. (See Fig. 116.)

In this new arrangement there are four Leyden jars divided into batteries in series of two, joined to one of the balls of the sparker by their internal armatures. The four external armatures are united to the resonators in such a way that the two armatures of a given battery are attached, the one to the lower coil, the other to the coil above, or what we may call the primary of each of the resonators.

Under these conditions, although the two resonators have an influence upon each other, they are electrically separated and act like two resonators commanded by the same physical interrupter and receiving each one an equal current, but going in an inverse direction in each primary of the resonator. D'Arsonval has devised a bipolar coil which has its great utility in local applications. Upon an isolating cylinder there is coiled an induced wire making a large number of turns; surrounding this, but at a certain distance from it and insulated by air, are four spirals of large induction wire upon a movable base, so that its position can be changed by moving in a parallel way to the induced coil. (See Fig. 113.)

Simple or double effluvation can be carried out by this apparatus by using a single or double pole.

Second: Application by Derivation or Direct Application. If we attach a patient to two points of a solenoid, this patient is said to be placed in derivation or shunt, and his body is traversed by high-frequency currents which, as is well known, circulate in the solenoid.

In consequence of the phenomena of self-induction, the solenoid offers great resistance to the current, which passes by preference in the derivated circuit, of which the patient under these conditions forms a part. The portion of the body upon which therapeutical localization is desired may be covered with a metallic plaque, or two regions can be treated simultaneously by employing bifurcating wires.

If the skin is sensitive, a strip of moistened flannel, cotton, or other substance can be interposed. Erythema of the surface is avoided by moulding the plaques accurately to the region so as to obtain good contact. No painful sensation is produced by this method, and no muscular contraction, providing there is no interruption in the circuit. We may then employ either direct stabile applications, the patient being attached to the two extremities of the solenoid by electrodes fixed upon the areas subjected to treatment, or direct labile applications; the patient being attached to the solenoid on the one hand by means of a fixed electrode, on the other hand by means of a mobile electrode.

Third: Autoconduction. This consists in enclosing the patient to be acted upon in a solenoid without being in communication with any metallic substance. The solenoid having currents of high frequency passing through it, induces extremely powerful currents not only on the surface of the body, but even in the depths of the tissues.

The frequency in a large solenoid is very high, and because of this the solenoid produces a very intense oscillating magnetic field. This intensity is illustrated by introducing into the field a single turn of copper wire. The induction produced in this wire is sufficient to light two lamps mounted in series. In employing such a solenoid in treatment it must be large enough for the patient to stand well within it, or to cover his body in the prone position.

Even without contact with the current the patient is the recipient of extremely powerful induced currents.

Fourth: Application by Condensation. In securing this form of electrical influence, the patient is made to become one of the armatures of a condenser. This is accomplished by placing the body upon a reclining chair covered with a sheet of woven wire, lead, zinc, or other metal attached to one extremity of a solenoid. An insulating mattress is placed upon the metal sheet; the patient is then connected to the opposite extremity or to an intermediary point of the solenoid. This arrangement constitutes a condenser; the two armatures are represented by the patient on one hand and the metallic sheet on the other. The mattress represents the dielectric. The system may be traversed by a current of 300 milliampères, at every oscillation the condenser charging and discharging. A monopolar application can be made by attaching the patient to one extremity of the solenoid.

An experiment illustrating the scheme of application by condensation consists in attaching an incandescent lamp to a solenoid by a single wire. If this be taken in the hand, and especially if the other hand is brought near the opposite extremity of the strand, the carbon in the lamp glows brightly.

In this case the film plays the role of internal armature, the moist skin that of the external armature, and the glass the role of the dielectric.

Therapeutic Application. In forming a just estimate of what these currents will actually accomplish in therapy, we must make a distinction between what has been claimed for them on various sides during the past dozen years, and what a critical review of the literature and personal experience seem to show. That there exists a physiological and chemical action upon tissue and tissue change would seem to have been experimentally proven. That these currents furnish a force hitherto unknown of stimulating vital energy must be accepted. We have, therefore, some *a priori* grounds for the assumption that these currents might prove of benefit in systemic deviations from the normal.

The practical demonstration by many observers, that lesions upon the surface are benefited, and actually cured, strengthens the belief that deeply seated pathological processes might be influenced for good by the employment of stronger currents and accessory apparatus. On the other hand, the claims made have at times seemed so extravagant that the evident belief held by some, that in this agent we were to have a panacea for almost all ills, was quickly followed by a reaction of sentiment and marked skepticism, fortified by an abundance of unsuccessful results which were published. The well-known tendency for new methods to be crowned with early successes, especially in the hands of their discoverers and their followers carried away by a certain enthusiasm had to be reckoned with. Likewise the psychical effect produced upon some patients by the novelty and general attractiveness of a method involving new principles and theories, and attended with a brilliancy of pyrotechnic effects well calculated to impress the senses and imagination, had to be considered.

The various hues produced within the glass electrodes, depending upon the degree of vacuum or the nature of the contained gases might well carry to the nervous system through the patient's sense of sight an influence which could prove deceptive. The beautiful delicacy of the *Aurora Borealis* effect when treatment is given in a darkened room; the abundance of ozone, with its effect upon the olfactories; the soft glow from the conducting wires; the glittering stream of multitudinous sparks which flow from the electrode to the patient; the power suggested by the detonations of the spark as it leaps between the balls of the sliding bar of the static machine make up a weird combination, which might well impress a susceptible individual. The charlatan was not slow in making the most of these impressive features of a method, which he found very aidful in *doing* his patients good. Leaving aside the psychical and suggestive effects which must be admitted to have their useful place in certain diseased states, there still exists abundant testimony vouchsafed by careful and conscientious observers, that high-frequency currents are of great utility in the cure of many diseases. These can best, perhaps, be studied by considering the external and internal affections separately. In external affections, local application is usually the mode of administration, while in systemic disease autoconduction or some form of the D'Arsonval method is generally employed. The former is, however, claimed to be at times very effective in deep-seated lesions. Oudin has achieved some of the same results by external means as claimed for the D'Arsonval method. Thus he has noted an increase in blood pressure and an improvement in arthritis, old pleuritic exudations, and lung tuberculosis.

It is quite possible and even probable that the luminous effects always or almost always attending the application of these currents have much to do with the therapeutic effects secured.

In a recent conversation with Professor Bissérié, in Paris, he told me that he believed many of the good results in skin therapy were due to the ultraviolet rays given off. The number of actual cures that can be attributed to this method is small, but almost all who have employed the currents report decided improvement in a great variety of cases.

As a general rule painful and contractive effects are to be avoided. When they occur it is usually because the current is too dense for the frequency with which it is employed, or else the apparatus is not working at its best.

External Diseases. There appear to be only three classes of affections in which the method's utility has been fully demonstrated: (1) those of the skin; (2) those of the mucous membrane, and (3) those of the superficial and accessible nerves.

While a great variety of skin diseases have been treated, the greatest benefit has been found in the pruriginous affections and those in which there is present marked circulatory disturbance. In the first class we have general and local pruritus, especially pruritus vulvæ, pruritus ani, and pruritus scroti. Besides these it has been shown that prurigo, lichen planus, urticaria, scabies, and other itching parasitic diseases, and many of the various forms of eczema, are markedly benefited, and many cures have been reported. The mode of application is usually by the breeze or effluviation and contact friction with a large glass electrode. Sparking is at times of benefit in individual lesions and infiltrated plaques; the duration depends somewhat upon the extent of the surface to be influenced, varying from fifteen to thirty minutes. Either monopolar application is employed, or for stronger effects the patient may hold the opposite electrode in the hand. The congestive conditions include the various erythemas, lupus erythematosus, many eczemas, rosacea, seborrhœas, etc.

The same mode of application generally speaking is here applicable.

Eczema. So-called eczema being the most widely prevalent and one of the most pruritic affections, naturally comes in for a large number of reports. Subacute and chronic forms are those which seem to be most influenced, and this has been my personal experience. In 28 cases treated I have found invariable benefit, but often not greater than is to be obtained from other measures. While external application, feathery discharge, and ironing with a large glass electrode are the usual ways of applying the currents, autocondensation by means of the couch can often be added with benefit, especially in presence of faulty metabolism. The element of itching is almost always decreased, and infiltrated patches may be made to disappear. In lichenoid thickenings, as well as in other dermatoses, strong currents by means of the effluvium or shower of sparks, if persistently applied with the electrode almost at a painful distance, is followed by diminution and sometimes complete disappearance of the infiltrated plaque.

In eczema about the genitals and anus excellent effects may be obtained, even when glycosuria is the exciting cause. In this case D'Arsonvalization with the aid of foot-bath or condenser couch should be coincidently employed for its general effect upon the processes of tissue change. In a number of cases I have succeeded often with but a few sittings in securing lasting results, and the immediate effect in relieving the pruritus is at times greater than I have been able to secure by other means.

Psoriasis. A number of observers including Oudin, Williams, and Grubbe make rather enthusiastic claims for the method in psoriasis. My experience has been too limited to substantiate them. The spark applied to the plaque, preferably after removal of the scales, produces the same spasmodic anæmia mentioned under urticaria; and if itching is present it promptly disappears. The patches become bright red, gradually fading out, and after a few sittings may disappear if they are of recent origin, but, if of long standing, may require protracted sittings. Desquamation is decreased and there is gradual lessening of the infiltration. I have thus far seen no cures aside from one patient who presented three recurrent patches, which entirely disappeared after three sittings.

Individual plaques may at times be made to disappear promptly.

Urticaria. The vasomotor effects may be well studied in urticaria. Here "sparking" the wheal produced entire disappearance of the lesion, which is replaced within a few moments by a dehæmatized area. Within a few minutes redness returns, which exceeds the bounds of the wheal whose borders are lost in the diffuse congestion. The effect of contraction followed by dilatation of the vessels is very marked. A feathery discharge over the whole body has a soothing effect, relieving the itching for a time, and appears to shorten the course, though the usual internal measures are not to be neglected. In the succeeding outbreak I have noted that while wheals tend to return upon original sites, those previously sparked failed to so reappear, a slight reddened staining of the skin marking their situation. In these regions there was entire absence of itching as well as of renewed eruption. General effluviation with metallic pointed electrode, giving what I call a "feather duster" brush, seems to diminish the pruritus, shorten the individual attack, and decrease the entire course in subacute or persistently recurring urticaria.

Lupus Erythematosus. In Brocq's service at the Broca Hospital, Jacquot reports 56 cases with 39 cures. Of these 9 were of the fixed and 31 of the aberrant or wandering variety. Of the latter there were 25 cures.

It would seem from this report that the method for the aberrant form is superior to both phototherapy and radiotherapy.

Leredde and Pautrier regard high frequency as the method of choice, and it surely is the easiest and safest for both patient and operator.

In the fixed or stationary form the conditions approximate more those of lupus vulgaris and applications of Vigo plaster, salicylic dressings, deeply acting chemicals, scarifications, electrocautery, radiotherapy, and phototherapy are to be energetically carried out.

From the reports to be found scattered in literature, we must believe that for this affection no method is superior at the present day.

Bissérié has reported 62 cases with 33 cures, while 8 received no benefit.

The spark often causes decided pain if directed upon the surface of the plaque. A carbon electrode can be held almost in contact until there is produced a vesiculation with a rupture of the skin and a serous exudation.

Lupus Vulgaris. Here little has been accomplished compared with the ultraviolet and *x*-ray methods. Individual nodules can be as painlessly, promptly, and permanently removed by sparking as by any other method with which I am familiar. Strebel[1] reports very prompt and brilliant results from a short spark applied for a brief period, the cells being promptly destroyed or disintegrated.

[1] Deutsche med. Wochenschrift, January 12, 1904.

Zoster. In cases of my own I found a large, flat, glass electrode promenaded over the area of vesiculation and hyperæsthetic and painful areas to be followed by prompt and decided relief. It is said to have a marked effect on the resulting neuralgia which, as is well known, is apt to be severe in elderly persons.

The list of other diseases in which experienced workers have found benefit are acne molluscum contagiosum, sycosis, impetigo, lupus, venereal and common warts, keloid, atrophy of the skin, alopecia areata, pityriasis versicolor, and pigmentations.

In the destruction of small tumors, vascular and other nævi, epithelioma, lupus, etc., the spark can be well limited and prevented from jumping to adjacent skin surfaces by applying a flat sheet of vulcanite having an orifice just sufficiently large to include the neoplasm.

Diseases of the Mucous Membrane. The affections of the mucous membrane which have been experimentally and clinically studied include diseases of the eye, ear, nose, mouth and throat, vagina and uterus, urethra and bladder, rectum and anus, as well as tuberculosis and other pulmonary affections and diseases of the digestive apparatus. The accessible mucous membranes are treated for the most part by the direct contact, or effluve, while for influence upon the deeper tissues the autocondensation or autoconduction methods are more employed.

In **chronic ear affections** attended with pain, purulent discharge, etc., temporary and sometimes more lasting relief from the subjective symptoms may be secured by partially filling the external auditory canal with warmed peroxide of hydrogen, saline or other solution; placing cotton in the external meatus and applying the current by means of a glass electrode of the size and shape of a test-tube, whose extremity rests upon the protruding cotton. This I have called the high-frequency ear-bath. By means of a smaller pointed electrode, sparks can be given directly to the membrana tympani in a variety of conditions of subacute or chronic nature, including perforation of long standing, chronic thickenings, temporary deafness resulting from the pressure of accumulated cerumen, tinnitus, etc. In malignant growths in this region, the spark may accomplish destruction of morbid tissue just as it can be made to do upon the skin surface, and this without as much pain as attends almost all other methods.

In a sarcoma involving the inner ear, still under treatment, the current and spark have proven very useful and given the patient much relief.

In **diseases of the nose** a delicate spray of painless sparks given off from a flat nasal electrode passed well within the nostril, may improve conditions attended with congestion and infection, and aid in the prompt healing of ulcerations. Taylor claims to have cured in a fortnight, with a nasal electrode, a long-standing and very offensive ozæna. We must remember that a considerable amount of ozone is given off under these conditions, which may aid materially in the result secured in such conditions.

The sense of smell and taste, long lost in a patient of our own who showed other stigmata of hysteria, was promptly restored by a short course of intranasal applications. In subacute catarrhal states it has seemed to act well.

In **affections of the eye** we have report of cures of trachoma by Stephenson and Walsh.[1] In a patient with long-standing trachoma of both lids a cure was effected in less than four months. Exposures were made of from eight to fifteen minutes' duration over the non-everted lids. Sealing-wax electrode was first used, then glass, and subsequently vulcanite. Williams has cured one severe case after twenty-two applications of a mild brush discharge

It has been suggested that the marked benefit derived in trachoma by *x*-ray exposures may be due, in part at least, to the electric discharges simulating the high-frequency brush. Geyser (as well as others) has successfully treated many subjects of granulated lids by combined radiotherapy and high frequency.

Conjunctivitis accompanying eczema and dermatitis is soothed and improved by the glass electrode over the closed lids. I have applied the spark to cancer of the globe, but it is distressing, and not more beneficial than the *x*-ray.

[1] Medical Press and Circular, February 18, 1903.

In **rectal diseases** the method must be said to have scored decided success. Numerous instances of pruritus ani in my own practice substantiate the claims made by many writers. Thickened conditions of the membrane and skin in this region are made to disappear more promptly by adding this to the older methods.

Fissure of the anus is likewise benefited and sometimes promptly cured. A rectal electrode in conjunction with the sparks along the fissure is the method employed. Doumer reports complete cure after as few as from two to six sittings of three to six minutes' duration. Tschdanow employed the method in eighty-five patients, with reported satisfactory results. He succeeded after from fifteen to thirty applications, using the bipolar method without resonator.

In **hemorrhoids** the rectal electrode may be employed in acute cases, if mild or not too extensive; but subacute and chronic cases of both internal and external piles are more amenable to treatment.

While I have at times seen very prompt results in both bleeding and itching hemorrhoids, relaxed and congested conditions of the bowel, I am convinced that in chronic and obstinate cases persistent effort will alone result in a satisfactory outcome. Much can be gained from the rectal electrode in various conditions of proctitis.

Gastrointestinal Disorders. Among other conditions in which the high-frequency currents have been reported as of decided benefit may be mentioned dyspepsia, constipation, colitis, atonic dilatation of the stomach, in which condition A. Crombie and T. J. Bokenham report a series of seventeen cases, with a number of cures and marked improvement in all. I have observed decided effects in nervous dyspepsia.

W. H. Dieffenbach[1] reports good results in constipation from the use of the rectal electrode. He advises treatments of fifteen minutes' duration, to be given daily until improvement sets in, when triweekly or biweekly treatments will suffice until permanent results are obtained.

[1] North American Journal of Homœopathy, October, 1903.

Caution. A caution should be given against employing sparks or the effluvia near areas to which collodion has been applied. An accident due to this cause happened to me in treating a chronic proctitis with great thickening and deep fissures of the mucous membrane at the anal orifice and an infiltrated, eczematoid dermatitis of the skin of the buttocks. Having applied a coat of medicated collodion to the skin surfaces before attempting to introduce the sparking glass electrode there was a sudden conflagration, involving the entire region thus painted, necessitating prompt action to save the patient from a burn of the parts. A similar accident was subsequently related to me by a gentleman in Paris, who also set his patient on fire by applying the electrode over the spinal column, after blistering collodion had been painted on. In another instance which has come to my notice there was ignition of the fumes by a high-frequency spark of ether given off from an open collodion bottle, involving the dressings on a patient's limb and the applicator held in the hand of the assistant.

It is likewise dangerous to apply the spark in the presence of the fumes of alcohol, as might be the case in applying a hair tonic just before the sparking.

In **gynecology** the various mucous membranes of the female pelvis have been subjected to these currents by a number of observers. Mangin[1] was one of the first to report good results, using one electrode in the vagina and the other upon the abdomen. Many since him have found decided relief from pelvic pain, whether due to congestions, neuralgias, new-growths, or postoperative conditions.

Besides the sedative effect, an emmenagogue action has been noted, and a number of good results in amenorrhœa have been obtained. In congestive hyperplasias of the uterus, acute metritis, and gonococcic infections, the intrauterine electrode with current passing from four to ten minutes gave excellent results at the hands of Doumer.[2]

Bloch[3] reports a cure of vaginismus.

[1] Annales d'electrobiologie, 1898.

[2] Les courants de haute fréquence, Denoyés, Paris, 1902, p. 332.

[3] Bull. offic. de la Soc. d'electrother., July, 1903.

My associate, Dr. Stern, reports treating two patients for sterility caused by infantile uterine development.

One patient who has been fruitlessly married for five years became pregnant after two months' treatment. The second patient, whose uterine organs were very small, and who never menstruated more than once every seven or eight weeks, lasting not more than one day, is at present menstruating every four weeks, lasting from two to three days. The method of application was with a vaginal electrode passed up to the uterus with gentle massage over the abdomen, the other pole being held by the patient.

Genito-urinary Diseases. In functional impotence Freund has recorded remarkable success following a brief course of treatment, at times after all other previous methods have failed. There are a number of very favorable results reported in the treatment of patients suffering from chronic prostatitis. We have had decided benefit in these cases from the use of the vacuum rectal electrode applied with some gentle pressure and moved back and forth over the enlarged prostate, after the manner of digital massage. This method has also been found of decided advantage in some cases of seminal vesiculitis.

Gonococcic infection in the male has been reported upon by Doumer[1] and Sudnik.[2] The latter found at times that by plunging the organ in a vessel containing a boric acid solution and having glass sides and a metallic bottom, connected with one extremity of the solenoid, while a carbon electrode was applied to the perineum, good results were secured. When at times a strength of 100 milliampères was without effect, 300 to 400 milliampères produced decided benefit.

Ten-minute sittings are usually given each day. Doumer employs effluvia from a resonator, or passes a moistened cotton tampon fastened to a metallic electrode connected with one pole up and down over the urethra.

The painful phenomena are markedly affected, while the inflammatory signs gradually subside. The greatest influence is appreciable upon the anterior urethra.

[1] Congres internat. d'electrobiologie et de radiobiologie médicales, Paris, 1900.

[2] Annales d'electrobiologie, September, 1900.

High-frequency Currents in General or Systemic Affections. Quite as important as the results obtained in pathological processes upon the surface of the body, are those which are claimed for the method in disease of internal organs and affections of the blood and nerves. Based upon experimental physiology which has demonstrated chemical tissue change, the chief claim for these currents has been made that metabolism and general nutrition are improved. There would seem to be no question that in many conditions acceleration of tissue changes brought about in this way would not only make the system better fitted to throw off pathological processes, but would also make it better able to resist microbic and other noxious invasion. To secure such effects a single-pole electrode applied to the surface, or to an accessible cavity, would be inadequate. Either the solenoid cage, the condensation couch, or the bath method, should be employed. These accessories seem capable of raising arterial pressure, increasing oxidation and elimination.

In this way we are capable of producing decided effects. Among the constitutional diseases which have been treated with more or less success, according to the reports of European and American workers, are included a variety of so-called rheumatic states, tuberculosis, diabetes, obesity, anæmic conditions, affections of the nervous system, etc.

Arthritis. In conditions of rheumatic or rheumatoid arthritis, especially in single joints, pain is relieved and motion improved. The application of the current is found to be most beneficial in chronic rheumatism, but is not of so much value in subacute. According to Apostoli and other observers it is contraindicated in acute rheumatism, which, it appears, may be aggravated. Apostoli has found that the chronic cases yielded very readily to this treatment, and that a number were very much improved in as few as four sittings, and even the severe cases rarely required more than thirty. The improvement showed itself in the lessening of the pain, the shortening of the attacks of pain, and improvement in motion. The beneficial effects appear to be more lasting than those derived from any other form of electricity, such as the continuous currents.

Williams found that the ratio of uric acid to urea is at first gradually increased, and then diminished, until it drops down to normal, coincidently with improvement of all symptoms. The method of application is by means of the autocondensation couch, accompanied by gentle massage, with the flat vacuum electrode over affected areas, beginning with daily treatments of ten minutes' duration and gradually diminishing the frequency of sittings and increasing their duration up to fifteen minutes.

In **subacute muscular rheumatism about joints** rather long sparks from a pointed carbon electrode have appeared to act favorably. This local administration may be made as the patient lies upon the couch receiving his general treatment. Chronic rheumatism being usually regarded as a disease of nutrition, the general and more powerful method would seem the more appropriate. Some so-called rheumatism is undoubtedly infectious, as exemplified in the gonorrhœal form. Here the monopolar method with the massage electrode gives the same relief as in other painful conditions, and, according to Denoyés, at times complete disappearance of symptoms and restoration of movement, in one case after thirteen sittings. He also thinks that the trophic disturbances and muscular atrophy may be also alleviated. The effluvium over the affected joint is also beneficial.

Lumbago. In a number of patients with this form of muscular rheumatism we have found that not only is the pain and stiffness in the muscles markedly diminished immediately after the treatment, but that the whole course of the attack is modified and shortened, at times seeming to be almost aborted.

In spasmodic torticollis and painful rigidity of the muscles about the neck and upper part of the back prompt relief has often been given in a few sittings. Besides the condensation method, sparking, and effluvia, a metallic plate may be employed as one electrode over the lumbar region, in lumbago, the other electrode being applied through the abdomen so as to concentrate the effect more definitely in the muscles implicated.

Gout. In gout no less than in rheumatism a method which will increase the activity of the nutritive processes should be of aid in eliminating the autointoxication believed to be present.

Here, too, the double action of general and local measures is called for. Intervention in the acute period is advised against. Apostoli and Laquerrière begin treatment with a mild current and increase gradually, stopping at the very beginning of any acute symptoms. They believe that if treatment is sufficiently prolonged, acute attacks will be more or less completely prevented. In deposits about finger joints, great toe, and elbow we have secured at times temporary relief. Williams speaks very favorably of the autocondensation and conduction methods in these cases.

We have found that in addition local massage over the affected parts with vacuum electrodes, or at times even held at some little distance from the skin, so as to secure the reaction effect of the spark, appears to add to the efficacy of treatment.

Calculi. Biliary and urinary lithiasis are so closely allied to the gouty and rheumatic conditions that we might believe the systemic influence of high-frequency currents would prove of benefit in the one as in the other class. Moutier[1] has especially studied this branch. He, together with Guilloz, reports two apparent cures of urinary calculus in eighteen and twenty-five sittings respectively at intervals of two or three days. Moutier also claims to have cured several patients suffering from gallstones. Besides the autocondensation plan, effluvia and sparks were applied along the spinal column to relieve arterial tension. Bonnefoy has observed improvement in these conditions, as have also Apostoli and Laquerrière, who saw gradual disappearance of the attacks, believing that the exciting condition is arrested or retarded.

A prolonged treatment, improving general nutrition, might well act in a prophylactic manner.

We cite these cases as they have been reported, doubting whether such statements could be satisfactorily substantiated. As it is not unusual to observe gallstones of small size pass through without resort to any treatment whatever, it would be rather difficult to estimate just how much the

[1] Annales d'electrobiologie, January, 1899.

high-frequency current has aided in bringing about such a result.

Diabetes. D'Arsonval[1] reports two cases of diabetes and one of obesity in which he had remarkable success. The patients stood with their feet in water connected with one of the poles, the other being a fork-shaped electrode which the patients held.

In one case, after forty-two days of treatment, the daily amount of urine was diminished from 11 litres to 7 litres and the sugar from 620 gm. to 180 gm. The treatments were given daily and were of ten minutes' duration. Vietta adds four successful cases to the list.

Williams[2] mentioned a patient whose output of urine was decreased after a month's treatment from 16 to 7 pints and the sugar from over 32 to 3 grains per ounce.

Apostoli[3] claims to have achieved brilliant results with general D'Arsonvalization in similar cases of impaired metabolism. He reports 518 patients who received in all 12,728 applications with the following results:

There was a progressive improvement in the general condition of the patients; an increase in the strength and energy; increased appetite; improved sleep; improved digestion; the return of pleasant disposition; ability to work, and ease in locomotion.

The beneficial results obtained in this class of cases are not conceded by all observers. Doumer, at the Congress of Radiology in 1900, stated that he observed no beneficial results from D'Arsonvalization in patients suffering from impaired metabolism. All present agreed with him. Among those who have reported negative results may be mentioned T. Cohn, Löwy, Kindler, and Bädeker, who has treated a number of diabetic subjects without observing any diminution in the amount of sugar. The annoying symptoms, such as the pruritus, dryness of throat, etc., were markedly improved. Against this I can report the prompt disappearance of glycosuria in an obese subject of pruritus vulvæ, which latter was likewise cured.

[1] Encyclopædia Medica, vol. xiii. p. 529.

[2] The High-frequency Currents, London, 1903, p. 159.

[3] Compt.-rend. du XII. Congr. internat. de méd., vol. ii., sec. iv., p. 69.

Obesity. There are a number of very encouraging results reported in the treatment of this condition. Boinet and Caillol de Poncy[1] speak of a number of patients treated by autoconduction, in whom the average loss in weight amounted to as much as fourteen pounds a month. Williams reports one instance where the girth of a patient was reduced four inches within nine weeks, practically without loss of weight. He thinks that the increase of the digestive functions and the increase in the elimination of the phosphates and urates is mainly responsible for the beneficial results.

Moutier claims that the high-frequency currents do not bring about a diminution in weight, but that they decrease the body volume by making it more dense.

Foreau[2] saw no result in obesity, but he noticed that patients treated with the high-frequency currents tolerated the thyroid cure better. As early as 1897, at the Moscow Congress, Apostoli and Berlioz pointed out the influence which could be exerted on obesity. When this condition is associated with diabetes and arthritism the chances of benefit are greater. Autoconduction or autocondensation is the method recommended. Heart disease furnishes a contraindication here as well as in other conditions.

Malignant Diseases. In deep-seated and recurrent malignant growths the same retarded development, diminution of pain, and improvement in general health, as from the *x*-ray, have been recorded by a number of careful observers. Taylor[3] reports great improvement in pelvic carcinoma after four months' treatment by the rectal electrode. While all the symptoms disappeared the tumor, however, remained. Two instances of recurrent scirrhus of the breast and a sarcoma of the antrum, reported by Allan,[4] were apparently arrested. These patients were reported upon by Williams as being quite well two years after the treatment. Lyster believes that the good results are attributable more to the tonic action of the rays than to any direct action on the growth itself.

[1] Soc. de biologie, July 31, 1897. [2] Fortsch. d. Medicin, 1901, No. 13.
[3] Bristol Medico-chirurgical Journal, September, 1903.
[4] West London Medical Journal, 1902, vol. vii. p. 173.
[5] Archives of Middlesex Hospital, vol i.

In small cancerous growths the spark of an inch or more in length can be applied from the pointed tip of a carbon with little pain, and with destructive mummification of the neoplasm.

This I have practised several times with success in small sarcomatous nodules as well as in epitheliomas as an adjunct to *x*-ray or other plans of treatment.

Pearsons and Rivière, among others, have found the method useful in epithelioma.

Affections of the Nervous System. A decided change of opinion from that held by early writers has occurred within the last few years as to the effects upon the nervous system. All probably here depends upon the proper method of application. While the more general and powerful methods are perhaps of little use, or may even prove a cause of aggravation of the symptoms, local application may at times give most brilliant results. The selection of cases for the particular form applicable is here, too, of the utmost importance. Affections characterized by nervous irritability, excitement, palpitation, etc., are not benefited as are those patients whose nervous system is depressed and who lack in nerve energy and force. Thus, as Freund states, subjects of melancholia and hypochondriasis, and those showing little self-reliance, are more benefited, while those showing erratic forms of nervousness are aggravated, and increased restlessness and sleeplessness may be noted. While auto-conduction has proven beneficial in insomnia, some forms of hysteria, and in neurasthenia, especially at the hands of Bädeker, Cohn, Kindler, and others, the most marked success has seemed to be in the more localized nerve affections, such as the various neuralgias and neuroses. Bädeker found the method of distinctive value in sciatica; intercostal, cervical, and occipital neuralgias; but in trigeminal the pain seemed to be increased. Other observers, however, have found marked relief in obstinate tic douloureux.

MacIntyre[1] in two instances succeeded in completely relieving severe neuralgias of the second division of the fifth nerve, giving local applications by means of Oudin's elec-

[1] British Medical Journal, June 6, 1903.

trode. In one case after months of intense suffering, all the teeth and alveolar processes having been removed without relief, three weeks' treatment brought about complete disappearance of the pain. There was no recurrence in six months. In the second case, the pain was relieved for a year, but the recurrence could not be relieved.

In our own experience the effect is especially good in the neuralgia attending and following zoster, while in pelvic pains the results have been such as to offer encouragement.

While not always successful in sciatica, local applications have given at times most beneficial results. The relief of various pains is established beyond question. Freund speaks of this effect in such a serious condition as tabes, while it is an almost daily observation of those who employ the method extensively that headache, whether due to conditions of nerve or an anæmic or uræmic state, is often promptly relieved. Although suggestion may play a part in many nervous conditions, Freund's view that currents prove beneficial in this way only can scarcely be claimed at the present day. As an analgesic the method has little value compared with other methods in use. Surface sensitiveness can be lessened for a brief period, but high frequency as applied to painless dentistry, for example, has not proven markedly successful.

Tuberculous Affections. Going back to the experimental work which should serve as a basis for our expectations of benefit, we find that D'Arsonval's investigations on guinea-pigs demonstrated a retarding influence upon the growth of bacilli. Grünbaum[1] also found that toxoids are capable of producing immunity and that the modification brought about by these currents is one from toxin to toxoid. That the virulence of the toxins are attenuated is stated also by Rivière;[2] repeated applications decrease the reproductive power of the bacillus. In Williams' report we find 32 tuberculous patients all so much improved, if not cured, that none has required treatment for eighteen months, most of the subjects performing their usual work. Of 43 cases originally reported 3 have died.

[1] British Medical Journal, 1902, vol. i. p. 654

[2] Ibid., p. 93.

Among those who speak with some enthusiasm of the effects in phthisis may be mentioned Oudin, Rivière,[1] Gandil,[2] Doumer,[3] and Cunningham Bowie.[4] The latter reports very satisfactory results from the use of his apparatus in these cases, especially when combined with intralaryngeal injections of antiseptics. In Doumer's seventeen observations of advanced phthisis, treated over a period of four years, five were still under observation two years after the cessation of treatment, the symptomatic cure having been maintained. The method employed was to direct the breeze over the regions of the thorax corresponding to diseased areas, especially over the supraclavicular fossa. Treatments were given daily for from five to twelve minutes, in rare instances three times a week. The first effects noted after from five to eight sittings were disappearance of night-sweats and lowering of evening temperature. After about two months improvement was noted in the emaciation, cough, and expectoration.

The general improvement always preceded the diminution in the number of bacilli, from which the observer concludes that the decrease and occasionally the entire disappearance of bacilli is due to the general improvement, increase in resisting powers, and defensive reaction of the organs. Oudin's method of procedure calls for the most powerful breeze of which his resonator is capable. During the ten- to fifteen-minute sittings he places his fingers upon the chest wall over the affected region and opposite that upon which the breeze is directed, so as to localize the maximum of current in the tuberculous area. In several instances the results were favorable. Rivière's method differs somewhat in his use of autoconduction, employing the solenoid cage. While his results gave promise, a variety of other measures, including *x*-rays, were coincidently employed, thus vitiating the scientific worth of the observations from the high-frequency standpoint. In surgical tuberculosis, including ulcers and other skin tuberculous affections, a number of

[1] Congr. internat. d'elect. et de radio. méd., July 27, 1900. [2] Ibid.

[3] Acad. des Sciences, February, 1900.

[4] Lancet, May 2, 1903.

writers, including Cattelani[1] and Rivière, have recorded good effects in cutaneous gummata, cervical adenitis, cold abscess, etc. Still, nothing of very great moment up to the present time has appeared in literature.

RESUME.

A review of the somewhat meagre literature, confirmed in many instances by personal experience, leads the writer to state his belief that we possess in this new modality an addition to our means of cure which will be more appreciated as time goes on.

New possibilities for these currents are being daily brought to light, and even when not positively curative in themselves they furnish an additional means of giving relief in a wide range of affections.

General as well as local effects can undoubtedly be secured by modifying the manner of administration. The currents can be most conveniently applied to accessible mucous membranes and through the natural orifices to deeper-lying organs.

In General Therapy. My experience with these currents in general therapy is somewhat more limited than in diseases of the skin. It has been to a certain extent confined to those cases of impaired general metabolism and affections of the nervous system which are accompanied by changes in the integument, such as pruritus, jaundice, various forms of eruption, and affections accompanied by neuralgic pain of different characters.

In this way I have been called upon to treat a number of patients suffering from diabetes, who have come to me for the relief of pruritus vulvæ, or other dermatological conditions associated with this disease. Here, as well as in rheumatoid and lithæmic states, gouty conditions, neuralgias, etc., decided improvement can at times be noted.

In chronic processes in which pain is a marked symptom, autoconduction or autocondensation, accompanied by local

[1] La riforma medica, 1898, No. 48.

effluvia and sparking, massage with the glass electrode or metallic roller, frequently gives marked and prompt relief.

In impaired nutrition and faulty metabolism the same general treatment appears to do good. In a variety of subacute and chronic inflammatory processes attended with exudation and painful thickening of tissues, local mild effluviation and electrode massage hasten the *restitutio ad integrum.*

In Skin Affections. As a result of a close clinical study of over 250 cases treated in my office I am convinced: (1) That in a comparatively large number of dermatological affections the local action of high-frequency currents aids in their cure. (2) In a limited number of patients in whom nutrition is at fault D'Arsonvalization or autocondensation helps to bring about a prompter removal of local lesions. (3) In parasitic affections, while it has an influence, I have not been able to convince myself that the results are prompter or better than in older methods. (4) That the broadest field of usefulness is in the markedly pruriginous affections, and in those intimately connected with the nervous system and associated with pain. (5) An important and, as I believe, a growing sphere is that filled by the high-frequency spark in the almost painless destruction of the small neoplasms, including nævi, moles, warts, tumors, and malignant growths, as well as in lupus and lupus erythematosus. I have for years advocated early and radical destruction of nævi moles and other congenital growths as a prophylactic measure against cancer. While I have seen disastrous results follow improper attempts at removal, I have never observed anything but benefit follow recognized methods of cure. In a paper read by Prof. W. W. Keen,[1] twenty-five instances are given in which such growths degenerated malignantly, and were known to have caused death in at least eleven subjects. Patients who would refuse the knife will consent to the painless method here advocated, which leaves little or no scar. (6) Compared with the Roentgen ray, skin affections as a whole are less benefited by these currents; but the two methods often enhance each other's influence.

[1] The Danger of Allowing Warts and Moles to Remain Lest They Become Malignant, Journal of American Medical Association, June 7–10, 1904.

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