AMERICAN GAS WORKS PRACTICE

Standard Practical Methods
in Gas Fitting, Distribution
and Works Management

GEORGE WEHRLE

THE GAS AGE

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PREFACE

The subject matter contained in this book is along the line that I have always wanted to see collaborated in one book. The gas employe, to my mind, has struggled through a great many years without accurate information in concrete form to guide him in his work. There have not been the proper books to which a man in the ranks could turn to better himself and grow in his profession. Time and again I have been asked by young men who are ambitious to learn the gas business where they could find the proper information. I have had to refer them to technical periodicals on the subject and to the proceedings of the various associations, knowing full well that they would be discouraged long before they had been through the various files. While it is true that literature of the gas business is full of a great many valuable books and articles, these are written very largely in a very technical manner.

The American Gas Educational Course has been the path to advancement for many a studious employe. The course in this book offers a more popular route for advancement to the gas employe. I have seen, in my twenty-odd years' connection with the gas business, a number of gas fitters become superintendents and managers of plants. These advancements were very largely due to the efforts and co-operation of a few men in the industry who have realized the importance of attempting to educate the employe, from the humblest up.

There still exist in this country a great many gas companies who make no effort at all to develop their employes and fit them for promotion. The real method of course is to put the information or instruction in such shape that the man himself can largely be responsible for his own development and I believe that the following pages more nearly meet this condition than anything heretofore written. The time is coming when the gas business must be made a true science in all of its departments. It is going through a wonderful development in the manufacturing end. The design of street mains and services and distribution systems is becoming more a true science than it was in the past. There is still a lot of work to be done between the street main and the ultimate customer's burner.

We have in this book well laid down rules for computing the sizes of pipe to be employed and methods of doing work, but if the commercial end of the business is to reach and hold all that it should, many details which are now handled by the gas fitter must be improved upon and brought nearer perfection.

It is not at all difficult to find in a great many gas companies today annoying conditions to customers which must be removed. We have seen the electric business grow up alongside of us and become an exact science in most every detail, and we have lagged behind. We sell gas fixtures and appliances that get out of adjustment and leak and give trouble within a year of their installation. We run gas services and pipe houses that leak and give trouble long before they should. A big chance for improvement in this situation is through building up a more highly educated force of gas employes.

When a man enters the gas business, even at the lowest round, he should have the gas manager's job in view, and he should have every opportunity made (almost compulsory) to study and progress with his work. No vacancies should be filled in a good sized gas company (outside of the very most technical positions), except from the ranks; for example, young men graduating from high school might have a year's work in the fitting department, before going to college, to prepare to do the technical work for their company. This method of education would develop an esprit-de-

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corps and final perfection in the gas business that would be hard to beat.

I recognize more and more how much the commercial success of the business depends upon the man whom the public meets. The good will built by a commercial salesman can be thrown to the winds by the hands of a poor fitter, for example.

As a result of the European war we are going to have many men return who have been subject to discipline and who will appreciate the method of development I have outlined above. I believe the best managers for properties are bound to be the ones who come through the plant and distribution departments. The manager who can say that there is not a job in the company that he has not actually performed is the strongest type of man to become an executive. No college man nor technical engineer should expect to step into a manager's job without having served some time in the fitting department.

This book offers a most excellent text-book for employes' associations, student bodies within the organization, as well as students who intend to enter the gas business. The book contains many tables and formulae that are valuable, and many methods and descriptions of operations. There is an attempt made to give the fitter an idea of other departments of the business than his own. These descriptions are general, of course, and give the student only a smattering idea from which he can delve deeper if he so desires. The book is well worth placing in the library of any man who has the interest of the gas business at heart.

J. D. SHATTUCK.

Chester, Pa., June 9, 1919.

INTRODUCTION

The work of publishing a series of handbooks on subjects pertaining to the gas industry, and of which this is the fourth, was undertaken by THE GAS AGE for the purpose of providing references on American gas practice which had been decidedly lacking and in great need by the gas industry.

The original intention in assigning the subject of Instructions for Gas Company Fitters to the author was to provide a book primarily for the fitter which would be instructive and educational to him, particularly on the work of especial interest to him. It was further intended that the subject be covered in such a general manner that it would provide a reference book on standard American gas fitting practice for the use of the entire gas industry as well as for the information of architects and contracting pipe fitters.

After the work was outlined it was seen that it would require the covering of a much broader scope than originally planned in order to furnish the elementary information necessary to a full understanding of the purpose and importance of gas fitting work. It was then considered advisable to broaden the scope to such an extent that a reference book would be produced covering in a general way the entire field of American Gas Works Practice and specializing in a number of chapters on gas fitting work. This would fulfill the purpose of the original plan while adding other information of value to the gas industry as a whole.

Following out this plan, the skeleton of Gas Fitting Practice was surrounded by an envelope of other information which it is the hope of the author will prove to be of interest and benefit to American gas men. The chapter on History and Development of the Gas Industry was added for the purpose of showing the really tremendous progress of the gas business which is not generally appreciated in this age of matter-of-fact methods. A chapter was also added on Labor Saving which is a subject of vital importance to all gas men, as well as other employes of labor, at this time when man power has become such a predominating factor in the cost of production and handling of all commodities.

In gathering data for this book the various gas companies were asked: First, for their opinion upon the idea of getting out such a book. Second, for various practices employed in the operation of their fitting shop and, third, for their rules governing the installation of gas piping. They were unanimous in agreeing that the work would be of value to the gas industry and generous in sending their rules and methods of practice. In addition to securing the co-operation of gas companies the United States Bureau of Standards gave permission to use their National Gas Safety Code which was then under consideration by the Bureau and various committees from the gas fraternities. It was hoped that the Code would be completed by the time of publication of this volume, but unfortunately an unforeseen emergency prevented the Bureau from carrying out their original plan on schedule, and the work has been postponed pending more favorable conditions. This book, therefore, refers to the code as standard authority at such time as it may be completed and issued, and the author wishes to hereby declare himself automatically corrected on any matter that may appear herein and hereafter found to be conflictory to the same subject appearing in the Code.

The public utility commissions of most of the states furnished copies of their rules and regulations of service, which were made use of in the text of the book.

From the data thus obtained and with the addition of the other data gathered from various text books, periodicals, etc., and from manufacturers of appliances and apparatus and the writer's own practical experience this book has been written, and is dedicated to the gas fraternity of the United States with the hope that it may be of some small value to them as a stepping stone toward a more general standard practice in gas work.

The author wishes to extend his thanks to the various gas companies, utility commissions, manufacturers and to the Bureau of Standards and others who contributed data used in this work.

GEO. WEHRLE.

Denver, Colo., May 12, 1919.

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CHAPTER I

HISTORY AND PROGRESS

Despite the existing proofs of a high state of civilization attained by the ancients, their acquaintance with the existence of gases seems to have been lacking. In books of ancient history, particularly the Scriptures, reference to the term "smoke" is made, which seemed to have been applied alike to all gases and vapors. Chemistry was studied and practised in a crude way, but was considered to be something bordering upon the supernatural and alluded to as "Magic."

Early Discoveries in the Chemistry of Gases

The first record of importance relating to gases was in the sixteenth century, when a Flemish chemist by the name of Van Helmont discovered the existence of certain aeriform bodies that differed in their nature from the air. These he found were produced by certain actions in various substances and were designated by him as "spirit," a name in common use for all things invisible. The records show that he actually produced gas in some of his experiments but believed that it was not possible to confine it in any kind of a vessel. He afterward referred to his new discovery as "Gas," which is the first record of the use of that now well known word. It is believed that he derived the word "gas" from the Flemish word "geest," meaning a spirit. Van Helmont must have carried on some extensive experiments as he is accredited with the statement that "flame is produced by ignited vapors." With his period may would result in good to mankind, and in fact it is not definitely recorded that any serious thought was given to the matter of utilizing these gases practically until the time of Murdoch, to whom credit is given of being the father of the gas industry.

William Murdoch was an engineer at Redruth in Corn-

Fig. 3. Old Print of Pipe Making by Medieval Chinese

wall, and in 1792 he first entertained the idea of utilizing illuminating gas as a substitute for lamps and candles. He conducted experiments along the lines of removing the impurities contained in coal gas and tried out different kinds of coals for the purpose of gas making. It is recorded that he first lighted his house and office with this new illuminant in 1792, distilling the coal in iron retorts and conveying it through tinned iron and copper tubes to the burners. He also utilized a gas holder, similar in function to those of the present day, which had been invented by the French chemist, Lavoisier, in 1781. He substituted lanterns with bladders filled with the gas, and to which burners were at-

Fig. 4. Modern Installation of Gas Mains in Tunnel

tached, for lighting the way between his house and the mines. This is the first known practical use of gas and from which the history and progress of the gas industry dates.

To Murdoch is due the credit of carrying on the first experiments in gas purification and early in his studies of gas production realized its necessity and importance.

We, however, lack record of his having gone any further than the use of water as a purifying medium so that his early gas must have been strongly impregnated with

Fig. 5. Old Print of Medieval Laundry

sulphur. We learn that he continued his experiments with gas making substances other than coal for the express purpose of avoiding the disagreeable odor of his coal gas, which was undoubtedly caused by the large

Fig. 6. Modern Gas Laundry

Fig. 7. Gas-heated Laundry Dryer

amount of sulphur contained. The use of lime as a purifier is accredited to Dr. Henry and Clegg.

In 1798 the Soho engine works was lighted with gas, which was the first instance of gas being used for industrial purposes. It seems that Murdoch nor his partner Watt, son of the inventor of the steam engine, ever applied for a patent on the process of making and using gas, seemingly not realizing the great importance of the discovery.

At about the same time Murdoch was carrying on his experiments a French engineer by the name of Lebon was experimenting along the same lines in Paris and in 1799 he obtained in France the first patent on the process of making gas, which was called "an economical method of employing fuel." Record is given of the lighting of his residence in Paris with gas in 1802, ten years after Murdoch had done the same thing in England.

To Murdoch must be given credit for perfecting the first gas burners and for experimenting extensively along this line. In 1802-03 Murdoch erected works for the supply of gas to the premises of Messrs. Boulton and Watt. In 1804 George Lee, of the firm of Phillips and Lee, lighted his house and in 1805 the cotton mills of the above named firm was lighted.

The cost of the erection of these isolated plants must have been a serious impediment to the development of gas lighting as of course the thought of a central plant was out of the question at this stage. However, Murdoch states in comparing the cost of lighting the cotton mills with gas with the cost of candles for the same purpose that the former was practically two-thirds cheaper. This cost is supposed to have represented the entire cost of gas, interest on capital and depreciation.

Recognizing the importance of Murdoch's discovery and its adaptability for the purpose of lighting cotton mills in particular, other engineers went into the gas business about this time and a considerable number of isolated plants were erected. Messrs. Henry, Winsor and Clegg were particularly active in the early developments of the gas industry and to the latter is due many of the inventions and improvements that later made this business a permanent success. In 1804 Winsor obtained a patent on a process of making and utilizing gas and claimed credit as its inventor and discoverer. In 1807 he obtained capital by subscription and formed the first company for manufacturing and distributing gas.

His plant was located in the basement of a building in Pall Mall, London, and from these premises he laid the first main in a public street and receives credit for achieving the first gas street lighting in the same year, 1807. It seems that Winsor was a man of high ambition and conceived the idea of forming a gigantic (for that time) stock company for the purpose of obtaining a royal charter or exclusive privilege for lighting the entire British Empire with gas. He may thus be called the first promoter or gas syndicate magnate. He obtained a charter in 1812, but the privileges accorded were very moderate as compared to those requested. Competition was not prevented in the terms of this charter and the activities were confined to the city of London. The plant was erected and the first gas distributed for commercial purposes about the year 1813.

The first recorded instance of the use of gas for illuminating purposes in the United States was in 1806, when David Melville of Newport, R. I., lighted his house and the street in front of it with gas of his own manufacture, made on the premises. Melville improved his apparatus from time to time, finally patenting it in 1813. He introduced gas for lighting of a cotton mill at Watertown, Mass., and of a mill near Providence, and in 1817 employed it in lighthouse illumination.

Development of the Gas Industry

From the year 1813, when the first real gas plant was put in operation in London, the industry grew, at first slowly, then more rapidly as improved apparatus was developed and knowledge of the physical laws involved acquired.

By the year 1819 gas works were in operation in England in not less than a score of towns and cities and by 1829 this number had been increased to 200.

The first company chartered in the United States was in Baltimore in 1816. In 1822 Boston adopted gas lighting. In 1823 a company was organized in New York City, in 1825 in Brooklyn and Bristol, R. I., and 1835 in New Orleans.

We are indebted to Mr. Walton Clark of the United Gas Improvement Co. of Philadelphia for the following record of development in this country:

From 1860 the growth of the gas business has been

thirds of the manufactured gas sold to American consumers is used for other purposes than illumination.

In the first days of gas lighting coal gas was almost exclusively manufactured. This gas had an illuminating value of 15 to 17 candles, and was considered a brilliant illuminant in the earlier days when comparison was made with whale oil lamps and tallow dips. But the advent of kerosene and the improvement in oil lamps marked the beginning of an era of higher candle power, and by creating a new factor in the

Fig. 10. War-time Coke Handling in London

competition for urban lighting promised to reduce the rapid growth of the gas business.

At this crisis in the history of gas lighting a Frenchman, Tassie du Motay, and an American, Prof. T. S. C. Lowe, were independently experimenting in the manufacture of gas by the dissociation of steam in contact with incandescent carbon. The result of these experiments was the development of the so-called "water gas" systems that bear the names of their distinguished inventors, the cupola-retort system of Du Motay, and the generator-superheater system of Lowe, the latter being the most important of all inventions affecting the manufacture of gas.

A few years after the invention of the water gas processes, and during their development, the electric light appeared on the field as a competitor which promised to prove more formidable than the previous danger of cheaper oils and improved oil lamps for illuminating purposes.

About 1890 the gas lighting industry received a new and powerful weapon for use in its competition with

Fig. 11. Modern Coal Storage Plant

electric lighting in the incandescent mantle gas lamp. This lamp is the invention of Carl Auer von Welsbach of Vienna.

Development of Coal Gas Generation

In the early experiments carried on by Murdoch for the production of coal gas various methods of retort setting were employed, the chief object in arranging the position of the retorts being the removal of the coke and residue. His first retorts were arranged vertically, then inclined at various angles, and finally horizontal, which was considered as standard for many years.

For a number of years after the first coal gas plant was erected the retorts used were made of cast iron. About 1820 the first clay retorts were introduced in England. The general adoption of clay retorts was very gradual, and it was not until about the year 1860 that their advantages became so apparent as to warrant their common use. When first employed clay retorts were made of plastic fire clay only, which broke into

Fig. 12. The First Large Retort House in America

pieces when exposed to the heat of carbonization. Afterward they were formed of a compound of plastic clay intermixed with granulated burnt clay or calcine, which withstood the heat without breaking. Within recent years the fireclay retort has given way almost entirely to those made of silica material which possesses many advantages.

The first retort settings consisted of one retort heated by its separate furnace. Afterward various numbers of retorts were grouped together in a single setting, but groups of three retorts seemed to be the prevailing method of setting for a number of years.

After progress had standardized retort settings to some extent, benches of sixes and nines became the groups generally adopted and which prevail in the common carbonizing plants of the present day.

While the horizontal retorts of early days are still

Fig. 13. Modern Gas Retort House Architecture

in common use they have been supplanted to a large extent by inclined and vertical types, and by the oven, while the old horizontal stop end type has in many cases given way to the horizontal throughs. The use of mechanical stokers and other means of economically charging and discharging the retorts has influenced the evolution in carbonizing equipment, which is brought about by the ever increasing cost and scarcity of stoking labor and by the necessity for cheapening production costs so as to enable the company to sell their product at a lower price.

The first furnace used for heating coal gas retorts was of the direct fired type, which has been supplanted in the last thirty years by the regenerative and recuperative type, the latter being the prevailing kind at the present time. The evolution in furnace construc-

Fig. 14. Old Time Shovel Charging Retort

tion has been as pronounced as that in retort settings until one would not recognize in the modern gas bench the simpler setting of a century and less ago. By the adoption of the recuperative full depth furnace fuel consumption per ton of coal carbonized has been decreased practically 50 per cent, the life of the entire bench has been increased, as has also the efficiency of operation, all due to the temperature control obtainable.

A striking example of the progress of carbonization

plants in a little more than 100 years is seen in a comparison of the Astoria Plant of the New York Consolidated Gas Co., with a sketch of the original plant in London. One can hardly conceive of this huge Astoria plant with its immense stacks of inclined and through retorts as having been evolved from the small beginning of Murdoch and other pioneers in the industry. Going further we see other types of construction, as for instance, the vertical settings of Providence, Rochester,

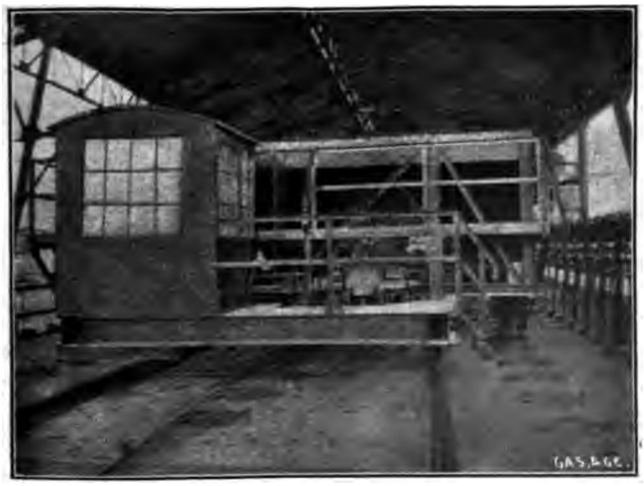

Fig. 15. Larry Charging Retort Ovens

Fall River, etc., the coke oven plants of Milwaukee and St. Louis, the slot oven retorts of Jackson and Ann Arbor and the hundreds of plants employing various mechanical means of charging and discharging horizontal retorts.

It is not necessary to go back 100 years for striking examples of progress in the gas industry; that which has been seen by a great many of our present-day gas men is sufficient. We may conclude that the advent

of the regenerative furnace was the real beginning of this progress.

History and Development of Water Gas Generation

There are records of attempts being made to produce water gas as a substitute for coal gas as early as 1824 when Ibbotson obtained a patent for producing hydrogen by the decomposition of steam which he proposed to mix with tar or coal. Many schemes were tried out, the one in particular which offers the most striking contrast to present-day methods being the liberation of

Fig. 16. Modern Mechanical Retort Charger

hydrogen from water by admitting steam into retorts filled with red hot iron. Scarcely, if any, success was attained in these early experiments in water gas making and it remained for an American, Prof. Lowe, to perfect the process and to him is due the major credit for the development of this part of the industry.

The first attempt to distribute carburetted water gas on a commercial scale was made by Donavan in 1830.

This gas was experimented with for lighting the streets of Dublin, but was not a success. In 1846 Gillard attempted to manufacture and distribute non-luminous water gas in Narbonne and Passy, France. His scheme was to heat platinum wire cages, attached to the burners, to incandescence by the combustion of the water gas, but this was also a failure from a commercial standpoint.

It was not until the early seventies that anything

Fig. 17. This Scene Is Common Even Today

bordering on success was achieved in the manufacture of water gas, although something like sixty patents were taken out on such processes and apparatus during the forty years interval between Donavan's and Lowe's experiments.

The discovery and development of the oil fields of Ohio and Pennsylvania and the invention of the Generator-Superheater apparatus by Prof. Lowe, made possible the successful and economical production of carburetted water gas.

The Lowe patents were granted in 1872 and 1875 and the first apparatus was installed by Prof. Lowe in

Fig. 18. Vertical Retort Coke Discharge Provisions

Phoenixville, Pa., in 1875. In the latter part of 1882 the Lowe patents were purchased by the newly organized United Gas Improvement Co. of Philadelphia, and to them is due the remarkable improvements and development of the modern water gas apparatus which still carries the name of the American inventor, Lowe.

After the acquirement of the Lowe patents a bitter fight was waged against the newly organized company by infringers and critics of the new process. The first apparatus was crude and many obstacles had to be overcome, but the survival of the Lowe apparatus over all other types and the fact that in the first thirty years of its existence the United Gas Improvement Co. installed 787 sets of apparatus having an aggregate daily capacity of 654,225,000 cu. ft. is sufficient proof of the

Fig. 19. Old Time Hand Discharge of Coke

quality and efficiency of the Standard Lowe apparatus.

In the year 1915 the quantity of water gas manufactured and sold in the United States was 124,129,569,000 cu. ft., or 47 per cent of the total quantity of artificial gas output, while the number of plants in operation is given as 553.

Development of Oil Gas Manufacture

Methods of distilling oil into gas dates back to the time of the discovery of petroleum, but as the distillation in the early period took place in cast iron or clay retorts very little success was obtained until the invention of Prof. Lowe made possible the manufacture on a commercial scale of a mixture of water gas and oil gas which is now known as carburetted water gas.

The development of the process of making oil gas without the use of solid fuel was brought about within the past twenty years in the Pacific coast states, by the discovery of enormous quantities of crude oil in close

Fig. 20. A Metropolitan Gas Office One Generation Ago

proximity to the market for the gas. The scarcity or high cost of solid fuels and the abundance and low cost of oil made it an economic necessity for the development and adoption of a process for utilizing this oil a the raw material for gas manufacture.

As an example of the progress made in oil gas manu facture the state of California is typical of the grow of this industry in other communities on the Paci coast.

Until the year 1884 coal gas was made exclusively in California from coal brought from Australia in ballast. In 1899 the plants in operation in the state were: 1

Fig. 21. Replaced by This Building on Same Site

crude oil water gas works, 10 Lowe process carburetted water gas plants, 18 coal gas works, and 5 oil and air gas works.

From this small beginning the oil gas industry grew until in 1909, ten years later, California had 56 oil gas works and but one small coal gas plant.

The credit for discovering the method now used in manufacturing oil gas belongs to L. P. Lowe of San Francisco, while the chief credit for developing the

Fig. 22. Natural Gas Lighting of an Ancient Temple

apparatus and process should be given to E. C. Jones, who has done more than any one else to make this industry the tremendous success that it is today. It is now the principal method of gas manufacture in the states of California, Oregon and Arizona, and the fact

Fig. 23. A Modern Gas Lighting Fixture

the amount of gas produced was in excess of 500,000,-000,000 cu. ft. It is estimated that the number of consumers exceeds 1,000,000.

Until the last few years difficulties were encountered in constructing pipe lines of sufficient size capable of holding high pressure. This prevented the marketing of gas at points far distant from the source of supply. Modern steel pipe, rubber-packed couplings, the welding process and the development of compressors, driven by gas engines of 1,000 horsepower and more, have furnished a means of surmounting difficulties in transmission and gas is transported as far as 600 miles at the present time.

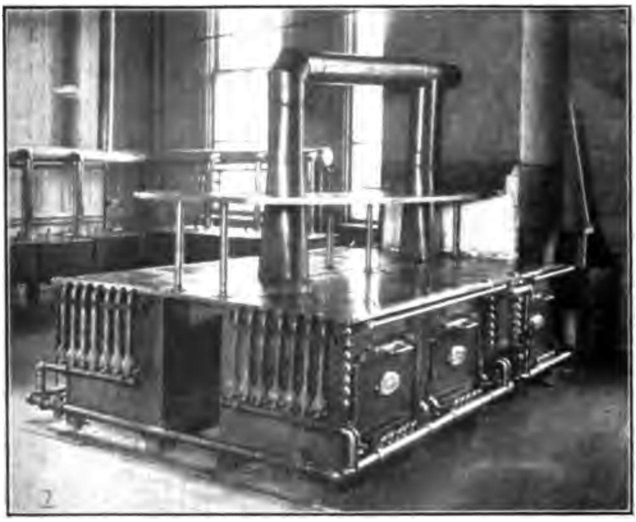

Fig. 26. A Modern Bank of Hotel Ranges

The Empire Gas and Fuel Co. have but recently finished the construction of a 12 and 16-in. transmission line a distance of 113 miles from fields in Oklahoma to points in Kansas for the express purpose of improving service. Most of this line lays in solid rock and extreme difficulties of many kinds were encountered and

Fig. 27. Another Early Gas Range

overcome. This serves only as an example of modern practice as compared with the 2-in. pipe line five miles long laid in Titusville forty-six years ago.

History and Development of Apparatus and Methods

A great part of the apparatus in use in gas plants today is the result of the evolution of the apparatus

Fig. 28. A Modern Gas Grate for Room Heating

originally used in a crude form by the pioneers of the industry. While the improvements are pronounced and the form unrecognizable, the modern Corliss engine is but a steam engine just as was the first one built by

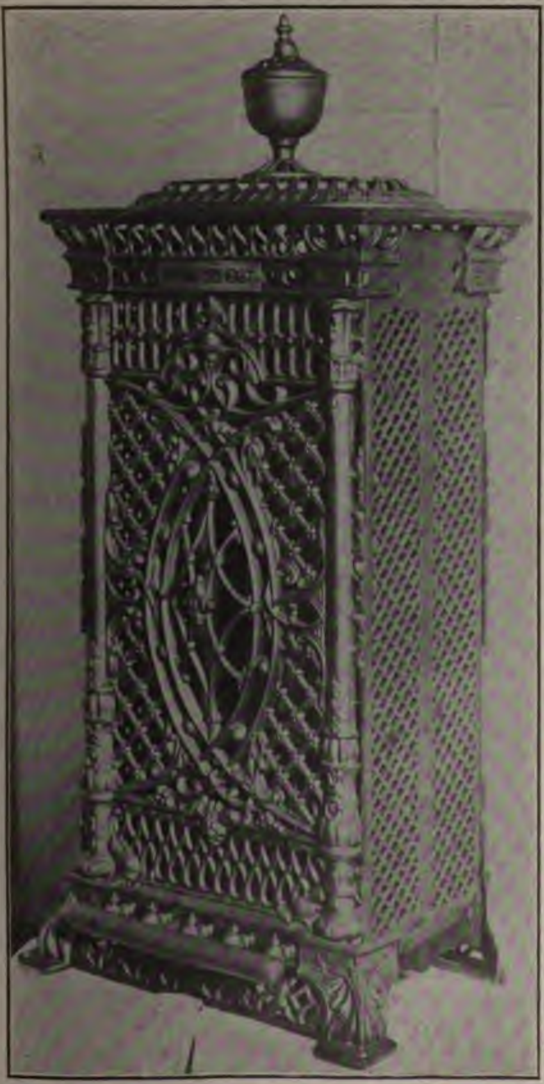

Fig. 29. One of the Original Gas Heaters Dated 1887

Watt over a century ago; by the same analogy, many pieces of modern gas apparatus are performing a function outlined in a crude manner by the early inventors and designers for similar though smaller apparatus.

Exhausters

The actual necessity of an exhauster for drawing gas from the retorts and forcing it through the succeeding apparatus into the holder was made apparent by the adoption to common use of the clay retort. With cast iron retorts, where the leakage was not so great, heats not so high, and the causes of deposition of hydrocarbons not so thoroughly understood, this piece of apparatus, so vital to successful operations of today, was dispensed with.

The advent of the exhauster dates from the first use of the clay retorts, about the year 1820, and its development has been in harmony with other important apparatus. In the early days various types of exhausters were used. Some of them worked like an ordinary pump, some were of a rotating type, some were modifications of the gas meter, while others consisted of one or more gas holders, working in tar, that were elevated and depressed by use of a steam engine. The simplest type of all was the one employing a steam jet effect to pull the gas by injection and force it by ejection.

The Beale exhauster was one of the first to be adopted for common use, which was somewhat similar to the later Mackenzie type that is seen today in some of the American plants. The principle of the reciprocal pumps of the Root and Sturtevant type in common use in the gas works of this country today are too well known to require comment.

The need of washing and scrubbing gas to remove certain impurities was known to Murdock in his early experiments. It is doubtful, however, if he knew the character of the impurities contained, but it is certain that he recognized the necessity of removing certain constituents from the crude gas in order to at least rid

it of its disagreeable odor. His early experiments in purification consisted of washing the gas with water, but how he accomplished this is not recorded.

Washers and Scrubbers

Gas engineers early recognized the necessity of removing from the gas such impurities as tar, ammonia and water vapor, with the minimum reduction of illuminating quality, the accomplishment of which involved much study and experiment. The process at first must have seemed very simple indeed when it was thought that by cooling the gas all liquid matter would be removed therefrom.

First it was found that the quality of the gas was much impaired and later that fresh water was necessary for the removal of the ammonia and some mechanical action necessary for removing the last traces of tar.

The evolution of washing, scrubbing and tar extraction was very gradual and various types of apparatus are described in early books on gas manufacture. Washers, similar in function to the Chollar of today, were much in vogue, while the tower scrubber was the prevailing method of removing ammonia. Afterwards various forms of rotary scrubbers were invented and this type has prevailed to a large extent up to the present time. The Pelouze and Audoin tar extractor, for the removal of tar by mechanical action, came into general use about thirty years ago and has proved one of the most efficient pieces of gas works apparatus. When this apparatus was first introduced in England its use was prohibited due to the claim of English gas engineers that illuminating values were too seriously impaired. This, of course, was due to the lack of knowledge at that time of a necessity for temperature control in the removal of tar.

At the present time the functions of condenser, washer, tar extractor and scrubber are combined in one apparatus, known as the washer-cooler, which may [illegible] stage. The apparatus is [illegible] and the first ap- [illegible] Denver in 1909.

[illegible]

[illegible] sulphuretted [illegible] This [illegible] of the [illegible] discovery of [illegible] the first [illegible] was finally [illegible] the foul [illegible] purifi- [illegible] invented [illegible] was held [illegible] the wet [illegible] latter process [illegible] in the disre- [illegible]

[illegible] oxide of iron [illegible] sulphuretted [illegible] the purification [illegible]

[illegible] discovery of the [illegible] its use was [illegible] the dry lime [illegible] necessitating the [illegible] the iron oxide has no affinity [illegible] quality requirements are not [illegible] the removal of carbon dioxide [illegible] that removed with the ammoniacal liquor, and iron oxide is the universally adopted purifying agent.

The use of iron oxide caused a change to be made in purification methods that also involved the apparatus employed. In using lime shallow beds were necessary, due to the packing of material and its consequent exertion of back pressure. The boxes often had to be refilled every few days, which made the use of small units an advantage. Where the layers of lime could not be more than 12 in. deep the iron oxide sponge could be used in layers as deep as 3 ft. and several such layers arranged in one box. This led to the adoption of larger purifying units, while the property of revivification in the material caused changes in design and construction involving the handling of the sponge in and out of the boxes and during revivification.

Aside from the cheapness and efficiency of iron sponge over lime the most decided advantage was in the elimination of a necessity for housing the purifiers

Fig. 30. Outside Boxes Replace the Costly Purifier House

and at the present time most of the purifying apparatus is to be found out of doors, thereby saving a large construction cost. The present tendency in purifier design is toward the open air tank of cylindrical shape in which units may be added as required at small comparative cost.

A discovery made in the early '80s was the revivification of the iron oxide purifying material in situ. This practice has been generally adopted by all modern gas works and its discovery has proved to be of great benefit from a cost standpoint. The reversal of the gas flow through purifiers was the invention of Mr. Chollar and first adopted by him in St. Louis about 1899.

Many natural oxides have been discovered and are being used extensively in sulphur purification, processes having been perfected for treating the natural ores to rid them of impurities and make them efficient purifying agents. Iron sponge may be purchased of manufactures and dealers ready for use and in most cases they are superior in quality and lower in cost than the home-made material made from rusted iron borings and shaving or crushed corncob filler.

The Station Meter

Samuel Clegg may be called the inventor of the wet meter evolving the device along two lines: first an attempt to produce a revolving gas holder and second to produce a correct measuring device to measure the gas used by consumers. This invention dates back to early in the nineteenth century. Clegg's meter was similar in function to the present wet meter, but many improvements have since been made. John Malam in 1819 describes a wet meter embodying additions and improvements over Clegg's meter. Later Samuel Crosley obtained Clegg's patent rights and made further improvements over both Clegg and Malam. With the exception of the drum Crosley's meter was practically as we know the wet meter today.

The Crosley drum, with minor improvements, was the standard for many years. In 1882 William Parkinson patented in England a drum which proved to be a decided improvement over Crosley's. This drum, known as the Parkinson or three-partition drum, is familiar to all at the present time, but has been supplanted in most wet meters by a more improved and efficient drum known as the Hinman. The Hinman drum was patented by Charles Hinman in 1896 and proved to be a great advance in the correct and economical measurement of gas by station meters. It is now in general use in practically all wet station meters of modern times.

The next decided advance in the metering of gas in bulk, was the appearance of the Rotary Meter, which was first introduced in England in 1903, the inventor of which was the late Thomas Thorp, who was the pioneer inventor of the positive prepayment meter, and also the well known Thorp gauge, which has been in such general use in the United States as well as in Europe and who gained an enviable reputation in the scientific world for numerous practical inventions of instruments

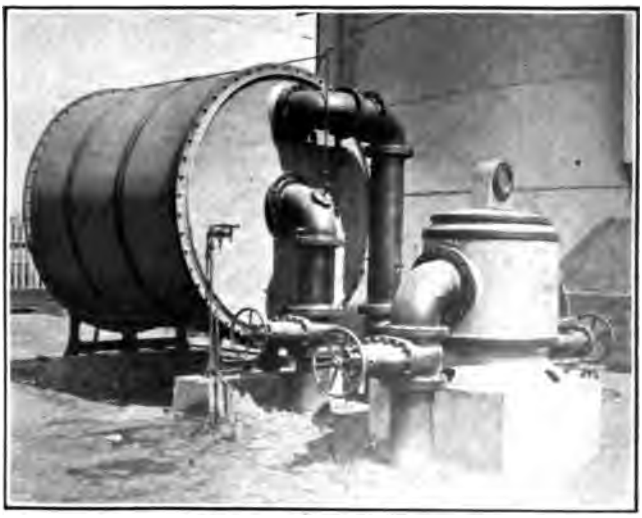

Fig. 31. Wet Station Meter and Rotary Meter

of precision. In 1905, E. C. Brown, while in England, found the Rotary Meter had been introduced into many of the important gas works undertakings of that country, and secured the patents for the United States and Canada. Shorly thereafter he organized the Rotary Meter Company, which has built and installed these meters in most of the important gas works of the country; and, in addition, many of these meters of very large capacity have been introduced into some of the largest

was given the name of gasometer by the inver
had designed it to be a measurer of gas rathe

Fig. 32. An Olden-time Pole Climbing Holde

means of storage. In the simple form as inve
as substantially the same as the holder of to
:pt on a much smaller scale

[redacted]

of the gas industry requiring larger holders caused the adoption of other materials in constructing the tanks. Brick work, masonry, concrete, and even cast iron, was then used, with the tank usually below the surface of the ground. This style of tank has now given way to the steel tank which is usually constructed for the most part above ground.

The first cylindrical holder was built about 1817 in Chester, England, and was 35 ft. in diameter. In 1840

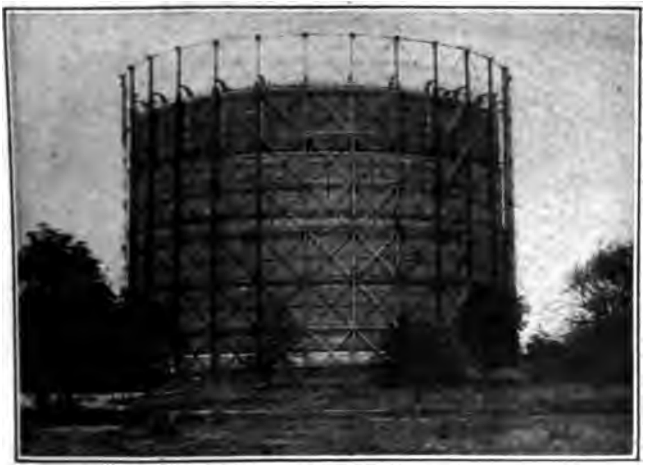

Fig. 33. A Modern Type of Storage Holder

the first telescopic or multiple lift holder appeared, which was 60 ft. in diameter and 36 ft. high, having a capacity of about 100,000 cu. ft. In 1847 a holder was built in London 100 ft. in diameter and shortly thereafter two more were built 200 ft. in diameter and having a capacity of 2,000,000 cu. ft. each. In 1874 a holder of 3,000,000 cu. ft. was erected, followed shortly by one of 5,500,000 cu. ft. Holder sizes continued to increase until about 1890, when the large 12,000,000 cu. ft. unit in East Greenwich was erected. It remained for the

United States to surpass this by the erection of the 15,000,000 cu. ft. holder at the Astoria plant of the Consolidated Gas Co. of New York some fifteen years ago, which has not been exceeded at this time.

From the square tank of Lavoisier inverted in another tank of water and the first cylindrical tank 35 ft. in diameter to the massive Astoria holder is a wide step

Fig. 34. Compressed Air Replaces the Hammer in Calking

covering a period of little more than a century, but it is typical of the growth and progress of the gas industry in that time and is shown by a similar development in all other lines of the business.

In the early days of the gas business various substances were used for main piping. The first were of wood made by drilling a hole of the proper size in a

Fig. 35. The Pick-and-Shovel Street Trenching Gang

log and using a sort of a spigot joint. Earthen pipes or tile were also used to some extent, but resulted in failure. Cast iron pipe was in service in Versailles,

Fig. 36. Trench Excavation by Machinery

France, as water pipe in 1664 and was first used for gas early in the nineteenth century. It soon became the prevailing kind of main and by development has remained so to the present time.

Mains and Services

Tinned and lead pipes were used for services in the early days, although it is said that the first services

Fig. 37. The First New York Gas Main and Valve

were made of old gun barrels screwed together. In 1812 an Englishman by name of Osborn patented machinery for welding gun barrels and other cylindrical articles and in 1824 James Russell filed an improvement on the process. This was the beginning of the manufacture of wrought iron pipe and was developed

gely through the requirements of the growing gas lustry. The first furnace for making butt welded pe in the United States was built about 1834 in Philadelphia. The first material used for making gas pipe vas wrought iron and this was generally used until the

Fig. 38. Valve Recently Turned Out by a Works Builder

latter part of the '80s when steel pipe appeared. In the beginning this steel pipe was not an entire success and in 1890 only about 5 per cent of the pipe manufactured in the United States was steel. New developments and discoveries, however, perfected this kind of pipe until at the present time approximately 90 per cent of all welded pipe manufactured is steel.

The use of increasing high pressures and the inven-

Fig. 39. The Old Way of Threading Pipe

Fig. 40. Now Gasoline Power Threads the Pipe

tion of the autogenous welding process in recent years have greatly influenced the use of steel pipe for gas mains and there is a growing tendency toward the adoption of this kind of pipe where permanency is one of the predominating factors.

Mains and services of the early period were of small size which, as the industry grew, required frequent replacement. It is only within recent years that means have been adopted of increasing pressures rather than continuing the enlargement of mains. As pressures cannot practically be increased to suit any required volume of gas through any size of pipe it is still necessary, however, to employ large sized mains under high

Fig. 41. Compressed Air Breaks Up Paving Over Trench

pressure, which still requires frequent enlargement of pipes. The largest gas mains in the United States are those carrying gas from the Astoria plant into New York, which are 72 in. in diameter.

Pressure

As explained elsewhere in this book distribution systems and pressures carried are in most cases the result of evolution. Pressures used in the early days than illumination and the means thereby furnished of making possible the stupendous progress noted in the statistics that follow.

Gas ranges were made in London as early as about the year 1840, but it is recorded that they were not appreciated by the public and success was not had by the firm engaging in their manufacture. In 1851 Goddard improved this appliance and the attempt was again made to interest the public, but without success. In 1857 an English engineer by name of Somerville made the third attempt by hiring the stoves out to the consumers and is said to have met with a success that was the beginning of the use of gas as fuel.

Fig. 45. Baltimore Meter Repairer of the Olden Days

The cost of gas in comparison with other fuels restricted its use for many years and it has been within the last twenty years that the development in manufacture and distribution, coupled with the inauguration of commercial or sales developments, has allowed a reduction in price which put gas in open competition with other fuels and made possible the wonderful growth of the business in these few years. There is scarcely a gas man of today who is not familiar with this development, having passed through it and contributed his share toward the common end, namely, the success of the industry.

Rates

Quite as much improvement has been made in rates as in any other phase of the gas business and it is

Fig. 46. Meter Man of To-day and His Special Car

given the same attention by modern companies. The first gas consumers must have been charged on a flat rate as the meter was not perfected until some years after the birth of the gas industry. Even after the meter came into general use its accuracy was unsatisfactory and much trouble must have been experienced in adjustments at that time. In 1872 George Livesey, in England, first proposed the sliding scale rate, which met with considerable opposition from the gas companies, who could not at that time see the relation between output and price. It was finally adopted in 1875 and met with a great deal of success. The readiness-to-serve rate is of quite recent origin and embodies within its terms the factors which go to make up the expenses of the company. First there is a consumer's charge which takes into consideration the fixed expense of the company and is the same in all cases regardless of the amount of gas consumed. The second is a demand charge, which is based upon the instantaneous demand occasioned by the consumers' appliances and which regulates the size of main, service, and meter. Third there is a consumption charge of so much per 1,000 cu. ft. of gas consumed, the rate usually being considerably lower than the regular meter rate in order to encourage large consumption. As this rate penalizes high demands without large consumption it discourages disuse or partial use of appliances connected and at the same time encourages large consumption by lowering the net cost per 1,000. This rate is especially applicable to industrial consumers and large users of gas, but is usually prohibitory to the small domestic consumer. In order to find the turning point or amount of consumption per month where the net cost is the same for the readiness-to-serve and meter rate the formula is:

$$X = \frac{A + B}{C - D}$$

Where A equals the consumer's or fixed charge.
Where B equals the demand charge.
Where C equals the meter rate.
Where D equals the readiness-to-serve consumption rate.
Where X equals the amount of gas per month.

As the consumption of gas is increased beyond this figure for the same appliances connected the rate per 1,000 cu. ft. is automatically lowered. This rate, therefore, has all of the advantages of the sliding scale rate with the additional advantage to the company of affording the proper revenue for investment and fixed expense. Contracts under such a rate should not be signed up for a shorter term than one year as a protection to the investment necessary to give service.

Residuals

The chief residuals of gas manufacture are coke, tar and ammonia, but lately two other by-products have claimed the general attention of the gas industry, namely, toluol and cyanogen.

Fig. 47. Typical Emergency Car of To-day

There was a time in the gas business when tar and ammonia were a nuisance around the plant and where possible were run into the river, while coke was used with ashes to fill up the yard. That time of course has now passed and the marketing of residual products is quite as important as the sale of gas.

Coke has taken the place of coal in a great many operations and a ready market is found for all produced. The problem of storage during times of slack demand has in a large measure been mitigated and few companies are now able to supply the complete demand.

Sizing plants are installed in practically every gas works and the product supplied as required.

The ammonia produced from coal gas manufacture represents the largest source of production of this article. It is always readily marketable and at the present time the demand exceeds the supply. Most gas works maintain concentrators, increasing the strength of liquor from about 2 per cent strength as produced to 15 per cent as sold. Ammonia is generally marketed by the gas companies in the form of concentrated liquor, the buyer usually being chemical works who dispose of the product in other forms.

Tar commands a ready sale and is used in a multitude of forms. Its derivatives are innumerable and some of the larger companies operate distillation plants in conjunction with the gas works whereby a greater profit is made than through the sale of the raw tar. The copper flotation process using coal tar is a recent invention that created a large demand.

A great deal of work is being done at this time toward the recovery of toluol from gas. A large number of plants are now in operation, with more in contemplation. The demand for this article is so great that its recovery is receiving the attention of the most eminent engineers in the country.

Consumers' Meters

Samuel Clegg receives credit among his other great achievements of being the inventor of the meter which is previously mentioned under the heading of station meters. His meter was of the wet type, which was the kind of consumer's meter used for a number of years after the beginning of the gas business. The wet meter for use as a consumer's meter had so many disadvantages that it was generally superseded upon the invention of the dry meter.

The dry meter was first patented by John Malan in 1820 and the one now universally employed was patented by Richards in 1844. As with the wet meter improvements were made from time to time, and are still being made; however, the principle of the dry meter is the same today as it was seventy years ago.

The greatest improvement to the dry meter was the bringing out in 1904 of the high capacity "B" meter now so generally used. This meter was first put on the market by the Maryland Meter Co. of Baltimore and has proved to be almost the last word in consumers' meters. The Sprague iron meter was put on the market in 1900 and also proved to be a great innovation in supplying a meter of practically every feature embodied in the tin meter with the advantage of the cast iron case for withstanding hard service and usage.

Statistical

The following figures reproduced from the report of the United States Geological Survey show very conclusively the progress in the manufactured gas industry:

Average Capacity of Manufactured Gas Plants

Year	Kind of gas	Sales, M. cu. ft.	No. plants	Sales per av. plant, M. cu. ft.
1898	Coal gas........	18,431,201	433	42,566
1902	Coal gas........	25,069,000	522	48,024
1903	Coal gas........	25,670,000	514	49,942
1904	Coal gas........	30,109,449	514	58,579
1905	Coal gas........	30,722,279	508	60,477
	Oil and water gas	77,412,025	477	162,289
1907	Coal gas........	34,302,954	493	69,580
	Oil and water gas	94,634,603	520	181,990
1908	Coal gas........	37,355,886	482	77,502
	Oil and water gas	103,347,497	552	187,224
1912	Coal gas........	35,202,124	424	83,024
	Oil and water gas	122,697,796	604	203,142
1915	Coal gas........	43,747,432	396	110,473
	Oil and water gas	138,100,902	646	213,778

Manufactured Gas Consumed in U. S. by Kinds

Year	Kind of Gas	Sales. M cu. ft.	Value	Av. price. M. cu. ft.
1898	Coal gas......	18,431,201	$21,502,295	$1.17
	Water gas.....	30,418,987	....	....
	Oil gas........	497,016	....	....
	By-product gas	3,620,673	....	....
	Total.......	52,967,877	....	....
1902	Coal gas......	25,069,000	....	....
	By-product gas	4,010,074	....	....
	Total.......	....	29,342,881	1.01
1904	Coal gas......	30,109,449	....	....
	By-product gas	4,705,542	....	....
	Total.......	....	32,090,998	0.92
1905	Coal gas......	30,722,279	....	....
	By-product gas	9,731,936	....	....
	Total.......	....	32,937,456	0.81
	Oil & water gas	77,412,025	78,072,500	1.01
	Total.......	117,866,240	$111,009,956	....
1907	Coal gas......	34,302,954	33,331,465	0.97
	By-product gas	20,516,731	3,130,839	0.15
	Oil & water gas	94,634,620	90,173,112	0.95
	Total.......	149,454,305	$126,635,416	....
1908	Coal gas......	37,355,886	34,670,418	0.93
	By-product gas	16,205,925	2,557,483	0.16
	Oil & water gas.	103,347,497	96,343,221	0.93
	Total.......	156,909,308	$133,571,122	....
1912	Coal gas......	35,202,124	32,031,367	0.91
	By-product gas	54,491,248	4,650,517	0.09
	Oil & water gas.	122,697,796	111,600,841	0.91
	Total.......	212,391,168	$148,282,725	....
1915	Coal gas......	43,747,432	40,257,108	0.92
	By-product gas	84,355,914	8,624,899	0.10
	Oil & water gas.	138,100,902	124,950,125	0.90
	Total.......	266,204,248	$173,832,232	....

[redacted]

Manufactured Gas Consumed in the U. S. in 1915

Kind	Illumination, M. cu. ft.	Domestic fuel, M. cu. ft.	Industrial fuel, M. cu. ft.
Coal gas.........	14,345,059	24,204,443	5,197,930
Water gas......	47,816,398	65,920,911	10,392,260
Oil gas.........	1,438,990	12,273,252	359,091
By-product gas..	17,196,426	27,590,624	39,568,864
Total.......	80,796,873	129,889,230	55,518,145
Per cent of total	30%	49%	21%

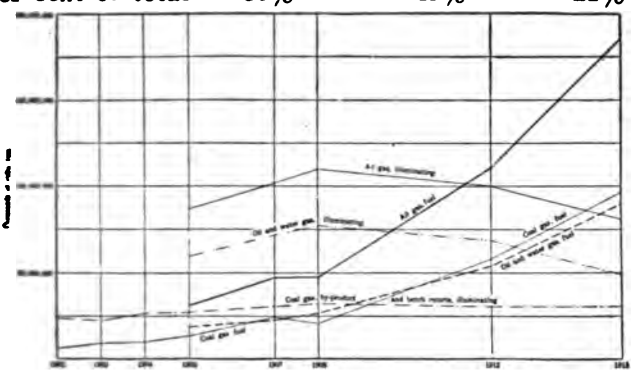

Fig. 48. Increasing Importance of Gas for Fuel

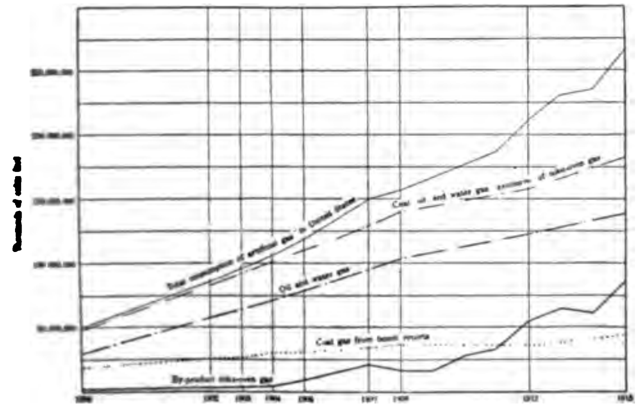

Fig. 49. Comparative Production of Various Gases

Total and Per Capita Gas Consumed in U. S.

Year	Illuminating, M. cu. ft.	Fuel, M. cu. ft.	Total, M. cu. ft.	Per capita, cu. ft.
1905....	**86,349,641**	**31,516,599**	**117,866,240**	**1,286**
1907....	**102,088,386**	**47,365,921**	**149,454,307**	**1,477**
1908....	**109,290,117**	**47,619,193**	**156,909,310**	**1,582**
1912....	**100,000,321**	**112,390,847**	**212,391,168**	**1,655**
1915....	**80,796,873**	**185,407,375**	**266,204,248**	**1,809**

		Per cent
Increase in gas consumed..........	1915 over 1905	**126**
Decrease of illuminating gas.......	1915 over 1905	**7**
Increase in fuel gas...............	1915 over 1905	**500**
Increase in per capita consumption..	1915 over 1905	**40**
Per cent of total used for illumination in 1905....		**73**
Per cent of total used for illumination in 1915....		**30**
Per cent of total used as fuel in 1905.............		**27**
Per cent of total used as fuel in 1915.............		**70**

From the foregoing tables it is shown that in **1915** the increase in percentages of manufactured gas consumed over 195 were:

	Per cent
Coal gas	43
By-product gas	770
Oil and water gas......................	80
Total	166

Value of Manufactured Gas and By-products in 1915

Kind of gas	Gas	Coke
By-product	$8,624,899	**$48,558,325**
Coal	40,257,108	**7,198,377**
Water	112,281,956	....
Oil	12,668,169	....
Total.............	$173,832,132	**$55,756,702**

Tar	Ammonia	Other residuals	Total
$3,568,384	$9,867,475	$7,763,821	$78,382,904
1,555,363	1,329,651	53,488	50,393,987
1,118,656	....	68,351	113,468,963
4,268	....	174,659	12,847,096
$6,246,671	$11,197;126	$8,060,319	$255,092,950

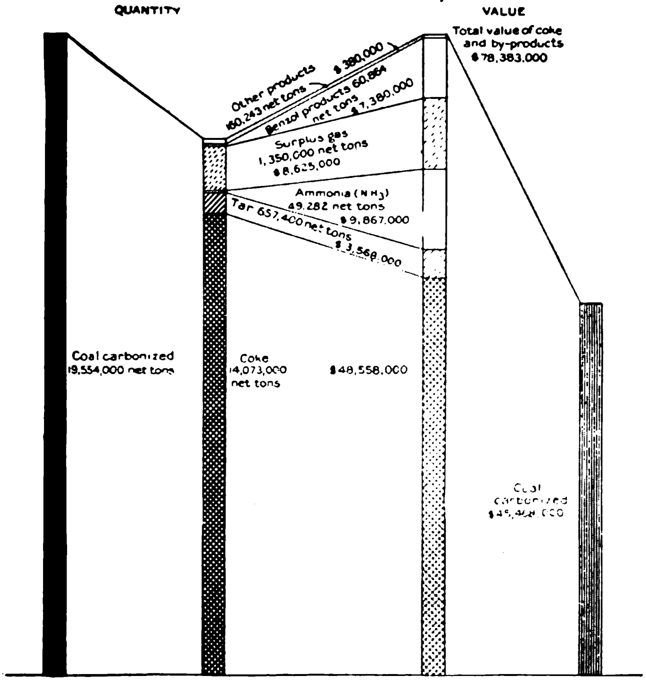

Fig. 50. Conversion of Quantity and Value Through By-product Coking

The Department of Commerce in its 1914 census of manufactures gives the number of persons engaged in the manufactured gas industry as 63,993 as compared with 28,363 in 1899, 40,043 in 1904 and 51,007 in 1909.

The number of establishments is given as 877 in 1899, 1,019 in 1904, 1,296 in 1909 and 1,284 in 1914. The capital invested was:

1899	$567,000,506
1909	915,536,762
1914	1,252,421,584

(The latter figures are probably inaccurate and only indicate the general condition.)

The miles of main in the United States in 1909 was 45,119 and in 1914, 58,727.

CHAPTER II

GASES AND THEIR PROPERTIES

The word "gases," in its full meaning, includes air and all of the gaseous elements and compounds known to man, but in this heading it refers only to the various kinds of so-called "illuminating" gases, manufactured or produced for utilization by the public in the production of light and heat for domestic and industrial purposes.

Kinds of Gases, Characteristics

Of the different kinds of gases manufactured or produced for commercial purposes in the United States, those of greatest importance are coal gas, carburetted water gas, oil gas and natural gas, the first three being designated as artificial gas to distinguish them from the latter.

Coal Gas is the gas resulting from the destructive distillation of bituminous coal, at high temperature, in a retort or oven externally heated. Under efficient operating conditions, using a good grade of gas coal, there should be obtained from each ton of coal carbonized 10,000 cubic feet of gas having a heating value of 550 B.t.u. and illuminating value of 15 candles, 12 gallons of tar, 4½ pounds of ammonia and 1,300 pounds of coke. Of the coke residual, 300 pounds would have to be used as furnace fuel to heat the retorts, for each ton of coal carbonized.

Coal gas is usually the most profitably manufactured of the artificial gases, due to the credit obtained from the sales of the by-products produced; but, owing to municipal or state regulation of heating value and candle-power, it is generally necessary to employ some method of enrichment whereby these qualities are increased.

The most common form of enrichment is by the mixture of a proportion of carburetted water gas with the coal gas, which brings the "mixed" gas to the proper quality to meet requirements.

Carburetted Water Gas is a gas produced by decomposing steam by contact and union with carbon at a high temperature, then adding to and mixing with a certain proportion of oil gases, the richness of the gas depending upon the proportions in which the water gas and oil gas are mixed.

It can be seen by this description that a wide range of luminosity and corresponding heating value may be obtained in this gas, which make it a most simple and flexible means of meeting quality requirements.

Carburetted water gas is usually made from gas coke, although anthracite coal is a superior fuel for this purpose, due to its lower cost. Good operating results should show a fuel consumption of 30 to 35 pounds of coke per 1,000 cubic feet of gas made.

The oil used is what is known as "gas oil," which is a petroleum distillate. The results obtained from an oil depend primarily upon its specific gravity and composition, but an average production of 1,000 cubic feet of gas, using three gallons of oil, should be considered good. The illuminating value of this gas would be about 20 candles, and heating value about 640 B.t.u.

In the manufacture of coal gas the operation must be constant, as the retorts and settings are injured by bringing up and letting down "heats," as would be necessary were the make of gas inconstant. A water gas machine, however, may be brought up to heat from "stone cold" in an hour's time, and may be let down and brought up innumerably without injury to any part of the apparatus. For this reason it is common practice in plants making both coal and water gas to maintain a certain constant make per day of each kind of gas in the proper proportion to meet quality requirements, with a fluctuating quantity of water gas to meet varying sendouts.

One man with a helper may make as much water gas as fifteen men in the coal gas plant, where hand-stoking is employed; but as there is scarcely any residual credit; the cost of the gas generated, which is practically that of the gas making materials, is higher in most cases than coal gas. As gas oil is subject to erratic fluctuations in market price, and in this day and age a contract of any length is a curiosity, it is practically impossible from an economy standpoint, unless the plant is located close to the oil supply, to readily operate a straight water gas plant. Few cities have both coal and water gas equipment of ample capacity to supply their demands, so that they are prepared to meet any conditions that may arise, favorable or unfavorable, to the manufacture of either kind of gas, for while water gas has its conditions of oil shortage or high price, coal gas is not entirely without its troubles, as there are coal strikes, railroad troubles, mild winters effecting coke sales and labor troubles at the gas plant, which, due to the difference in number of men employed, falls heaviest upon the retort house, which effects the cost or difficulty of production of coal gas. Therefore, the manager who has the combination plant is the one who sleeps best at night and has the fewest gray hairs. At the present time one of the largest gas companies in the United States, which up to this time made nothing but water gas, is building a coal gas plant.

Oil Gas is the least used of the artificial gases under consideration. Strictly speaking, it is the gas resulting from the destructive distillation of oil (liquid hydrocarbons). Pintsch gas, which is used in coach lighting, and Blau gas (liquid), which is used for domestic purposes, are the principal kinds of pure oil gas; but under the heading of oil gas must be included that manufactured and used in California and other Pacific Coast states, which is no small industry.

The Pacific Coast oil gas is made by a process similar to the manufacture of carburetted water gas, except that oil instead of solid fuel is used to heat the apparatus. In Pintsch and Blau gases the heating value ranges from 1,350 to 1,500 B.t.u., and the candle power from 50 to 60 candles. The California oil gas has an average heating value of 680 B.t.u. and illuminating value of 20 candles. It is made from crude oil obtained in the fields close to the point of manufacture, so that a low price prevails. Gas coal is not found in the coast states, and oil gas is of necessity the prevailing kind. A large quantity of lamp black is produced in the manufacture of California oil gas, which is made into briquets, constituting a valuable by-product.

Natural Gas, as the name implies, is produced directly from the earth by means of wells drilled to the subterranean cavities where it exists. It is usually found in the same localities as petroleum. The greatest producing gas fields in the United States are in Pennsylvania, West Virginia, Ohio, Kansas, Oklahoma, Louisiana and Texas, although natural gas is found in varying quantities in nearly every state in the Union. The chemical composition and characteristics of natural gas more nearly resemble coal gas than either of the others, both being high in methane (marsh) gas. The gas comes from the earth under a varying pressure, depending upon the rock pressure exerted, which decreases gradually if the well is under constant flow, until it becomes necessary to install compressors to force the gas through the pipe lines to the consumers. Some wells will show a great production of gas for a short while and then cease flowing entirely, proving that a pocket has been tapped and exhausted. Natural gas is piped from the field to cities several hundred miles away, and sold in competition with artificial gas produced in the city.

Properties of Gases

Illuminating gases are produced and marketed for the purpose of supplying the public with an efficient source of light and heat at a reasonable price, as compared with other fuels and light-producing substances. Therefore, the most important considerations in gases are their heating and illuminating values. The standard unit of heat in the United States is the British thermal unit (B.t.u.), which is equivalent to the heat necessary to raise one pound of pure water through one degree. It is customary to express the heating value of gases in B.t.u. per cubic foot, while solid substances are expressed in B.t.u. per pound. When we say, "The heating value of coal gas is 550 B.t.u.," it means that each cubic foot of the gas contains heat energy capable of raising the temperature of 550 pounds of water through one degree F.

The illuminating value of a gas is expressed in candle power (c.p.) A standard candle power is the illumination of a spermacetti candle of six to the pound burning at the rate of two grains per minute. The candle power of a gas is its equivalent illuminating value, as compared to that of a standard candle, when burned in a standard burner at the rate of five cubic feet per hour. The statement, "This is a 16-candlepower gas," means that the illuminating value of the gas in question, when burned at the rate of five cubic feet per hour in a standard burner, is equivalent to the illuminating value of 16 standard sperm candles of 6 to the pound, each burning at the rate of two grains per minute.

CHEMICAL PROPERTIES

A chemical analysis of the four kinds of illuminating gases under consideration will show that they are composed of practically the same constituents, but in different proportions. Upon these constituents, and the proportion in which they are contained, depend the heating and illuminating value of the gas. Some of the constituents have no heating or illuminating values, and are therefore undesirable, yet it is not economical or practical to eliminate them entirely; others have a heating value but no illuminating value, while the most desirable have both a high heating and a high illuminating value. It is possible to manufacture an oil gas of three times the heating and illuminating value of coal gas, due to the large proportion of desirable constituents, but the cost of such a gas is prohibitive for ordinary commercial use. It can therefore be stated, in a general way, that the cost of gas varies in proportion to its heating and illuminating value.

The following show average composition of the various gases:

Coal Gas. (Trustees Gas Ed. Fund)

Carbon Dioxide (CO_2)	1.60%
Oxygen (O_2)	0.39%
Heavy Hydro-Carbons (C_2H_4)	4.25%
Carbon Monoxide (CO)	8.04%
Hydrogen (H_2)	47.04%
Methane (CH_4)	36.02%
Benzine Vapor (C_6H_6)	0.50%
Nitrogen (N_2)	2.16%

Carburetted Water Gas. (Trustees)

Carbon Dioxide	2.70%
Oxygen	0.70%
Heavy Hydro-Carbons	12.80%
Carbon Monoxide	30.70%
Hydrogen	32.40%
Methane	13.90%
Higher Paraffins	2.40%
Benzine Vapor	0.60%
Nitrogen	3.80%

California Oil Gas. (Jones)

Carbon Dioxide	2.62%
Carbon Monoxide	9.21%
Oxygen	0.16%
Hydrogen	39.78%
Methane	34.64%
Nitrogen	6.58%
Higher Paraffins	7.01%

Oil Gas, Pure. (Trustees)

Hydrogen	12.44%
Unsaturated Hydro-Carbons	35.65%
Saturated Hydro-Carbons (Ethane, Methane)	45.37%
Carbon Dioxide	0.74%
Oxygen	2.00%
Nitrogen	3.20%
Carbon Monoxide	0.60%

Natural Gas. (Westcott)

Hydrogen	3.00%
Methane	92.00%
Ethane (Olefiant Gas C_2H_4)	3.00%
Nitrogen	2.00%

The natural gas composition varies considerably with different fields. The above is a Pittsburgh gas.

A brief description of the various constituents follows:

Hydrogen (H_2).—Hydrogen is a colorless, odorless, non-poisonous gas, and the lightest substance known. It is very combustible, burning with a pale-blue flame. It has no illuminating value. Its heating value is 324 B.t.u.

Olefiant Gas (Ethane, C_2H_4).—This is a gas possessing great illuminating value, and is the principal illuminating constituent of coal and water gas. It possesses the very high heating value of 1,578 B.t.u. It is colorless, odorless and burns with a very luminous, smoky flame.

Methane (Marsh Gas, CH_4).—Methane is a colorless, odorless gas, and derives its name, Marsh Gas, from the fact that it is frequently produced by the decay of plants in swamps and the bottom of rivers. It is the principal constituent of natural gas and one of the principal ones of coal gas. It has a heating value of 1,003 B.t.u. and burns with a pale-yellow flame.

Carbon Monoxide (CO).—Carbon monoxide is an odorless, colorless and very poisonous gas, insoluble in water. It is one of the principal constituents of carburetted water gas, being produced by the decomposition of steam in the presence of incandescent carbon. It burns with a distinctive pale-blue flame. Its heating value is about the same as hydrogen, being 322 B.t.u. It has no illuminating value.

Carbon Dioxide (CO_2).—Carbon dioxide, or carbonic acid, is a colorless, odorless gas, soluble in water. It is non-combustible and will not support combustion. It is, therefore, valueless in gas for heating or illumination.

Oxygen (O_2).—Oxygen is a tasteless, odorless, colorless gas. It composes about one-fifth of the volume of the atmosphere. It is the support of combustion and all animal life. It is not of value in an illuminating gas.

Nitrogen (N_2).—Nitrogen is a colorless, odorless gas, which is non-combustible and will not support combustion. It composes practically four-fifths of the atmosphere. Its principal value is as a dilutent, as were it to be suddenly removed from the atmosphere there would be no control over combustion, while all animal life would quickly cease from the effects of breathing pure oxygen. It has no value in an illuminating gas.

Hydrogen-Carbons.—There exist about 200 hydrocarbons, which, as the name implies, are compounds consisting of hydrogen and carbon. These compounds exist in gaseous, vaporous and solid states. They are, in the gaseous state, the principal illuminating constituents of any illuminating gas.

Reasons Influencing the Selection of Process

Gas is a commodity, and as such is produced and delivered to the consumer by gas companies. The gas company expects, and is warranted in receiving, a fair return from the money invested in its plant and distribution equipment. The more gas a company can sell, the cheaper it can be produced and distributed and, therefore, sold. Conversely, the lower the selling price the greater the sales. A great number of cost elements enter into the production and distribution of gas, from the time the raw gas-making materials are unloaded from the cars until the gas passes the consumer's meter. Collectively, these elements may be grouped into four general heads: Cost of production, cost of distribution, cost of customer, and cost of general operation. For artificial gases, of the cost elements the the former is usually very nearly equal to the other three combined, therefore being of greater importance, as upon it must depend to a large extent the profits made from the sale of gas.

The principal item of production cost is the raw gas making materials, which is largely due to transportation charges thereon.

The price at which gas can be sold therefore depends principally upon the cost of production, which in turn is dependable upon the cost of gas making materials, and that upon transportation charges. Transportation charges are usually directly proportional to the distance transported, but not always so.

Coal Gas.—All coals are not suitable for gas making purposes. A coal to be a good gas coal must be a coking coal, high in fixed carbon and volatile matter, and low in ash and sulphur content.

An analysis of a good gas coal should show:

Gas-Coal Analysis

Fixed carbon	60%
Volatile matter	35%
Ash	Less than 5%
Sulphur	Less than 1%

As considerable profit is obtained through the sale of gas coke as a by-product of coal gas manufacture, the coking qualities and carbon content are very important.

Upon the volatile matter contained depends the amount of gas and tar obtained.

Ash being valueless is an undesirable constituent which adds weight to the coal and afterward the coke.

Sulphur is also an undesirable constituent which must be removed from the gas before distribution.

Where gas coal is mined at a distance sufficiently close to a gas plant that transportation charges are not prohibitive, coal gas may be manufactured at a cost below that of carburetted water gas or oil gas. This is a majority condition.

As gas coal is not found in close enough proximity to all gas plants it is not so profitable to manufacture it in all cities, however.

Carburetted Water Gas.—It is usually advantageous to manufacture some water gas in all plants for enriching coal gas and to compensate varying sendouts. It has many advantages as an emergency gas, such as simpleness of operation, small labor requirements, rapidity of putting into operation and amount of gas that can be made. It cannot economically be manufactured exclusively, unless the plant is located close enough to the source of the gas oil used, that transportation cost will not be too great or is so far away from a gas coal supply that its cost is prohibitive. Gas oil, itself, is subject to fluctuating prices, while transportation is always high, the rate charged being due to the inflammability of the oil.

In some cities illuminating quality requirements are so high that the manufacture of water gas is almost compulsory.

Oil Gas.—Pintsch and Blau gases are the two principal pure oil gases manufactured, both being subjected to a high pressure, in order that large quantities may be stored in tanks for transportation to the place of consumption.

Pintsch gas is principally used for lighting railway coaches, while Blau gas is used in isolated buildings, such as farm houses, etc., where the distance is too great to be supplied from city mains.

The gas manufactured on the Pacific Coast is the most important of the oil gases. It is used exclusively in California and to a large extent in Oregon and Washington. Close proximity to the source of oil production, the use of crude oil and scarcity of gas coal influence its manufacture in these states.

Natural Gas.—The principal cost, where natural gas is supplied, is in its transportation from the well to the consumer. Production operating expense is almost negligible so that this gas is often carried distances of several hundred miles. The equivalent production and plant costs of artificial gas can, in the case of natural gas, be used in installing and operating pipe lines, so that cities in close proximity to gas fields can be supplied at a lower rate than competing artificial gas. The reasons influencing adoption of natural gas would be strictly a matter of the distance of a city from an adequate natural gas supply.

The effect of changing from one kind of gas to another of greatly varying heating value is analogous to changing the pressure of a gas, and must be accompanied with a readjustment of the gas consuming appliance. The reason is apparent through the fact that with gas of high heating value a smaller quantity is required to accomplish a given purpose. For this reason a gas company, even where there are no municipal regulations, strives to maintain a constant heating value and therefore keeps its appliances in good adjustment.

Impurities, Effect Upon Distribution and Use

Crude gas contains a number of impurities which must be eliminated, or practically so, before the gas is fit for utilization by the consumer.

In the production of illuminating gas the theoretical object is to put the gas into the distribution mains in such form that no impurities or troublesome substances will exist. From a practical standpoint this is not possible, the object aimed at and usually attained being to limit the quantity of impurities contained in the distributed gas to a range where little or no trouble is encountered during distribution or utilization.

Provisions are then made for the possible handling of the impurities contained in the gas, without their becoming a nuisance or an interference to the continuity of service to the consumer.

The word impurity is herein used to designate any substance in a gas foreign to its ideal composition, whereby effects may be produced contrary to its perfect delivery to and consequent consumption by the consumer. The chief impurities which the fitter may

of the gas decreases. The last traces of tar are usually removed from the gas by some form of mechanical extractor.

Tar would cause very serious trouble if allowed to remain in the finished gas until it reached the distribution system, by stopping the main and service pipes. These stoppages would prove very obstinate to clear and would necessitate either putting in new pipes or heating the tar until it could be removed. They would occur to the greatest extent comparatively close to the plant, as the gradual reduction of temperature in the moving gas would eventually condense the tar all into liquid form, and if continued long enough, prove a complete obstruction to the passage of gas.

Ammonia (NH_3).—Ammonia is a colorless gas, with a very pungent odor. It is alkaline and has a destroying effect upon brass and even wrought iron. It is a valuable by-product of coal gas, but is not contained to any extent in carburetted water gas or oil gas. It is evolved in the production of coal gas through the union of nitrogen and hydrogen contained in the coal and is present in the first stages of production in the form of gas, being absorbed as the water vapor contained in the crude gas is condensed, in proportion to the quantity of water vapor and its temperature.

It is usually possible to remove all but a trace of ammonia from the finished gas through its great degree of solubility in water. If present in the finished gas to any great extent it attacks and corrodes brass gas fixtures, lamps and meter parts, and in large quantities would even destroy the wrought iron pipes used in conveying the gas.

Carbon Dioxide (CO_2).—This gas, which was heretofore described, is usually present in small proportions in the finished gas. Its chief effect is to act as a dilutent with a lowering of heating and illuminating values. If present in large quantities it might prove a hazard by extinguishing burning gas. It may be classed as an impurity in the same sense as nitrogen, which is also usually present in an illuminating gas in small quantities. No attempt is made in this country for its removal except that which is removed indirectly in other purification processes. The maintenance of a heating and illuminating standard by practically all companies eliminates the chance of its proving a detriment to the consumer.

Sulphur Compounds.—Sulphur compounds are present in crude gas in proportion to the amount contained in the coal, oil or coke from which the gas is made. The most important of the sulphur compounds is sulphuretted hydrogen (H_2S), which composes the greater portion of the total sulphur contained. This is a very obnoxious substance, easily proven by breaking a decayed egg, of which it is a noticeable constituent.

The distribution department should seldom encounter trouble from this source, as it would first be noted at the plant, where test lights are, or should be, maintained and frequent tests made for H_2S. Excessive quantities of sulphur in the finished gas would be noted first by the offensive odor given off by the burning gas; this usually brings in a large number of leak complaints from the consumers. It would also cause trouble by coating the gas mantles, stopping up pilots and burner nozzles and finally, if continued, contribute toward stopping the pipes themselves.

Water Vapor.—Water vapor is present in any gas which comes in contact with water during any stage of its manufacture, to the point of saturation at its existing temperature.

A full discussion of this subject, which in distribution is known as condensation, will appear later.

Naphthalene.—While classed as an impurity this is a valuable illuminant if conditions are favorable to its remaining in the form of a vapor until combustion of the gas occurs, but as there are certain seasons of the year when this cannot be done, precautions must be taken to prevent its becoming the most common source of trouble in the distribution department. In the early days of gas manufacture, and in fact until recent years, naphthalene was considered as a worthless substance and the bane of the gas man's life, the thing which caused him more worries than any other part of his daily work. Many were the schemes tried out for its elimination, which appear ludicrous now, but not much success was had until the modern gas man took

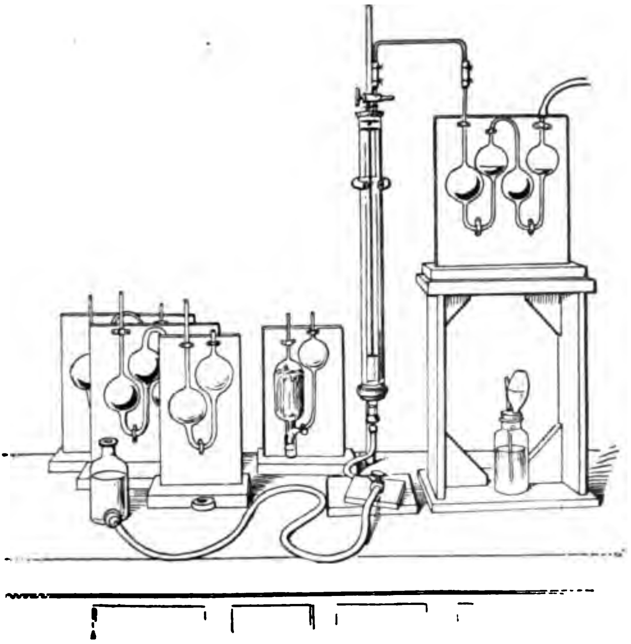

Fig. 52. A Typical Gas Analysis Outfit

to paying attention to the temperature of tar extraction, since which time naphthalene has ceased to be a "bugbear," and in some plants is a curiosity, anywhere but in the tar well, where it has become recognized as a valuable coal tar product, especially since the outbreak of the European war opened up great possibilities in this field.

Naphthalene is a hydrocarbon produced, in the manufacture of gas, by high temperatures during generation. It is more often produced in coal gas manufacture, although it is not impossible to produce it in water and oil gas generation. As its production is due to high temperatures, which are favorable to a large yield of gas, it is apparent that the two must bear relation to each other. If high yields are obtained naphthalene will be produced. Naphthalene is a source of trouble over which the distribution department has no control. This department may remove the evil, but if the root is not killed, which is located at the gas plant, repetition will certainly occur. The plant superintendent wants to make all the gas he can out of the materials given him. In doing so he makes naphthalene which must be removed at the plant or serious trouble is inevitable in the distribution department. In the present day and age there is no excuse whatever for serious naphthalene stoppages in the mains and services, unless the result of an accident at the plant.

The physical property of naphthalene changes with temperature from a vapor at higher temperatures to a liquid or solid at lower ones. The form most commonly encountered by the fitter is the flake naphthalene, which resembles pieces of mica; these crystals, when deposited in a pipe or fitting, adhere to each other, forming annular deposits until the pipe is completely stopped. The deposits usually occur at places where the pipe changes direction, such as ells and tees, or at some point where a resistance to the flow of gas causes an eddy or swirl. Pipes and fittings subjected to extremes of temperature afford a particular hazard for this trouble.

Tar absorbs naphthalene very readily at low temperatures. It is therefore the principal medium used in its removal at the gas plant, but as there are other valuable hydrocarbons in the gas, absorbable by tar at low temperatures, which it is necessary to retain for their illuminating and heating values, great care and attention must be given tar extraction so that the maximum amount of naphthalene is removed and the minimum of illuminants. The best temperature for this purpose has been found to be between 90 deg. and 100 deg. Fahr. In summer it is often hard to hold temperatures to this point, but as the temperature of the gas at the burner seldom goes below 60 deg. Fahr. any naphthalene in the gas remains as a vapor and is consumed, being beneficial instead of detrimental. In winter the temperatures of tar extraction can be more easily controlled, so that no trouble should be experienced. It is in the fall when the troubles occur, if any are ever experienced, when the temperature of the ground has become lowered with a consequent lowering of gas temperatures, while the days are still hot, causing some naphthalene to get by the plant.

Naphthalene is soluble in other hydrocarbons, such as gasoline, Pintsch hydrocarbon, naphtha, benzine, etc., so that deposits are easily removable when located. A form of washer is often used at the plants, using a solvent, as a precaution against possible ineffectiveness of tar absorption. It is possible to change the form from solid to oil or vapor by an increase of temperature, using steam or hot water as the heating medium. Care must be exercised, however, where the gas has a great velocity, or the steam is under high pressure, that the location of a stoppage is not merely changed, with a result more serious than at first.

Provisions should always be made in a distributing system for handling naphthalene troubles by providing tees or openings in accessible places.

Air.—This is one of the most improbable sources of trouble for the distribution department, whereas it is perhaps the most important of all the impurities encountered by the fitter, due to the life and property hazard always accompanying noticeable quantities of air in illuminating gases.

Where air is mixed with gases to such an extent that complaints are received from the consumer, it may be attributable to either the production or distribution departments, with the chances favoring the former. There are a number of ways from which it originates at the plant and but one way in the distribution department,—failure to purge a new or repaired gas line. The purging of all gas pipes installed, renewed or repaired is an important subject that will be fully covered later.

The damages attendant with mixtures of air and gas are: First—An explosive mixture formed in the pipes which, becoming ignited, does serious damage. Second—A gas flame burning in a room, unoccupied or occupied by a sleeping or helpless person, would be extinguished when air is present in the gas in large quantities, with the consequent danger of property damage or asphyxiation of the person, when normal conditions of the gas returned. The Trustees say:

"When a mixture of air and gas in the proper proportions is ignited, the combustion that ensues spreads through the mixture at a very rapid rate. This rapid their illuminating and heating values, great care and attention must be given tar extraction so that the maximum amount of naphthalene is removed and the minimum of illuminants. The best temperature for this purpose has been found to be between 90 deg. and 100 deg. Fahr. In summer it is often hard to hold temperatures to this point, but as the temperature of the gas at the burner seldom goes below 60 deg. Fahr. any naphthalene in the gas remains as a vapor and is consumed, being beneficial instead of detrimental. In winter the temperatures of tar extraction can be more easily controlled, so that no trouble should be experienced. It is in the fall when the troubles occur, if any are ever experienced, when the temperature of the ground has become lowered with a consequent lowering of gas temperatures, while the days are still hot, causing some naphthalene to get by the plant.

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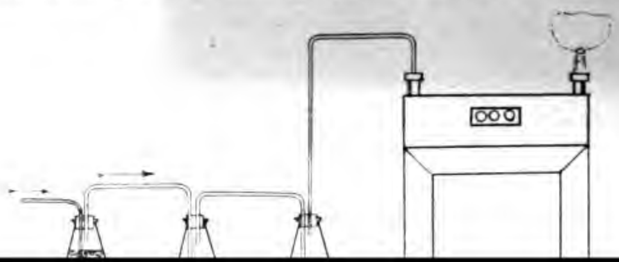
Where air is mixed with gases to such an extent that a small stream of gas through lime water. If carbon dioxide is present a white precipitate of carbonate of lime will be formed and the lime water will become cloudy.

A test for sulphuretted hydrogen may be made by allowing a jet of unlighted gas to impinge on a piece of white paper dipped in a solution of lead acetate (sugar of lead). If sulphuretted hydrogen is present in excessive quantities the paper will show a brown stain.

A test for naphthalene may be made by allowing a stream of gas to bubble through picric acid. If naph-



The Bureau of Standards of the United States Government, in its circular No. 32 on Regulations for Manufactured Gas, sums up the situation on gas quality in a very pointed manner, saying: "From the standpoint of the customer it is immaterial what the chemical composition of the gas is, so long as it contains no injurious constituents and possesses the specified heating value and candlepower." Much more might be written on this subject and less said than is contained in the above paragraph, which plainly means that "all is well so long as the customer is satisfied." Satisfied

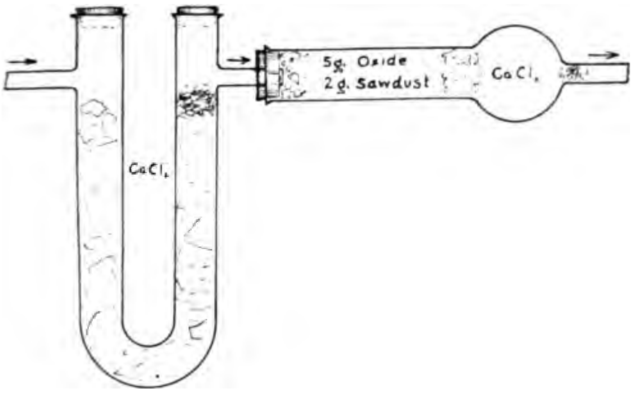


Fig. 54. Testing the Efficiency of Purifier Oxide

customers mean no complaints, which is synonymous of efficient operation and management. As it is the aim of all gas companies to give good service, without which they cannot progress, the benefit of enforced regulation is problematical.

Disregarding the apparent benefit to the gas companies in distributing gas to their customers as free from impurities as possible, many States and municipalities do regulate by ordinance or law the amount of certain impurities allowed per unit quantity of gas. The only impurities, however, which receive much consideration are sulphur compounds and ammonia. Those such as carbon dioxide, nitrogen and oxygen, while undesirable constituents, in their capacity as dilutents have effect upon the heating value and candlepower.

From the standpoint of the gas companies, who measure their degree of service rendered the customer by the number of complaints received, one impurity or cause of complaint is of equal importance with another, and were there no State or municipal regulations the

Fig. 55. Testing for Sulphur Compounds in Gas

quality of illuminating gases would not be materially changed. The gas companies could not afford to do otherwise than maintain a standard in keeping with the aforequoted paragraph from the Bureau of Standard's circular. The large companies do not maintain their expensive laboratories and corps of chemists and engineers so much through fear of penalties from the infringement of regulations as they do through fear of their customers, whose penalty for infringement of their right—good service—is decreased revenue.

In most of the State and municipal regulations a fixed amount of total sulphur and ammonia is specified in the finished gas. These amounts are from 20 to 30 grains sulphur and 5 to 10 grains ammonia per hundred cubic feet of gas. The gas companies have a reason, aside from a trouble standpoint, for removing the maximum amount of ammonia from the gas, as it is a valuable by-product and easily recovered from the crude gas. The process of purification for the removal of sulphuretted hydrogen is also a simple one, so that it is not necessary for more than a trace of that objectionable substance leaving the plant. The other sulphur compounds, however, are not so readily removed and the limit of 30 grains is specified to prevent the use of cheap coals high in sulphur.

The rules of practice of some of the State commissions require as follows:

State	Total Sulphur Grains per Hundred Cubic Feet	Sulphuretted Hydrogen Grains per 100 Cubic Feet	Ammonia Grains per Hundred Cubic Feet
Washington	30	Trace	5
Connecticut	30	"	5
Montana	30	"	—
Oregon	25	"	5
Pennsylvania	30	—	—
Missouri	30	—	5
Illinois	30	1	—
New Jersey	30	Trace	—
Wisconsin	30	"	—
Arizona	30	"	—

PHYSICAL PROPERTIES

The heating or calorific value is at the present time the most important requisite of a commercial gas. In the beginning of the gas industry, and up to the advent of the mantle lamp, the heating value of a gas was almost a negligible factor, the value being appraised by its illuminating power.

When Murdoch produced the first artificial gas and succeeded in lighting his house in London with it in 1792, his only thought was of producing a substitute for the crude illuminating means then known, the tallow dip and oil lamp. He succeeded so well that in 1812 the first gas company was chartered in the city of London, followed four years later by the first in this country at Baltimore.

Value of Heating and Illuminating Properties

The name "illuminating gas," which is still used in designating the common commercial product, is descriptive of the use for which gas was originally intended. For a great many years after the first production and commercializing of illuminating gas it was used for no other purpose than that for which it was produced. From an economy standpoint it was out of the question to consider it as a fuel. Manufacturing methods were crude and expensive, necessitating a high price for the gas, while wood, then the prevailing fuel, was plentiful and cheap. In due course of time, however, the cooking range appeared, but it was a luxury to be enjoyed only by the few for a great many years. Finally the electric light, through the efforts of Thomas A. Edison, came forth and by leaps and bounds threw the gas men upon their resources to meet the competition and continue in business. That they were equal to the situation, and have remained so to the present time, is very evident.

When the electric light became a commercial reality, instead of a laboratory possibility, it was freely predicted that the death knell of gas had been sounded. But the prophets of those days knew not the possibilities of this elastic fuel, nor the mettle of the men engaged in its production.

The flat flame burner, which was the only one known to the old-time gas man, did not compare very favorably with the incandescent electric lamp. But it, too, was crude as compared with the present day tungsten and nitrogen lamps, so that the flat flames were not completely eliminated, and, in fact, they are not to this day. The gas men, however, were wise enough to read the "handwriting on the wall" and see the possibilities of their competitor, so they cast about to find means of improving their product and its ways of utilization. Fuels had become more expensive while gas manufacturing methods had so improved that it had become possible to lower the price to such an extent that fuel gas was rapidly emerging from the luxury stage to the practical. Further manufacturing economies were therefore sought and practiced, and fuel gas campaigns inaugurated, with the result that the gas companies continued to thrive and increase at a healthy rate. Then came the incandescent gas lamp, which was the gas man's salvation in the illuminating line.

We come now to the present time with all the modern uses which have made gas indispensable. Who can say, with the newer methods of production and utilization continually sought, but that it shall always remain indispensable—the peer of all fuels and a very efficient illuminant.

The flat flame burner has become practically obsolete, and with it the necessity for a high candlepower standard. The incandescent lamp consumes gas in the same manner as a range or water heater burner, being what is known as a Bunsen or atmospheric burner.

In an atmospheric burner a certain proportion of air is drawn in and mixed with the gas before combustion, which produces a blue, non-luminous flame. Such a flame contains none of the carbon particles, the raising of which to incandescence furnishes the greater part of the light produced by a luminous flame and is supposed to be due to the activity of the oxygen in the air mixed with the gas before combustion in burning up the hydrocarbons before they can be decomposed. Such a burner will not smoke or deposit soot upon the mantle of an incandescent lamp or a cooking vessel, as would happen if a luminous burner were used, while combustion is more liable to be complete. However, the amount of heat produced by the consumption of equal amounts of gas is the same whether the gas be burned in a luminous or atmospheric burner, provided complete combustion is obtained in both cases.

As the light produced by an incandescent mantle is caused by the application of heat to the rare earths with which the mantle is saturated, which raises them to a temperature at which they become incandescent, the heating value only of a gas need be considered seriously as a quality standard. However, at the present time, state and municipal commissions have not entirely abandoned the candlepower regulation of gases, although they have agreed to modifications in most cases, so that consideration must still be taken of illuminating properties. No doubt before a great many years the double standard will be abolished and gas companies allowed to make gas under heating regulations with the candlepower an arbitrary point to be decided individually by each company in accordance with their judgment.

capable of producing heat are expressed are: The small calorie, the large calorie, and the British thermal unit. The calorie is the quantity of heat required to raise the temperature of one gram of water 1 deg. C. The large calorie is the quantity of heat required to raise the temperature of one kilogram of water 1 deg. C., and the British thermal unit (B.t.u.) is the quantity of heat required to raise the temperature of one pound of water 1 deg. F.

For converting quantities of heat expressed in terms of any of the above defined units to another the following conversion factors may be used:

One great calorie equals 1,000 small calories.

One B.t.u. equals 0.252 calories.

The calorie and great calorie are used as the units of heat in conjunction with the metric system of weights and measures and in countries where this system is used, while the British thermal unit is used as the standard in this country and England, and will be used as the unit of heat measurement throughout this work. The kilogram-centigrade calorie is the unit generally meant when the term calorie is used.

Gross and Net Heating Values

In the case of hydrogen and substances containing hydrogen as a constituent a distinction must be shown between gross or total heating value and net or available heating value. The complete combustion of such substances produces water (H_2O), which, while it is a liquid at ordinary atmospheric temperatures, is a vapor at the temperature at which it escapes as a product of combustion. It requires 966 B.t.u. to convert a pound of water from a liquid to a vapor at its boiling point (212 deg. F.). Since each pound of hydrogen burns to nine pounds of water there will be a difference of 9 times 966 or 8,694, plus the number of heat units given up by nine pounds of water in cooling from a vapor to the observed temperature for each pound of hydrogen contained in the combustible gas. If the temperature of the products of combustion is reduced to 60 deg. F. the heat given up by the water in cooling will be (212 — 60) times 9, or 1,368 heat units, and the gross heat value of one pound of hydrogen will be 8,694 plus 1,368 or 10,062 heat units. Knowing the percentage of hydrogen contained in any substance, the net heating value may be obtained by making the proper deduction from the gross.

As explained by the Bureau of Standards, the total heating value of a gas expressed in the English system of units is the number of B.t.u. produced by the combustion at constant pressure of the amount of gas which would occupy a volume of 1 cu. ft. at a temperature of 60 deg. F. if saturated with water vapor, and under a pressure equivalent to 30 in. of mercury at 32 deg. F., and under standard gravity with air of the same temperature and pressure as the gas when the products of combustion are cooled to the initial temperature of the gas and air and when the water formed by the combustion is condensed to the liquid state.

The net heating value of a gas when expressed in the Engilsh system of units is the number of B.t.u. produced by the combustion at constant pressure of the amount of gas which would occupy a volume of 1 cu. ft. at 60 deg. F. if saturated with water vapor and under a pressure equivalent to 30 in. of mercury at 32 deg. F. and under standard gravity, with air of the same temperature and pressure as the gas, when the products of combustion are cooled to the initial temperature of the gas and air and the water formed in combustion remains in the form of vapor.

According to the above definitions the net heating value is less than the gross or total heating value by an amount of heat equal to the latent heat of evaporation at the initial temperature of the gas and air of the water formed by the combustion of the gas.

It is customary in all ordinary work to express quantities of heat in terms of gross value unless otherwise stated.

Calorimetry or Heating Value Tests

There are two ways of finding the heating value of a gas—by the use of an instrument called a calorimeter and by analysis and calculation. By the former method a given quantity of gas is consumed in the calorimeter, imparting its heat to a known quantity of water and denoting by the rise in temperature of the water the quantity of heat imparted to it. In the latter method the chemical composition of the gas is found by analysis, the heating value is then calculated by multiply-

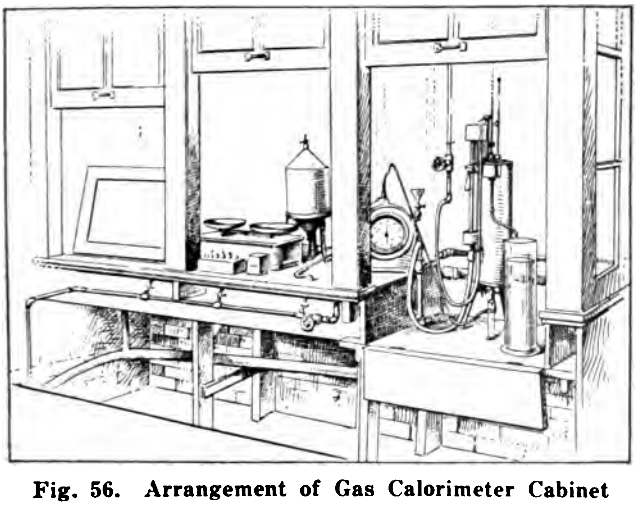


Fig. 56. Arrangement of Gas Calorimeter Cabinet

ing the known heating value per cubic foot of the various constituents by the volume of such constituent contained in a cubic foot of the gas, the sum of these multiplications being the required heating value per cubic foot of the gas.

It is customary in modern practice to take several heating value tests per day, usually at four to six hour intervals. The heating value of illuminating gases has attained such importance that the calorimeter is considered indispensable in the great majority of plants. From an economic standpoint in the reduction of complaints from the consumer the gas companies should, and do, consider a standard of heating value of equal importance with sending out gas as free from impurities as possible. A company cannot afford to distribute to the consumer 500 B.t.u. gas

[redacted]

heat is required to produce a certain change of state, as in the boiling of water, cooking of food, heating or melting of metals, heating the rare earths contained in mantles, heating of air for warmth, etc. This transmission of heat must be accompanied with a rise in temperature of the body receiving the heat, the corresponding rise in temperature, however, being not the same for all substances in proportion to the amount of heat given out by the heating medium. Every substance has a certain capacity for heat known as its specific heat, which denotes the amount of heat expressed in heat units which is required to raise the temperature of a unit weight of the substance one degree. Since a heat unit is the amount of heat expressed in heat units which is required to raise the temperature of unit weight of water one degree, the specific heat is the ratio between the amount of heat required to raise the temperature of a unit weight of the substance one degree and the amount of heat required to raise the temperature of a unit weight of water one degree.

More heat is required to raise the temperature of unit weight of water a given amount than is needed to raise by the same amount the temperature of unit weight of any other substance except hydrogen; therefore with this exception the specific heat of all substances is less than one.

By the following table it is apparent that a unit quan- of gas of a certain heating value will, if the total amount of heat energy in the gas was transmitted to

Specific Heats of Common Substances

Water	1.000	Steel	0.1181
Hydrogen	3.409	Iron	0.113
Alcohol	0.602	Copper	0.095
Ammonia	0.508	Zinc	0.0935
Ice	0.504	Tin	0.0562
Air	0.2375	Mercury	0.0333
Aluminum	0.218	Lead	0.0315
Glass	0.200		

equal weights of water and iron, raise the temperature of the latter almost nine times as many degrees as the former.

The amount of heat required to raise by one degree the temperature of a body that is free to expand or is kept under constant pressure is not the same as the amount required to produce the same change in temperature in the body if it is kept at constant volume. Therefore, for every substance there are two values for the specific heat, one for constant pressure and one for constant volume. There is also what is called constant heat by volume, which is the amount of heat expressed in heat units required to raise by one degree the temperature of unit volume of a substance. When the term "specific heat" is used without any qualifications it refers to specific heat by weight at constant pressure.

Knowledge of the specific heats of different substances will often be useful to the gas company fitter in deciding upon the quantity of gas required to accomplish a certain purpose. He will often be told the purpose by the customer, which will be all the data available with which to plan the sizes of pipes and meter to install. As for instance, a customer may have a 500 gal. water tank that he wishes to heat to a temperature of 180 deg. F. in two hours. In this case the inlet temperature of the water would first have to be ascertained. We will assume it to be 60 deg. F., with gas of 600 B.t.u. heating value, it will take 830 cu. ft. to do the work or 415 cu. ft. per hour. Pipes and meter can then be installed to handle this amount of gas. In another instance a customer wants to heat 1,000 lbs. of steel in a tempering furnace from 60 deg. F. to 1,000 deg. F., then (1,000 — 60) times 1,000 = 940,000 pound-degrees. The specific heat of steel is 0.1181, then, 940,000 times 0.1181 equals 111,014 B.t.u. required, or 185 cu. ft. of 600 B.t.u gas.

In both of the above examples it was assumed that all of the available heat energy of the gas was utilized, but under actual conditions this is impossible as there are heat losses to take into consideration under the law of nature which compels the transmission of heat from a body of higher temperature to another of a lower at a rate proportionate to the relative heat conductivity of the bodies.

There are three ways by which heat is transmitted—by conduction, by convection, and by radiation. All three ways may be illustrated by the ordinary hot water storage tank and heater. In this appliance the hot water is first heated by the conduction of heat from the flame against the coil to the water within. As the water is heated it rises, due to its change of density or weight, and the cold water takes its place, setting up currents which distribute the heat in the tank as the heating process is continued until the entire tank is full of hot water. This is known as heating by convection. As soon as the water is heated it starts conducting its heat to the colder pipes and tank and they, in turn, radiate the heat to the colder air.

It should be noted in this, as in all things, that nature is striving to preserve an equality, but in doing so has provided a means whereby we can make use of part of the energy by making different substances conduct heat in varying degrees. Were this not a fact it would, in the above case, be impossible to heat the water as the heat would be conducted to the pipes and radiated to the air as rapidly as produced. This phenomena, however, will occur in time, as the tank will become cold, or in other words, will attain the temperature of the surrounding air, after the heating process has been stopped for a period of time, even though none of the hot water is drawn from the tank.

In figuring the amount of gas required to accomplish a certain purpose heat losses must be taken into consideration as it is a practical impossibility to make use of the total heating value of a gas. Conditions of efficiency vary greatly in different gas consuming appliances; for instance, an instantaneous water heater has a much higher rate of efficiency than a gas engine, so that a safe method to follow is to consider any gas-consuming appliance but 50 per cent efficient, thereby pro-

...............al gas has become almost
It is to be understood that this s
apply to Pintsch or Blau gases. T
the illuminating standard would b
consumer in inducing him to discard
few flat flame burners still in use
mantle lamp giving greatly increase
cubic foot of gas consumed.

An illuminating gas depends upon
called illuminants, which it contains
power. These illuminants are effect
to a marked degree in the same mann
so that in cities where the gas is dist
areas in winter the candlepower ne
be excessively rich in order to main
illuminating value in the outlying
removed from the palnt. The illu
cases are to a great extent condense
drips.

The Bureau of Standards in its
"Legal Specifications for Illuminatin
following to say in regard to "Candlep
Value Regulations":

"It is commonly believed that the hea
is a better measure of the general usef
is the candlepower, and for most places

[redacted]

perience of those who have made a fair trial of the methods for works operating on a heating value standard indicates that greater economies of operation can be obtained as the details of the new methods are developed. Another practical advantage to the manufacturer is that the losses of heating value of the gas during distribution are much less proportionately than are the losses of candlepower, and further, abnormal weather conditions are less troublesome when control is on a heating value basis. It seems certain, therefore, that even from the

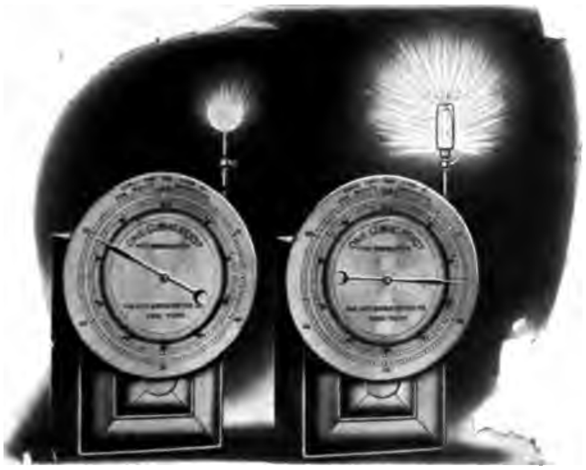


Fig. 58. Demonstrating Progress in Unit Light Yield

first a great economy will result under heating value standards as at present and that increased experience will permit appreciable improvements over present conditions.

"From the point of view of the usefulness of the gas to the customer, there is no doubt that both the heating and the lighting value of the gas should be maintained above certain minimum values. However, some engineers claim that a company should not be required to maintain both candlepower and heating value of specified amounts, as they believe that under the present methods of manufacture and with the present day appliances for gas consumption it is only necessary to regulate one of these qualities and allow the other to be what will correspond, having regard only for economy of manufacture.

"At the present time the methods employed in gas making are such that all coal and water gas made on a heating value basis will also have a reasonable candlepower; but gases of nearly normal heat value and very low candlepower are available, and whenever it is found practicable to supply these gases at a satisfactory price the question arises as to how far we may disregard the lighting value of the gas. There are those who say that if gas can be made cheaper by this procedure it is proper even at the present time to wholly disregard the open flame candlepower of the gas. However, the bureau has taken the attitude that there are still too many who are utilizing gas in open flame burners to do this.

"There is some question as to how far the change from open flame to mantle lights can be carried, as there are places for which the open flame burner is better suited than is the mantle light. These places are basements, halls, storage and attic rooms where the light is little used or where the burner is subject to such rough treatment as to make a mantle impracticable. In combination fixtures, where gas is used only in case of interruption of the electric service, the extra investment in mantle lights is not warranted, even if the mantle burner were adapted for use on combination fixtures, which is usually not the case.

"A nominal candlepower gas will be sufficient for use in such places as those just mentioned, and without legal candlepower regulation the gas made by the ordinary processes of the present day will be satisfactory in quality for emergency use in fixtures, even if only heat value is controlled, since the lowest candlepower would scarcely be less than 10 candles if the gas were of 600 B. t. u. or higher. On the other hand it is uncertain what would be the result if a gasmaker undertook to wash the gas with oil or to make considerable modifications in the retort or generator operation. We have not yet reached the time when customers requiring open flame candlepower in gas are neglible numerically; nor has it yet been proved that the manufacture of a non-luminous gas is most economical or desirable. We are therefore disposed to recommend retaining a minimum candlepower requirement as a secondary standard in addition to the more important heating value standard. Such a minimum candlepower value should be low enough so that the manufacture of gas is not thereby complicated and its cost is not increased. No penalty need be imposed for daily deficiency in candlepower under these rules and possibly a slight deficiency in a single monthly average might be allowed without penalty if subsequent averages were above the requirement.

"Whenever such methods of operation are devised that the methane content of the gas can be largely increased, we shall be confronted with this problem; and it is not improbable that such process will be devised in the near future. If the time comes when a nearly non-luminous gas is clearly to the advantage of the public, the price would probably have to be readjusted, and in that case the candlepower requirement can be readjusted also.

"The use of a minimum candlepower requirement as described above (say 12 to 15 candles measured in an open flame burner), is not what we understand by a double standard. The latter involves a candlepower requirement as difficult to meet at the heating value requirement, so that the company would find it necessary to watch both calorimetric and photometric values daily. This we do not recommend.

"Gas can be too rich in illuminants for the best service in mantles, as well as too poor for satisfactory service in open flames. Too high or too low a heating value will be less economical than some intermediate value. A wisely chosen mean, to be clearly specified and carefully maintained, is what is wanted; but this mean is not everywhere the same, and under special conditions it may be desirable to depart rather widely from usual values. Hence the state commissions should be authorized to fix

Fig. 59. Standard Form of Photometer Used for Making Candle Power Tests of Gas

the values required and to make exceptions for special reasons."

The bureau's view of the relation of a candlepower standard to the present usefulness of gas is very plainly stated and leaves very little that could be added at the present time. No doubt, as they mention, changes will occur in time which will necessitate a readjustment of both quality requirements and rates. There is not a doubt but that open flame burners used as emergency or special lighting units will be changed to mantles by the discovery of a cheaper and more rugged mantle. In the matter of combination lighting, no objection to the mantle light should appear, unless it be one of cost, as gas burners and glassware can be made, and are being made, to match the design of any electric lighting fixture.

Luminosity and Photometry

The principal causes of the luminosity or light-giving properties of a flame are: Presence of solid particles, density of the burning gases, and the temperature.

The solid particles are very finely divided carbon, which are heated to incandescence by the temperature of the flame before they meet with sufficient air for their combustion. These carbon particles are produced by the decomposition of the hydrocarbons in the gas while in the center of the flame and out of contact with the air but subject to the temperature of combustion on the surface of the flame.

In general the more dense the gases undergoing combustion the more luminous they are when heated to high temperatures, and anything which tends to raise the temperature of the flame increases the light given, other things being equal.

Smoky flames are produced by the escape of unburned particles of carbon.

The intensity of illumination is the quantity of light received on a unit of surface, which varies inversely as the square of the distance from the source of light.

A photometer is an instrument for comparing the intensity of one light with that of another assumed as a standard. The principle applied is that the ratio of the intensities of two lights equals the square of the ratio of the distances at which they give equal illuminations. As previously stated the standard in general use is the sperm candle of a size running six to the pound and burning at the rate of 120 grains per hour. The illuminating power of a gas is expressed by stating the number of times a flame of the gas burning at the rate of 5 cu. ft. per hour is greater than the flame of the standard candle.

Effects of Temperature Upon Volume

According to Charles' law, when a gas is heated it expands or increases in volume; conversely, when it cools it contracts, or decreases in volume. All gases, when heated or cooled, expand or contract to the same extent. Each volume of gas heated expands 1/492 part of a volume at 32 degs. F. for each degree of temperature raised. In other words, one cubic foot of gas at 32 degs. F. becomes 1.00204 cubic feet at 33 degs. F. It is customary, where approximate results only are wanted, to assume an increase or decrease in volume of 1 per cent for each 5 degs. F. raised or lowered. For accurate work the following formula may be used for correcting to standard conditions:

$$V = \frac{17.64\ (H - A)\ V_0}{(460 + T)}$$

V = Corrected volume at 60 degs. F., 30-inch pressure.
V_0 = Volume observed at temperature of T and a pressure of H inches of mercury.
A = Tension of aqueous vapor at temperature of T.

Effects of Pressure Upon Volume

The effect of pressure on gases is to diminish their volume. When the pressure is doubled the volume of gas becomes one-half, conversely when the pressure is reduced one-half the volume is doubled.

This law, known as Boyle's law, may be stated as follows: The volume of any gas varies inversely as the absolute pressure.

Effects of Temperature Upon Pressure

From the foregoing laws of Charles and Boyle it is evident that the volume which any given weight of gas occupies depends on both temperature and pressure. If the pressure is reduced or the temperature is raised the gas expands, and if the pressure is increased or the temperature lowered the gas contracts. Therefore, temperature and pressure bear relation to each other in their effects upon gas volumes; hence, if a gas is heated in a confined space, such as a closed gas pipe, the pressure will be increased.

Effects of Temperature and Pressure Upon Quality

Since the heating value and candlepower of gas are tested under a standard condition of 60 degs. F. and 30-inch mercury pressure, it is evident that anything which tends to displace these standard conditions changes the heating and illuminating values per unit volume of gas measured under the new conditions. For instance, 1 cubic foot of gas of 600 B.t.u. heating value at 60 degs. F. becomes approximately 1.06 cubic feet at 90 degs. F., or at this temperature the heating value per cubic foot is only 566 B.t.u.

Effects of Elevation Upon Volume and Pressure

The atmosphere has weight, therefore the atmospheric pressure decreases proportionately as the distance from the center of the earth increases. The atmospheric pressure at sea level is 30 inches of mercury; it is therefore evident that any elevation above sea level must have an atmospheric pressure less than 30 inches. If a cubic foot of unconfined gas, measured at sea level, is taken to an elevation above it, the pressure of the atmosphere acting upon it is decreased and the gas expands in accordance with Boyle's law; however, if a cubic foot of gas under constant volume is taken to the same elevation, a pressure gage at that point would show that the pressure had increased from that shown at the lower elevation.

As an illustration of the effect of elevation upon pressure, we will assume that a riser pipe runs from the basement to the top floor of a building. If a gage is attached to the bottom end of the pipe and another at the top, and no gas is flowing in the pipe, a difference in pressure will exist between the two gages equal to the weight of a column of air 1 square inch in cross section and as long as the distance between the two gages, less a similar column of gas, of which the specific gravity is known, divided by the weight of a cubic inch of water.

The reason that this occurs is because a gage does not register the actual or absolute pressure of the gas in the pipe, which would be the pressure within the pipe plus atmospheric or mean barometric pressure. If the atmospheric pressure was the same at the elevated position as at the lower, the pressure in the pipe at the top would actually be less than at the bottom, depending upon the specific gravity and consequent weight of the volume of gas. As the specific gravity of illuminating gas is less than 1.—that is, lighter than air—the weight of the column of gas will be less than that of the column of air; consequently, the actual pressure of the gas will decrease less than the actual pressure of the column of air, and the difference between the actual pressure of the gas and that of the air will increase with an increase in elevation. The lighter the gas—i. e., the lower its specific gravity—the smaller will be the decrease in its absolute pressure and the greater the increase in gage pressure for any given increase in elevation.

The following table shows elevations necessary to increase the gage pressure 1/10 inch and the increase in gage pressure for each 10 feet of elevation, for gases of different specific gravities:

Specific gravity	Elevation = 1″ pres.	Diff. pres. for 10′ elev.
0.300..........	9.7 ft.	0.103 in.
0.400..........	11.4 "	0.088 "
0.500..........	13.5 "	0.074 "
0.600..........	16.0 "	0.059 "
0.700..........	22.7 "	0.044 "

The fitter should bear in mind that the heating and illuminating value of gases are effected by elevation, just as they are by temperature and pressure, provided the gas is measured at the elevated position.

MEASUREMENT OF VOLUME

Gas is caused to flow in pipes by the differential pressure existing between two points, corresponding to the initial and terminal pressures. The initial pressure is the pressure at any starting point of the gas flow and the terminal pressure is the pressure at the discharge end of the pipe, the differential or loss of pressure is the difference between the initial and terminal pressures.

Flow of Gases

The flow of gas in pipes is opposed and retarded by friction with the walls of the pipe, so that a pressure sufficient to overcome the combined friction and inertia must be provided at the inlet end in order that the gas will flow through it.

The volume of gas which will be discharged from the end of a pipe depends upon: (1) the diameter of the pipe, (2) its length, (3) the differential pressure, and (4) the specific gravity of the gas.

All other things being equal, the discharge in cubic feet per hour of one pipe is to that of another as the square root of the fifth power of their diameters, inversely as the square of the lengths, as the square of the differential pressures and inversely as the square of the specific gravities of the gas. In accordance with the above laws, the following formula is generally used:

$$V = 1350 \sqrt{\frac{(P_1 - P_2)\, D^5}{S\, L}}$$

V = Volume in cubic feet per hour. D = Diameter of pipe, in inches. P_1 = Initial pressure. P_2 = Terminal pressure. L = Length of pipe, in yards. S = Specific gravity of gas, air = 1.

Gas-flow computers based upon the above formula are easily obtained and should be in the hands of every fitter, making the task of working out any problem involving the flow of gas a simple one.

Conductivity of Pipes

The conductivity of a pipe is its carrying capacity in volumes of gas, which is variable under certain conditions of pressure, length and gravity of the gas.

All fitters know that the elimination of "dead ends" in gas pipes is favorable to the carrying capacity of the pipe, but to just what extent and the cause should be understood.

In the accompanying chart explanation is given of results to be obtained under different conditions representing different methods of installing pipes. The first illustration represents a pipe supplied from one end, discharging from the other, as a service pipe. This condition is represented as unity in all quantities. The second illustration represents a pipe fed from both ends, discharging from a point midway between the ends. Here a comparison with the first illustration shows that such an installation, considering the specific gravity of the gas to be the same, will pass 2.8 times the amount of gas in a given time for the same length, diameter and pressure drop, will pass the same amount of gas for the same length and diameter with a pressure drop of 1/8 as much, will pass the same amount of gas with the same pressure drop and diameter with a length eight times as great, or will pass the same amount of gas for the same length and pressure drop with a diameter .66 as great.

The third and fourth illustrations bear the same relative value to each other as the first and second, but have different values, as shown, when compared with the first. Comparisons of any one with another are easily made. Exactly the same values are obtained if the pipe is fed from the center, discharging from both ends.

Problems very often occur in house piping where a knowledge of the above information proves of great value. In meter header installations, illustration No. 4 or its counterpart (fed from the middle, discharging both ways) should in all cases be used, even at the expense of additional pipe over No. 3. In street main work it is general practice to tie-in all dead ends possible, most companies allowing a considerable expense to be used for that purpose.

The importance of pipe conductivity will be more clearly seen later on, when the subject of pipes and pipe fitting is thoroughly discussed.

The Measurement of Gas

Gas is measured at least twice in its journey from the source of production to the customer's burner, for

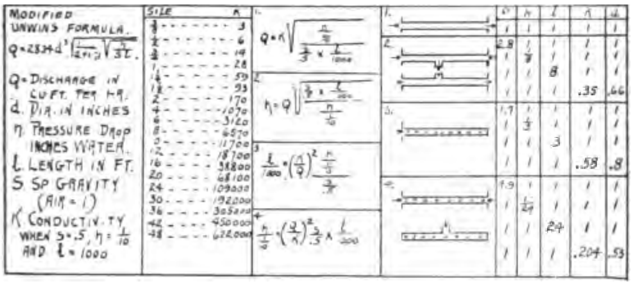


Fig. 60. Pipe Conductivity Chart

entirely separate reasons. It is first measured at the plant by a station meter, which is for a double purpose: that of giving the production department a check upon their operation, and of giving the distribution department a check upon lost and unaccounted for gas. It is finally measured by the customer's meter, for the purpose of ascertaining the amount of gas for which the customer is responsible to the company.

Other meters may be installed at intermediate points between the station and customer's meter, but their purpose must in any case be either a check on operation or a check on gas for which some one is responsible to the company.

ıanuara usea ıs 60 degs. F. and 30 inches r
ressure. In the production of artificial gas, h
'here the absolute pressure at the station mete
lightly above atmospheric and is fairly cons
; common practice to disregard pressure corı
ıasmuch as the gas is not corrected for pres
ıe customer's meter, and correct for temperatuı
ı the case of natural gas, however, where the
ften measured under very high or varying pre
is important that corrections be made for bot
erature and pressure. No corrections whatev
ade upon the registration of the customer's m
oth temperature and pressure are usually fair
ant and close enough to standard conditions fo
cal purposes.

The formula for correcting volumes of gases to
'd conditions follows:

$$V = \frac{17.64\ (H-A)\ V_o}{(460 + T)}$$

V = Corrected volume at 60 degs. F., 30-inch mercuı pressure. V_o = Volume observed at temperature of and a pressure of H inches of mercury. A = Tension (aqueous vapor at temperature of T.

nds of Meters

Gas meters may be divided into two general cl
pacity meters and flow meters. In the former

diaphragms have a certain known cubical capacity, and the gas in passing through the meters causes a movement of the mechanism by the filling and emptying of

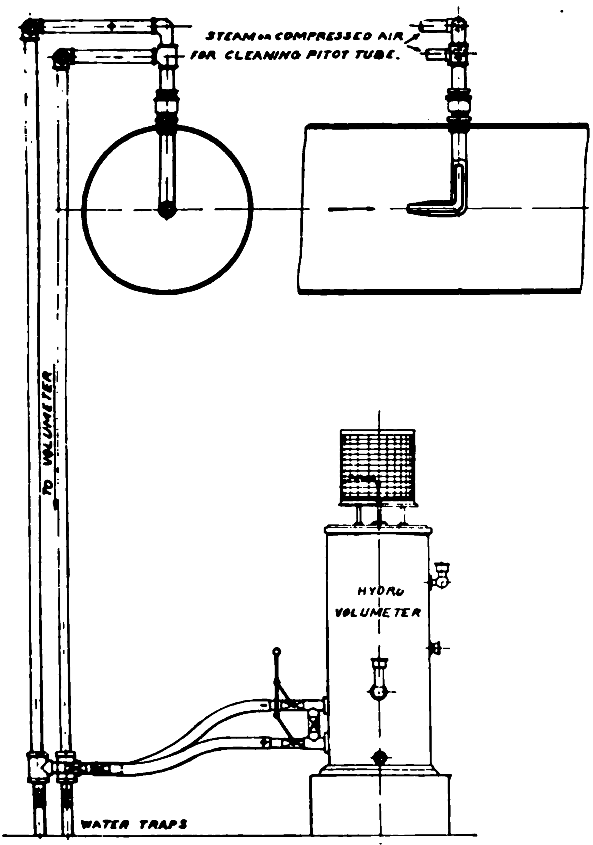


Fig. 61. Pitot Tube with Recording Chart

the measuring device, which is transmitted through a train of gears of the proper ratio between the cubical contents of the measuring device of the meter and some unit of one cubic foot, to a dial, where the gas passed may be read off direct in cubic feet.

The Rotary meter is a volumetric measurer of gas. Within its rated maximum (100 per cent) and its rated minimum (10 per cent thereof) it accurately records upon its dial the amount of gas passing through. There are today more Rotary meters in service among artificial gas companies than there are wet or drum meters. This type of meter is in service measuring volumes of gas of 700,000 cubic feet or more per hour.

In the flow meter class are included all meters which depend upon the velocity or speed at which the gas is moving as the principle under which they measure gas. The most common function used in flow meters is that of the amount of gas which will pass through an orifice of a certain size at a given differential pressure. These meters are commonly called orifice meters, and are in general use where the gas to be measured is under high pressure, as in natural gas work.

The Venturi meter, the proportional meter, the Thomas electric-gas meter and the Pitot tube are included in the flow meter class.

It will not be the purpose of this article to go deeply into the subject of the various types of gas station meters, as it is to be considered that the customer's meter is the one of greatest importance to the fitter. As the meter in general use for measuring the gas used by the customer is what is commonly called the dry meter, that type will be fully covered in a succeeding chapter.

PRESSURE AND OUTPUT

In its journey from the source of production, be it the gas plant or gas well, to the burner where it is consumed the gas is continually beset by a resisting force called friction, which strives to bring it to a state of rest. Every piece of apparatus, pipe, fitting, meter and appliance exerts a certain portion of this resistance to the flow of the gas, proportionate to the cross section, conditions of the walls, length and abrupt angles of the passageway, and to the volume of gas flowing. The specific gravity of the gas is also an important factor, as the denser or heavier the gas the greater will be the retarding influence of friction.

To offset this friction a force is exerted known as pressure, which is analogous to the force applied to water which causes it to flow when a valve is opened. However, gas pressure is applied in an entirely different manner, although producing the same result in the end. Water pressure is due to the weight of water above the level at which it is utilized, and is proportionate to the height of the column of water above this point. Thus a column of water 27 inches in height at sea level exerts a pressure of 1 pound at the base of the column. Gas pressure is obtained by compression, either through the weight of the bell of a holder acting upon the gas within or by means of pumps.

As explained before, the conductivity of pipes—i. e., the amount of gas which can be delivered through them —depends upon various conditions, namely the size of the pipe, its length, the specific gravity of the gas, and the differential pressure. In a system of distributing mains some means must be provided for taking care of varying demands for gas by the customers, which have effect upon the conductivity of the mains. As this demand varies greatly within very short periods of time, it is impossible to vary the amount of gas delivered except by increasing or decreasing the pressure.

In a simple distribution system the object desired is to maintain a constant pressure at the lowest pressure point, of the minimum amount of pressure for efficient utilization by the customer. This requires a varying initial pressure, with the consequent varying differential, and varying pressures all along the line of mains from the initial point to the terminal. In a more complex system, where a number of low-pressure points require attention, more elaborate means of supplying a minimum efficient pressure to all points in proportion to their possible varying demand are needed. These may consist of district holders and pumping stations, sepa-

.. .. the beginning of the gas i
and in fact up to within a comparatively short t
when the initial pressure was limited to that
by the weight of the holder, which was compa
low. It was necessary then, in order to sup
varying demand, to lay mains of sufficient cross
to supply the maximum demand with the diff
pressure desired, and to use governors to red
initial pressure during times of light demand
required the laying of mains of large cross-secti
neant that when a district outgrew the capacit
nain, even though it was for only one hour out
wenty-four, a larger main had to be installed.
ities and districts got to outgrowing their
nains with too great a regularity, somebody
red that it was much cheaper to increase initia
ures than to renew mains, with the result that
as a revolution in distributing systems and me

In gas fitting where the initial pressure is that
let of the customer's meter, and uncontrolable
ter, the differential and terminal pressures d
pon the diameter and length of pipe used.
stomary to have a fixed value for terminal or u
n pressure, which should be the pressure a
most efficient utilization. With the revolut
s-consuming appliances in the past twenty ...

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city of the gas in passing through the orifice, and a pressure of three inches should be the fixed terminal pressure on present-day gas consuming appliances.

A study of the accompanying chart shows the ratios between diameters and lengths of pipe and pressures and volumes of gas discharged. In curve No. 1 it is assumed that the differential pressure and diameter of the pipe is constant, and may be of any value, it follows that the amount of gas which will flow through the pipe

Fig. 62. Effect of Pressure, Diameter and Length

will vary inversely as the square root of the length or the length vary inversely as the square of the gas discharged. It is only necessary to assume a value for the length and volume to begin with, and any other value of length or volume may be found by comparison. It is seen by this curve that if 1,000 yards of pipe of a certain diameter will discharge 1,000 cubic feet of gas per hour, at a certain differential pressure, in order to discharge 15,000 cubic feet per hour under the same conditions the pipe could only be 4 yards long. Curve

No. 2 shows pipe sizes required to discharge varying quantities of gas when the length and differential pressure is constant. Here the volume discharged varies as the square root of the fifth power of the diameter. In curve No. 3 is shown the differential pressure required to discharge varying volumes of gas, when the diameter and length of the pipe is constant, under the rule that the pressure varies as the square of the volume, or the volume as the square root of the pressure.

Pressure Gages

Pressure gages are used for measuring the difference between absolute and atmospheric pressures. The most accurate and the common form used on low-pressure gas is the "U" gage, consisting of a glass tube bent in the form of a letter "U" and provided with a graduated vertical scale. The zero of the scale is located midway between the top and curve of the glass tube, graduations being marked up and down from this point. One end of the "U" tube is open to the atmosphere and the other to the vessel or pipe containing the gas, the glass tube being filled with water to the level of the zero graduation. When the pressure on both sides is equal—i. e., subject to the atmospheric pressure only—it will register the differential pressure when the gas pressure is turned on by forcing the water down the leg of the gage attached to the gas pressure side and up the leg open to the atmosphere, equal distances from zero. The pressure (it is customary to omit the word "differential," as it is understood that the pressure so shown is not actual) is therefore equal to the height of the column of water which it can support, or the distance between the water levels in the legs of the gage.

As gas under one pound pressure will support a column of water 27 inches high, which means that a "U" gage using water as the registering medium must be be 27 inches long from the top side of the curve to the top of the outside leg, it is evident that the use of a water gage is prohibitive where even ordinary high pressure is used, due to the length and consequent awkwardness of such a gage. A "U" gage containing a liquid heavier than water—as mercury—may be used where very accurate high pressures are to be recorded. As mercury is about 13½ times heavier than water, a "U" gage containing mercury would only have to be 1/13.5 as long as one containing water. Due to the weight and cost of mercury, except for scientific or very accurate measurements some other form of gage is generally used for high pressure measurements.

The ordinary spring gage is in common use for registering high pressures. In this gage a bent hollow spring, one end of which is open to the gas pressure and immovable and the other closed and free to move as pressure is applied, is used. The principle of this gage is based upon the tension of the bent hollow spring and the pressure required to straighten it when applied to the inside. The movable end is geared in such a manner as to impart a rotating movement to a needle or pointer, which travels around a circular graduated dial. The pressures which may be registered by spring gages are governed by the tension or stiffness of the spring used, so that different gages must be used for medium, high and very high pressures. Spring gages are not as reliable or accurate as "U" gages, being subject more or less to conditions effecting these qualities, so that they should be tested against some form of standard at frequent intervals.

Recording pressure gages may be used on gas under any pressure. In principle they are similar to the spring gage, except that instead of a hollow solid bent spring, the registering mechanism consists of a flexible accordion-shaped cylinder, which is immovable and open to the gas pressure at one end, while the other end is closed and restricted from expanding or opening except on one side. An arm containing a pen is fastened to the side which is free to expand, which travels through an arc of a circle on a graduated chart as pressure is increased or diminished. A clock mechanism causes a chart to revolve, while the pen is stationary to this circular movement. The chart contains concentric rings corresponding to different pressures, and is divided into a number of segments corresponding to units of time. Gages containing registering mechanisms of varying degrees of flexibility and travel must be used for accurate measurements of different pressure where the range is very great. It is, therefore, customary to have different gages to suit the conditions of the pressure to be registered and recorded.

A gage which is not as well known as it should be, and doubtless will be, is the Unison Telemetric Pressure gage. It consists of two pieces of apparatus, a transmitter and an indicator. The transmitter may be installed at any point where it is desired to measure the pressure, while the indicator may be installed at any other point where it is desired to register it. Electrical connection is made between the two instruments, using current obtained from a small storage battery. As pressures change at the transmitter the circuit between it and the indicator is opened and closed a number of times, corresponding to the change in determined units of pressure, which causes the pointer on the distant indicator to move to the new pressure indication, and there stop until the pressure changes again. These gages are of great importance in maintaining constant pressures at low points in a distribution system, in which case the transmitter is located at the low point and the indicator at the place of pressure control.

Gas Send-Outs

By "send out" is meant the amount of gas put into the suppy mains for the use of the customer in any given unit of time. It is equivalent to the amount of gas made plus or minus losses or gains in storage. Over certain periods of time it is apparent that the send-out will equal the make, inasmuch as they will be equal any time the amount of gas in storage at the beginning and end of a period is the same. The amount of gas made is always governed by the send-out, and never the opposite, unless through accident or other-

wise the capacity of the plant is exceeded. Send-outs are usually divided into hourly, daily, monthly and yearly periods, and vary greatly, due to different conditions effecting the consumption of gas. The most important factors effecting these variations are climatic and seasonal.

Gas Send-Out During 24 Hours

Hour	Coal gas made 1,000's	Water gas Made 1,000's	Total make 1,000's	Holder register 1,000's	Gain 1,000's	Loss 1,000's	Total Sendout 1,000's
7- 8.....	85	..	85	935-795	..	140	225
8- 9.....	85	..	85	795-680	..	115	200
9-10.....	85	65	150	680-680	..	..	150
10-11.....	85	80	165	680-720	40	..	125
11-12.....	85	80	165	720-710	..	10	175
12- 1.....	85	80	165	710-715	5	..	160
1- 2.....	85	80	165	715-755	40	..	125
2- 3.....	85	80	165	755-820	65	..	100
3- 4.....	85	80	165	820-895	75	..	90
4- 5.....	85	80	165	895-910	15	..	150
5- 6.....	85	80	165	910-775	..	135	300
6- 7.....	85	65	150	775-650	..	125	275
7- 8.....	85	..	85	650-560	..	90	175
8- 9.....	85	..	85	360-495	..	65	150
9-10.....	85	..	85	495-505	10	..	75
10-11.....	85	..	85	505-550	45	..	40
11-12.....	85	..	85	550-610	60	..	25
12- 1.....	85	..	85	610-670	60	..	25
1- 2.....	85	..	85	670-740	70	..	15
2- 3.....	85	..	85	740-810	70	..	15
3- 4.....	85	..	85	810-880	70	..	15
4- 5.....	85	..	85	880-940	60	..	25
5- 6.....	85	..	85	940-975	35	..	50
6- 7.....	85	..	85	975-910	..	65	150
Totals	2040	770	2810	High 975, Low 495	720	745	2835
					Difference 25		

The accompanying chart, which is self-explanatory, shows varying pressures during the 24 hours of the day and how the amount of gas made is compensated by that in storage to suit the amount sent out.

Lost and Unaccounted for Gas

The amount of gas sold does not equal the amount sent out, various influences tending to cause the former

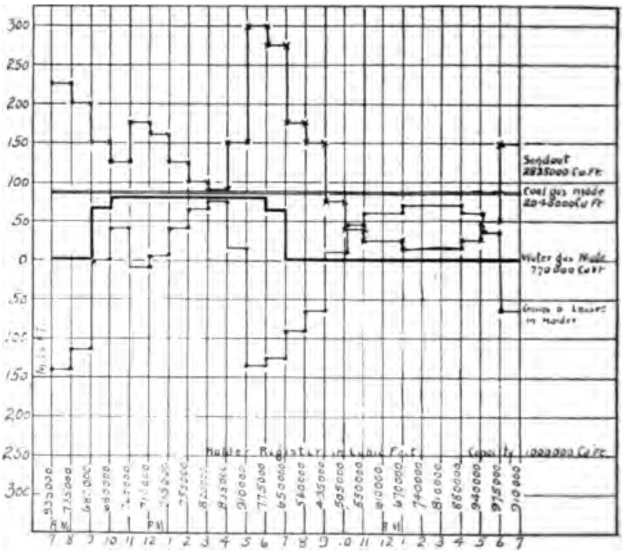


Fig. 63. Relation Between Make, Storage and Consumption

amount to be less than the latter. The difference between these amounts is known as gas lost and unaccounted for. All of the gas so classed, however, is not actually lost by leakage, some being due to slow customers' meters, contraction caused by temperature, gas lost in making connections, stolen or unmetered gas, purging mains, etc.

Perhaps the most important influence effecting lost and unaccounted for gas, and the one which will bear the most watching, is actual leakage. The pressure carried upon the distribution system has a potent effect upon this leakage, and in this day and age of high-pressure distribution the importance of good work-

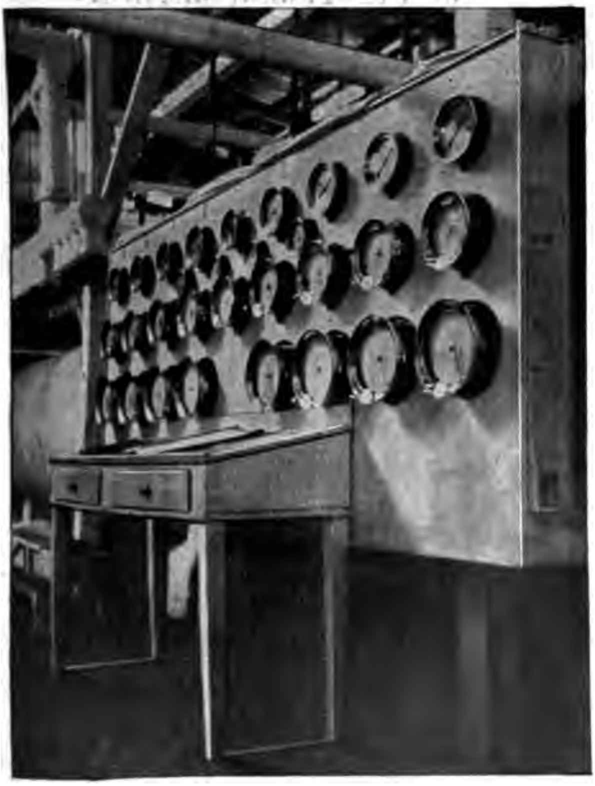


Fig. 64. A Well Arranged Gage Board

manship, materials and methods in the installation of new work and careful watching and permanent repairing of old work cannot be over estimated.

CHAPTER III

MANUFACTURING METHODS

Coal gas is produced by the distillation of coal in a carbonizing chamber which is externally heated. This process of distillation, more commonly called carbonization, takes place in the presence of a high temperature and in an atmosphere from which air is excluded, and consists of the breaking down of the coal into various

in use for which space does not permit a full description, but all employ the same general principle of carbonization. They may be divided into two classes, however: coal gas plants and by-products plants. In the former the production of gas is the primary purpose of manufacturing, with coke, tar and ammonia as by-products. In the latter, either coke, or tar products and

Fig. 66. Front of Coal Gas Retort Benches

ammonia, or all, are of primary importance with gas as a by-product of their manufacture.

COAL GAS

The generating equipment of a coal gas plant consists principally of: (1) Carbonizing chambers, known as retorts or ovens; (2) furnaces or producers for the generation of gases for heating the retorts or ovens;

(3) combustion chambers around the retorts or ovens in which the heating gases are consumed; (4) flues for conveying heating gases, air for their combustion and the waste products of combustion; (5) off-take pipes for conveying the gas away from the retorts or ovens; (6) hydraulic mains or seals for preventing the return

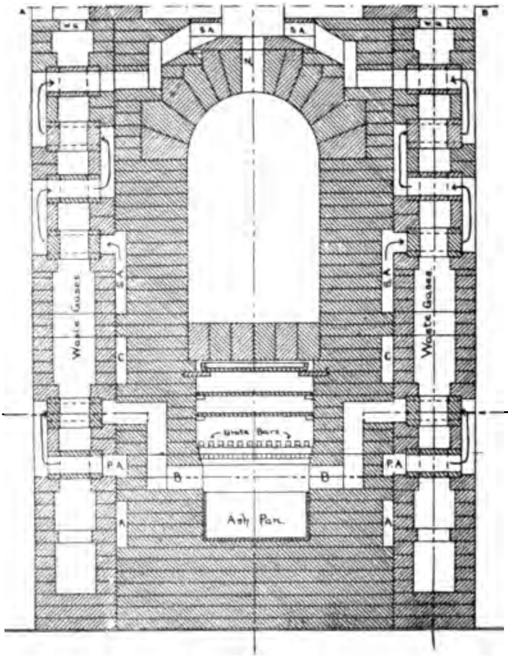


Fig. 67. Gas Producer Beneath Recuperative Coal-gas Bench

of the gas to the retorts or ovens and for the condensation of liquid matter; (7) foul mains for the conveyance of gas from the hydraulic main to the exhausters; (8) exhausters for the purpose of exhausting the gas from the hydraulic main and forcing it through the succeeding apparatus to the storage holder, and (9) coal and (10) coke handling and conveying apparatus.

The retorts, or ovens, are usually grouped together in various numbers heated by one furnace. These groups are commonly called benches, while a battery of benches is known as a stack. The most common type of furnace used for heating the benches is the recuperative type, which differs from the old direct fired type, now practically obsolete, in that combustion of the fuel

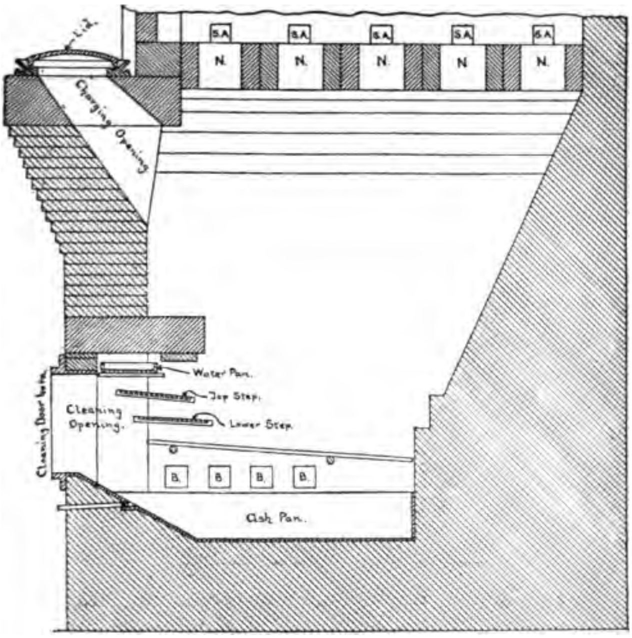


Fig. 68. Section Through Fig. 67 Showing Flues

used is carried on in two operations instead of in one. In the latter combustion takes place just as it does in the kitchen range, the fuel receiving sufficient air for its complete combustion in the fuel bed, the retorts being heated principally by the sensible heat possessed by the products of combustion passing to the chimney through channels or flues arranged under and around the retorts. In the recuperative furnace primary air is admitted under the grate bars in quantities insufficient for the complete combustion of the fuel in the fuel bed, with the result that carbon monoxide (CO) instead of carbon dioxide (CO_2) is produced. The carbon monoxide, which as we have learned is a combustible gas, passes from the furnace to the combustion chamber where it is joined with a quantity of preheated secondary air causing its complete combustion, with the

Fig. 69. Vertical Retort House at Brockton

consequent heating of the retorts. The chief advantages of the recuperative furnace over the direct fired are: (1) Combustion taking place where it is most efficient, under and around the retorts; (2) ease of adjustment and perfect control of "heats"; (3) fuel economy through the more perfect combustion and greater efficiency obtained, and (4) even distribution of heat over the entire bench.

It is essential in the operation of recuperative fur-

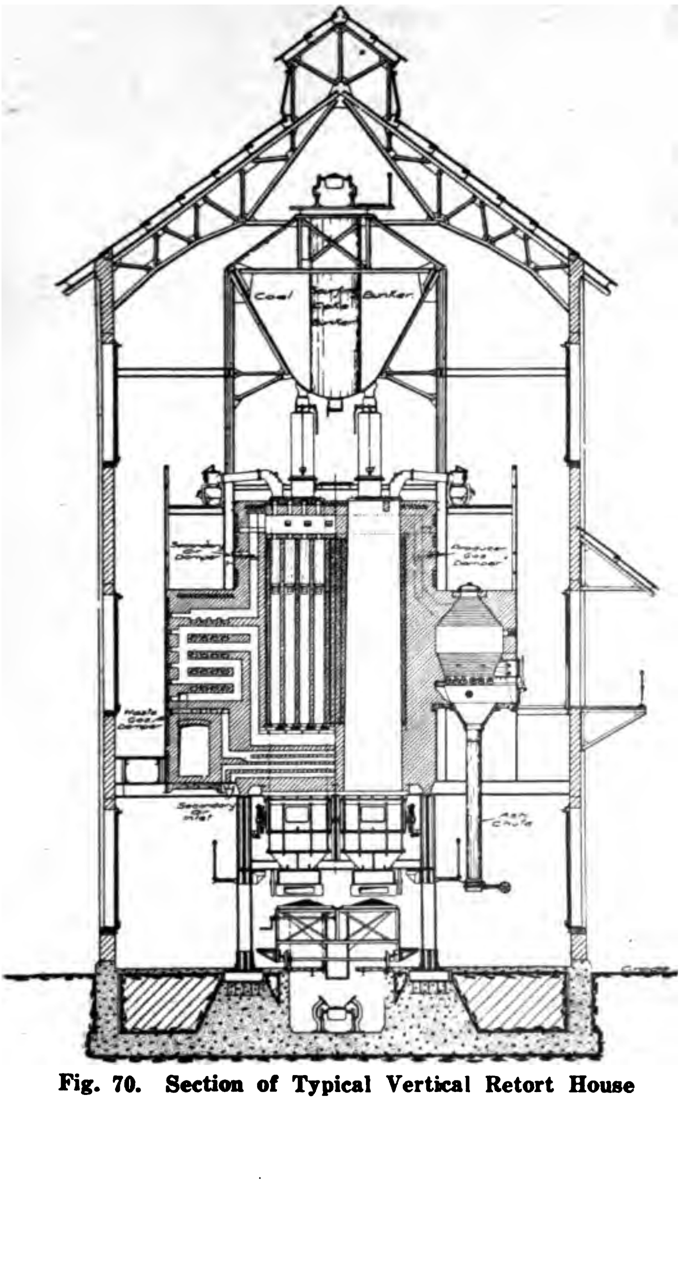


Fig. 70. Section of Typical Vertical Retort House

naces that a deep fuel bed be carried, while in the direct fired type a shallow fuel bed is necessary. Recuperative furnaces may be either full depth, three-quarter depth or half depth, the depth applying to the height of the furnace and consequently the depth of the fuel bed.

Hot coke drawn directly from the retorts into the furnace is usually used, the fuel being replenished at regular intervals with the amount required to keep the

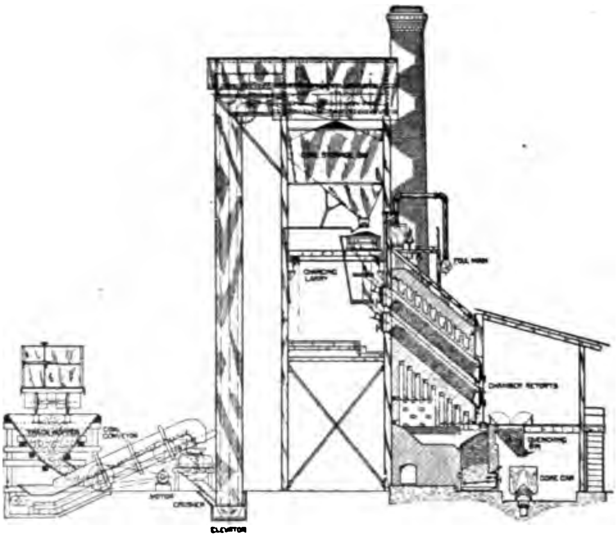


Fig. 71. Section of Inclined Chamber Coal-gas Bench

fuel bed at a constant depth. The fires are cleaned usually once in 24 hours, while in the direct fired type frequent cleaning is necessary. The operation of cleaning fires is not so laborious in the recuperative furnace, as the clinkers, if any are formed, are soft and easily gotten out, while in the direct fired furnace, due to the intense heat produced by the complete combustion of the fuel in the fuel bed, very hard clinkers are formed which are obstinate to remove. Under efficient operating conditions and where the equipment is kept in good repair a fuel consumption of 275 to 300 lbs. per ton of coal carbonized should be obtained with recuperative furnaces.

The average life of a coal gas bench depends greatly

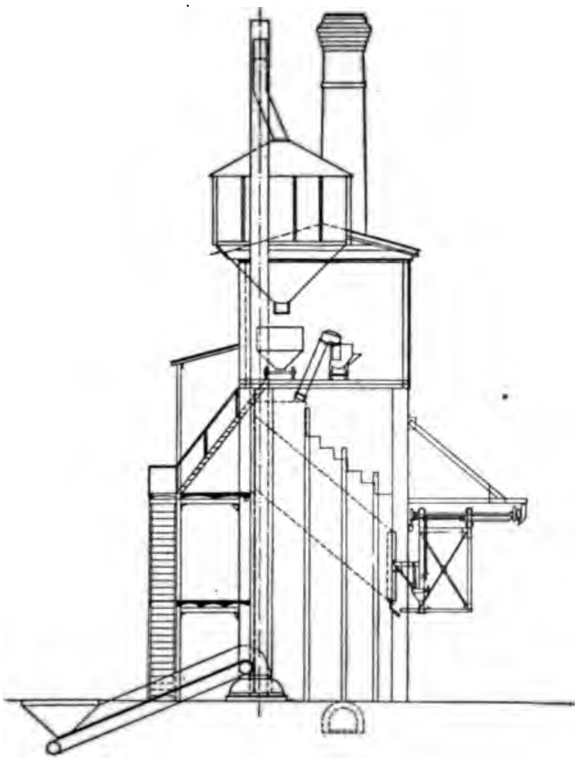


Fig. 72. Inclined Ovens at Auburn Junction

upon the conditions of service and efficiency of operating methods. Anywhere from three to five years' use, depending upon the above conditions, may be obtained on the retorts and their settings, after which they must be replaced. Usually everything within the sides and back walls, charging floor line and arch are renewed. The furnace, walls (except the front wall above the floor line), arch and settings below the floor line may last indefinitely, although they should, and usually do, receive minor repairs at the time the bench is refilled.

The material used in the construction of retorts and settings at the present time is mostly silica, which has a greater ability to stand the intense heat and strains of expansion and contraction than fireclay, although up to quite recently the latter material was used almost

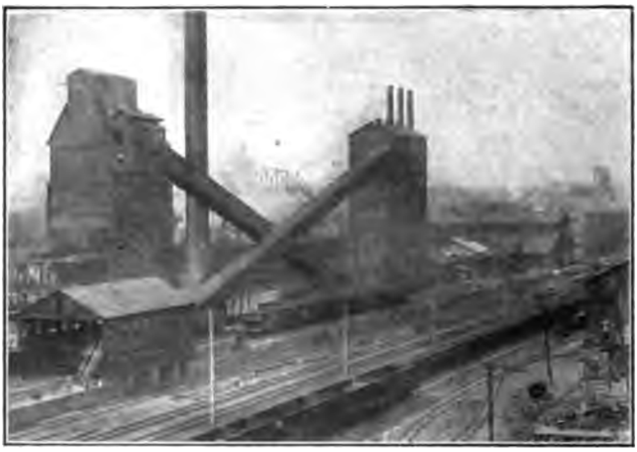


Fig. 73. Typical By-Product Coke Oven Plant

exclusively. It is still used in bench construction where the most intense heat is not encountered, as in the walls, arches and the settings below the combustion chamber.

Retorts or ovens are of various sizes and shapes, which is not of importance in this description, all are fitted with doors for the charging of the coal or withdrawal of coke, and are connected to the hydraulic main by off-take pipes for the passage of gas from the retorts as rapidly as evolved. The hydraulic main is a rectangular box, usually extending along the top of an entire stack of benches. It is filled with tar and ammoniacal liquor to a certain constant depth which is

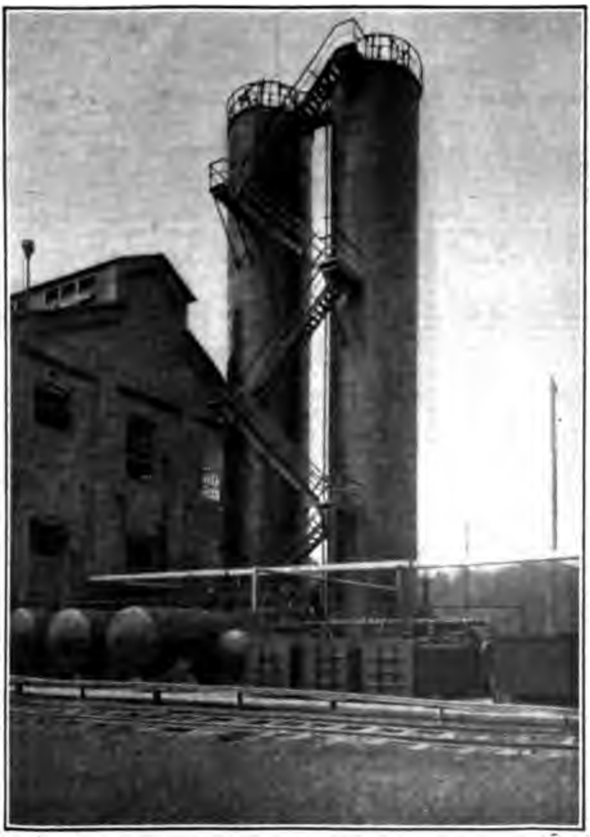


Fig. 74. By-Product Plant of a Coke Oven Works

governed by an adjustable overflow. The off-take pipes dip into this liquid to a depth depending upon the pressure desired upon the retorts, which should be sufficient to prevent the drawing of air or furnace gases through the porous retort but not sufficient to cause excessive waste of gas through cracks or around the joints of the doors. A pressure of from ¼ to ½ in. of water is usually employed. The hydraulic main performs the

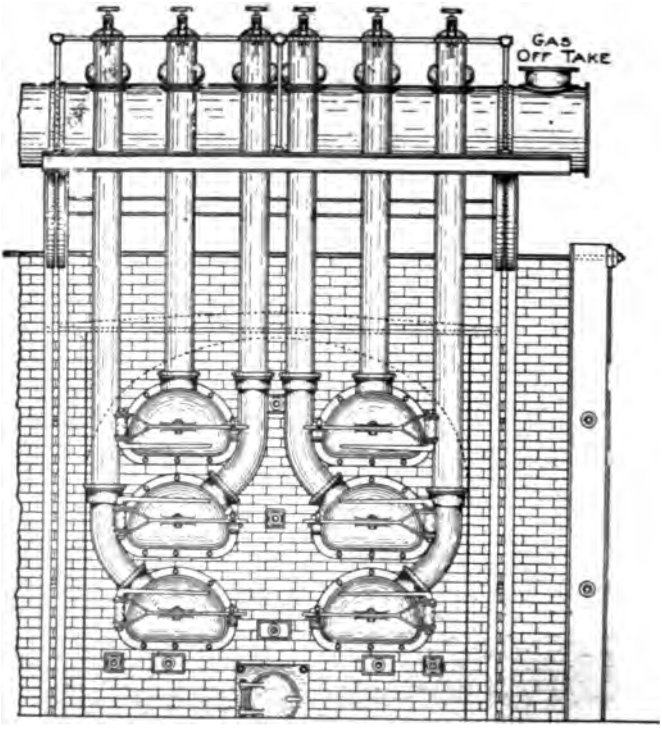


Fig. 75. Front of Coal-gas Bench with Hydraulic Main

double function of preventing the return of the gas to the retort and its consequent escape when the door is opened for charging and drawing, and acting as a condenser for the removal of the heavier tars and a considerable portion of the ammoniacal liquor.

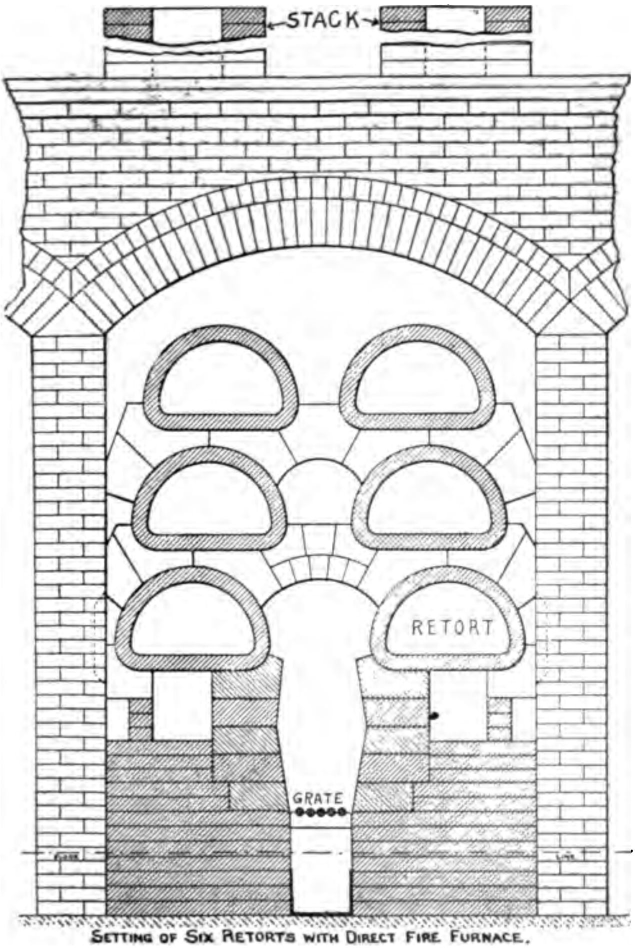


Fig. 76. Special Firebrick Shapes for Coal-gas Bench

The foul main connects with the top of the hydraulic main at one end and to an exhauster at the other. Its purpose is to carry the gas from the hydraulic main. Some form of a condenser or washer cooler is usually installed at an intermediate point in the foul main for lowering the temperature of the gas and thereby reducing the quantity handled by the exhauster, as well as performing the function of removing impurities and by-products. It is customary to call any part of the main piping used in coal gas generation, which is under vacuum instead of pressure, the foul main.

The exhauster is a pump, the speed of which is controlled by some form of automatic governor, which causes the speed to increase or diminish with varying quantities of gas being made or varying resistance of succeeding apparatus maintaining a constant predetermined vacuum upon the hydraulic main, which is essential to efficient operation. If it were not for the exhauster a pressure equivalent to that necessary to overcome the resistance of every piece of apparatus from the retorts to the holder would be exerted on the retort, resulting in a waste of gas that would prohibit coal gas manufacture. The exhauster overcomes this resistance, forcing the gas into the holder and maintaining a vacuum on the hydraulic main which allows the gas to leave the retort very rapidly.

The operation of coal gas generation begins with the coal in storage or in the cars. Sometimes an elaborate conveying system, but more often manual labor, is used to convey the coal to the charging floor, where again either mechanical or manual means are employed for charging and discharging retorts or ovens. The coal, which is broken or crushed to a small uniform size, is weighed or measured before being put into the carbonizing chamber, for the purpose of checking operating results. The weight of the charge depends upon the size of the carbonizing chamber, and the length of the carbonizing period upon the size of the charge and method of operation. The length of the carbonizing period has effect upon the quality of both the gas and coke produced. The gas evolved at the beginning of carbonization is richer in heating and illuminating value than at any later time, its quality varying inversely as the time the coal is in the retort. It is there-

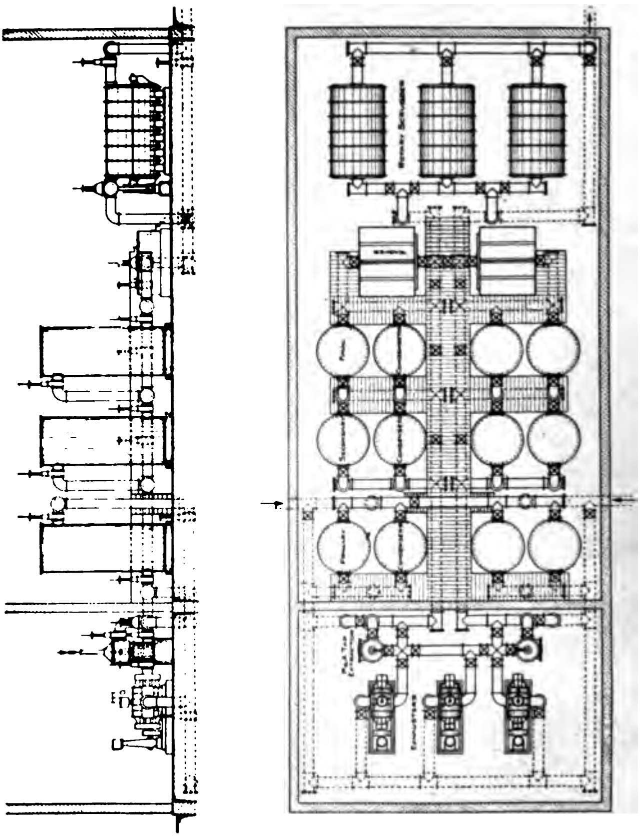


Fig. 78. Elevation and Plan of Coal-gas Cleaning System

fore evident that there comes a time in the carbonizing period when the gas given off is of such value that further carbonization is uneconomical. Where the production of gas is the prime object the length of the carbonizing period becomes the time required to reach this point in the quality of gas, or as commonly stated, the time when the charge is burned off. The time may be determined by frequent sampling and analyses of the gas, after which for the same quality and weight of coal, and under unchanged operating conditions it may remain constant. In by-product plants where the production of coke is of primary importance, its quality is the predominating factor, and as the hardness, which is an important quality, increases with the time the coke

Fig. 79. Exhausters Drawing Gas from Retorts

remains in the oven, the length of the carbonizing period depends upon the degree of hardness desired in the coke.

The coke produced as a by-product in the manufacture of coal gas is of a soft, porous texture, as compared with by-products oven coke, and is therefore subject to greater waste and breakage in handling and deteriorates more rapidly when exposed to the weather, but is an admirable fuel for domestic and many industrial

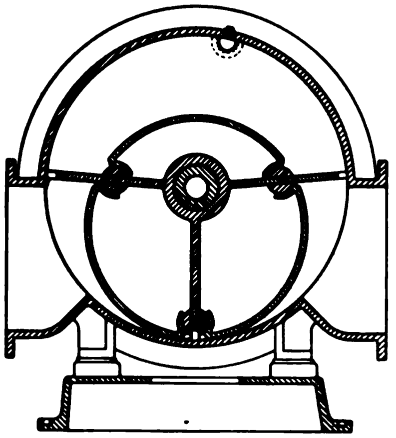


Fig. 80. The Mackenzie Type of Exhauster

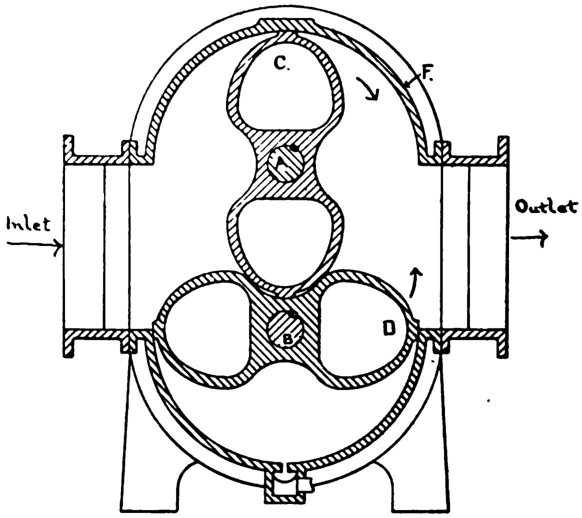


Fig. 81. Section Across the Root Type of Blower

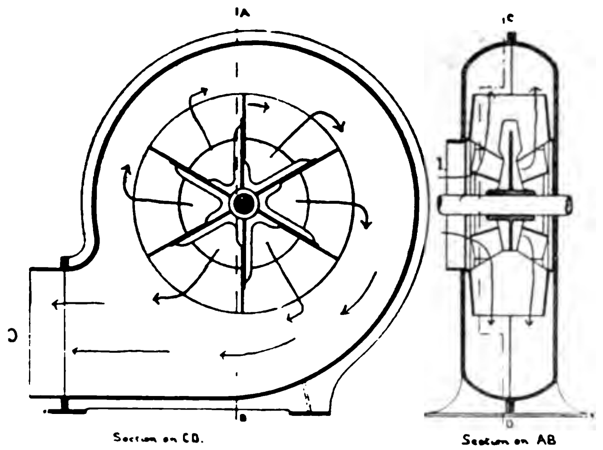


Fig. 82. Sections Through Fan Used as Exhauster

purposes. It is the most important of the coal gas by-products.

As the quality of the coal gas produced varies with the time of carbonization it is necessary to arrange the

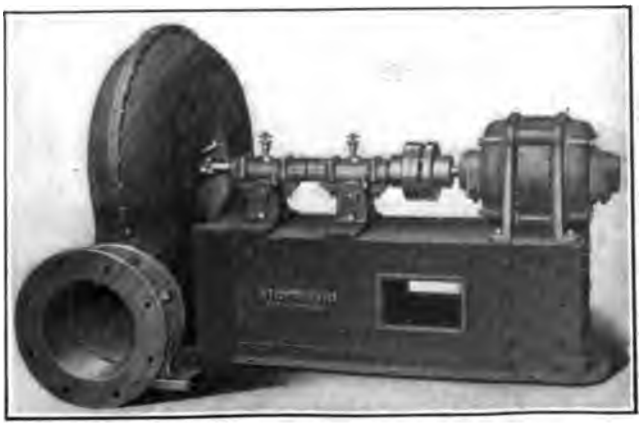


Fig. 83. Fan Operated by Electric Motor

time of charging the different units of generation so that the average quality remains fairly constant.

Coal Gas Treatment and Purification

Coal gas when first produced contains a number of impurities which must be removed before the gas may be distributed for use by the customer. The effects

Fig. 84. Electric Motor Close Connected to Exhaust Fan

of these impurities when contained in the finished gas having been discussed in a previous chapter it will be the purpose of this chapter to deal with their removal from the crude gas. The principal impurities that will be considered are tar, water vapor, ammonia, naphthalene and sulphur.

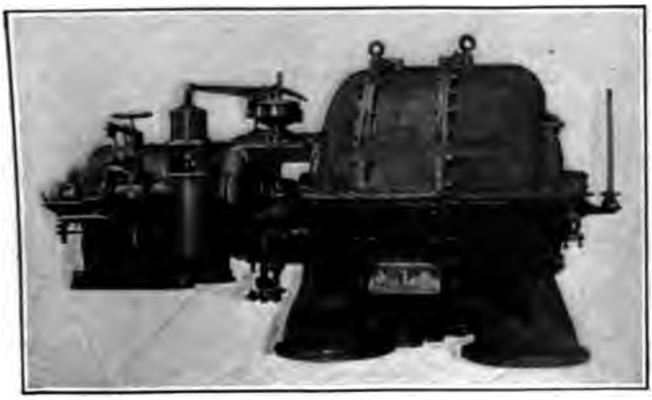


Fig. 85. Exhausters Driven by Steam Turbine

The process of purification begins with the condensation of liquid matter in the off-take pipe leading from the retort and continues until the gas reaches its

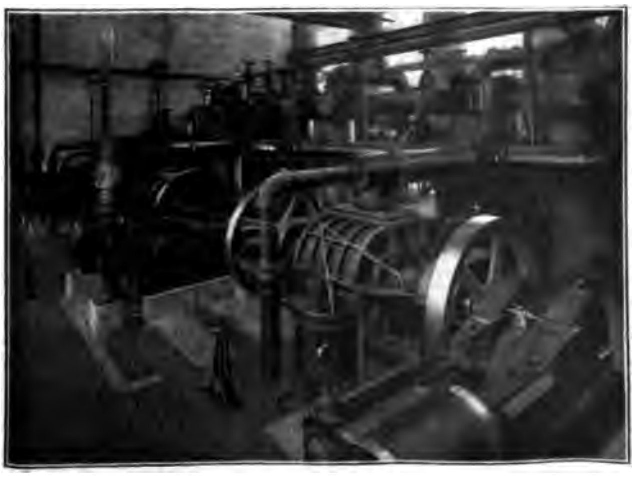


Fig. 86. Exhausters Driven by Steam Engine

minimum temperature. While the functions of the off-take pipe, hydraulic main, foul main and exhauster were considered as generating apparatus they are also included in the list of purifying apparatus

The principal pieces of purifying apparatus with the sequence they usually occupy in a gas plant are:

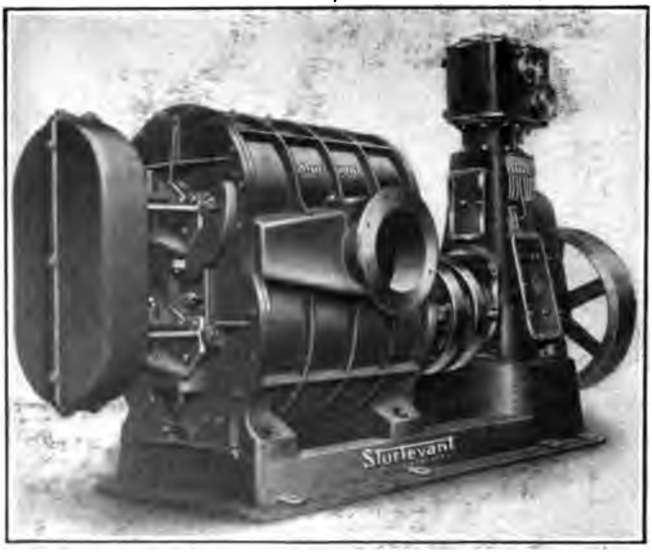


Fig. 87. A Common Form of Blower and Exhauster Drive

1. Off-take pipes.
2. Hydraulic main.
3. Foul main.
4. Primary condenser or washer-cooler.
5. Exhauster.
6. Secondary condenser.
7. Tar extractor.
8. Ammonia scrubber or washer.
9. Naphthalene washer.
10. Sulphur purifiers.

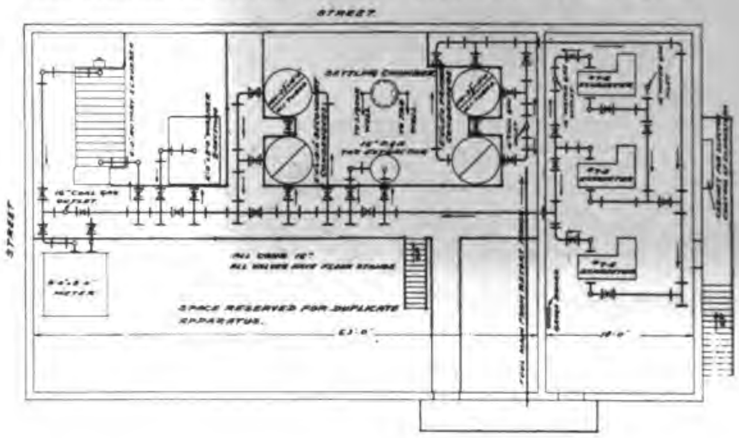
The entire process of coal-gas production and purification from the retorts to the sulphur purifiers involves a gradual lowering of the temperature of the moving gas, with the consequent condensation or dropping of liquid matter along the way in proportion as the temperature is lowered.

From the retort to the hydraulic main, though the dis-

Fig. 88. Modern Design of Rotary Exhauster

tance is rarely more than 10 ft., the drop in temperature is very rapid—from 1,500 to 1,800 degs. F. in the retort to below 200 degs. F. in the hydraulic main. The heavier tar starts condensing in the offtake pipe, while the hydraulic main and foul main condense the larger portion of the tar and water vapor from the crude gas.

In the distillation of coal, ammonia is produced, by the union of nitrogen and hydrogen, which is absorbed by the condensed water vapor in proportion to the quan-



ing process is carried on is known as ammoniacal liquor, and is of varying strengths.

The primary condenser may be of the tubular type,

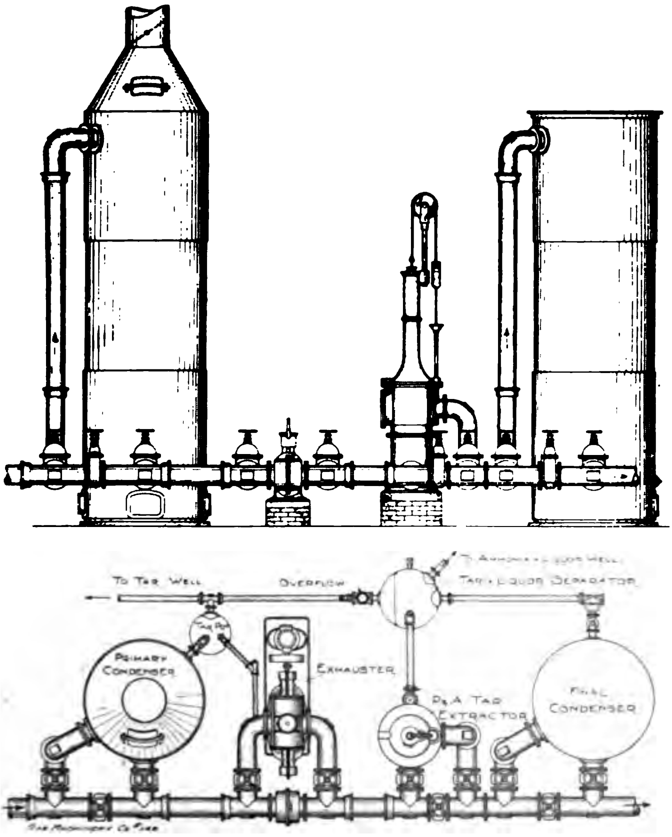


Fig. 90. Cleaning Arrangement for a Small Works

either air or water cooled, or of the washer-cooler type, in which the gas is scrubbed and cooled simultaneously with ammoniacal liquor and tar, which is circulated through cooling coils in series with the apparatus, the excess produced overflowing into a storage well. This piece of apparatus performs the function of further reducing the temperature of the crude gas, which is usually under absolute control from this point, the importance of which is very essential to the removal of naphthalene and the retention of valuable illuminants. Tar and ammoniacal liquor are here removed to a further extent by condensation, due to the decreasing temperature of the gas. The temperature at which the gas leaves this piece of apparatus is entirely dependent upon local conditions and arrangement of following apparatus.

The exhauster is usually the next piece of apparatus,

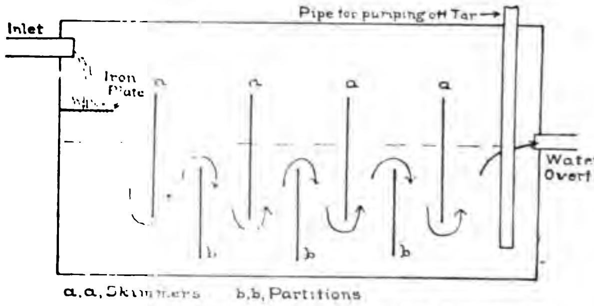


Fig. 91. Section Through Tar Separator

and performs its part in the purification process by removing a portion of tar by the mechanical action of the impellers in churning the gas while exhausting it from the foul main and forcing it through the succeeding apparatus.

A secondary condenser may be the next piece of apparatus preceding the tar extractor, or may succeed the latter apparatus, or it may be dispensed with entirely where a secondary washer-cooler is used. This arrangement is dependent upon local conditions. A secondary condenser performs the same function as the primary.

The tar extractor is used to quickly remove the last traces of tar, by mechanical action, after the temperature of the gas has been lowered to the desired point, between 90 and 100 degs. F., and by so doing practically all naphthalene contained in the gas is absorbed by the

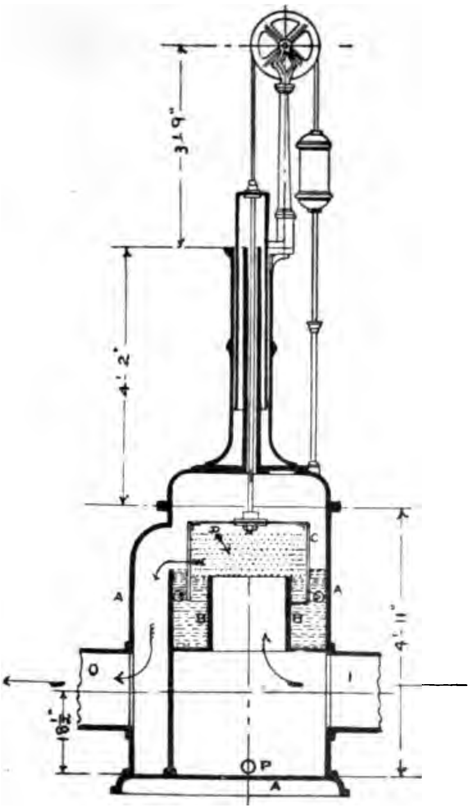


Fig. 92. Section Through a P. & A. Tar Extractor

tar at this temperature and removed with it, while the desirable illuminants, also absorbable by tar at lower temperature, is retained. The type of tar extractor generally used is the P. & A., in which the gas is finely

Fig. 93. Scrubber, Washer, Condenser and Tar Extractor

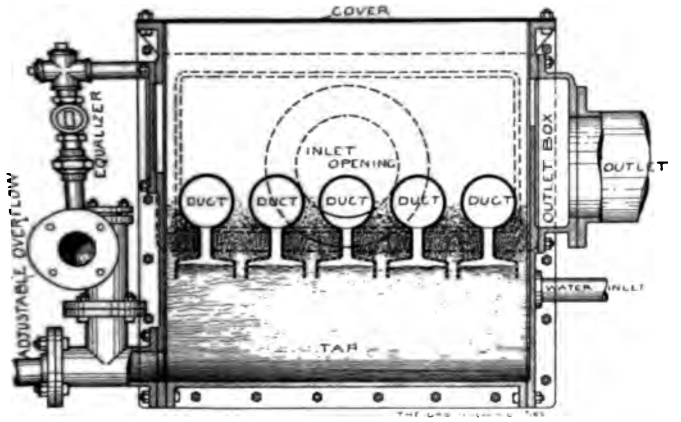


Fig. 95. Stationary Bubbling Washer

divided by passing through small holes in an outer series of plates, impingeing against the plates of the next series, again passing through holes in these plates, etc. The force of the streams of gas impingeing against the plates deposits the tar globules thereon, from which they flow to a reservior and thence to the storage well. The action of this apparatus is automatically controlled so that the area of plates presented to the flow of gas

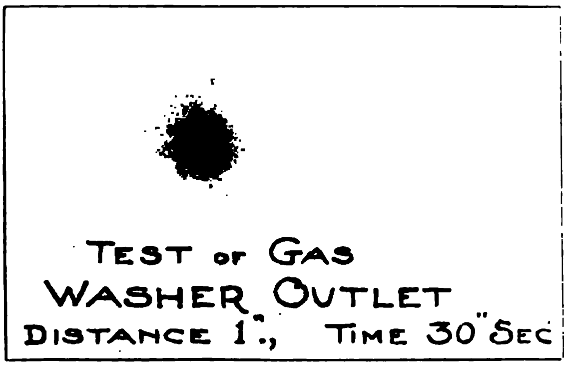


Fig. 96. Satisfactory Test After Washing

is in the proper ratio to the quantity of gas flowing.

The gas, after reaching the outlet of the mechanical tar extractor, is practically free from the tar it contained; but it still contains a portion of its ammonia, which is next removed by absorption through the introduction of fresh water. Water at 60 degs. F. will absorb about 700 times its volume of ammonia gas, so that

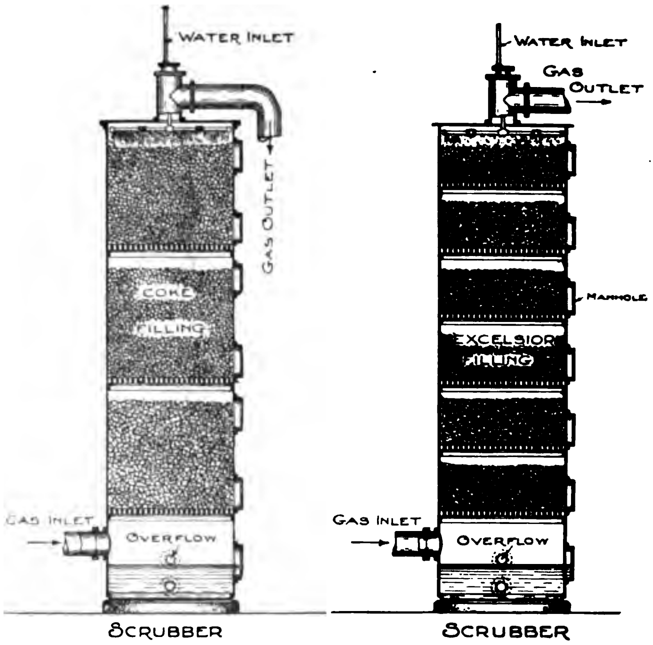


Fig. 97. Scrubbers with Two Kinds of Filling

it is only necessary to obtain a contact between the gas and water for the removal of practically the last trace of ammonia. However, the efficiency of an ammonia scrubber depends upon the degree of contact obtained, using the minimum quantity of water, taking into consideration the strength of the liquor obtained, and the amount of ammonia left in the gas. The strength of the liquor is of great importance, as in the concentration process, which is usually carried on at the gas works, the greater the strength of the weak liquor the smaller the amount that must be handled. Many types of ammonia scrubber and washer are in use, so that no attempt will be made to describe any one of them, as the function performed is the same in all.

It is sometimes necessary at this point in the process

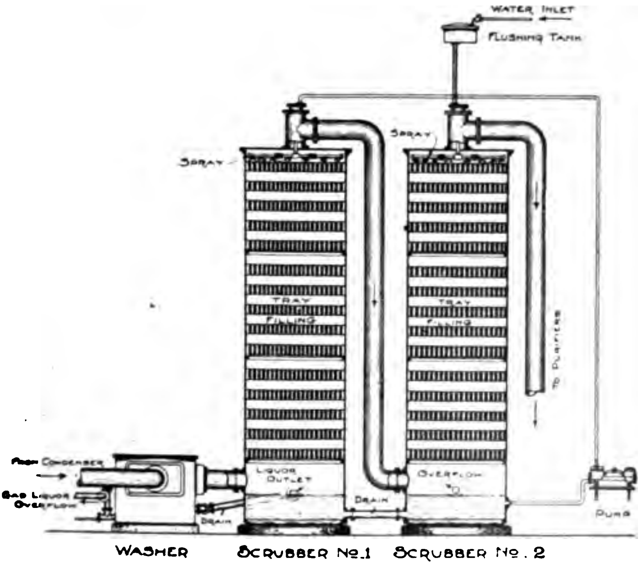


Fig. 98. Trickling Scrubbers Filled with Trays

of purification to provide means of washing the gas with light oils or tar for the removal of naphthalene; but when temperatures of tar extraction are kept under absolute control, especially where the washer-coolers are used, this apparatus can be dispensed with.

The gas is now pracically free from all impurities or substances detrimental to its distribution, except sulphur. A large quantity of the sulphur originally con-

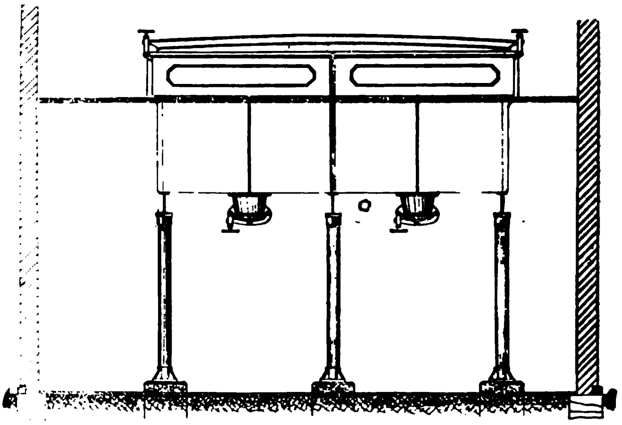


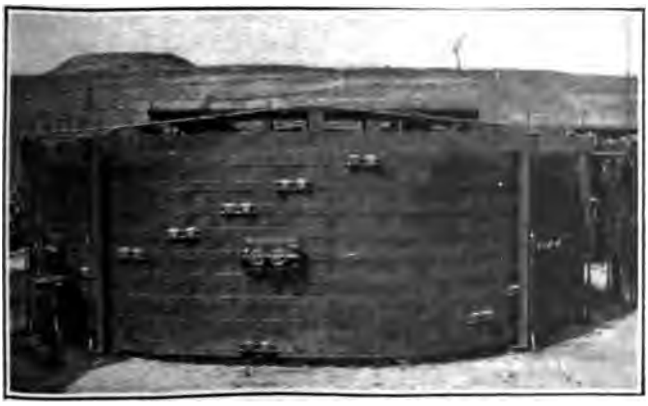
Fig. 99. Common Arrangement of Purifier Box

tained in the crude gas as it left the retort has been removed in the various washing and scrubbing processes that the gas has undergone for the removal of tar

Fig. 101. Outside Purifiers in California

quantity in the form of sulphuretted hydrogen, which is next removed by passing the gas slowly through beds of iron oxide.

It is desirable to reduce the temperature of the gas at the outlet of the last piece of condensing, washing or scrubbing apparatus to 60 degs. F., in order that a



F g. 102. Wooden Stave Outside Purifiers

from the foul main is drawn. In this

Fig. 103. Large Capacity Wet Sta

ture is equalized to some extent—i.
is cooled and the clean gas heated.

Sulphur purifiers consist of rectangu
boxes, made of iron, steel or concrete, i

The reaction which takes place in the purifying box, when reduced to simple terms, is as follows:

$$H_2S + FeO = H_2O + FeS$$

in which H is represented as the chemical symbol of hydrogen, S of sulphur, Fe of iron, and O of oxygen. Sulphuretted hydrogen is a compound containing one part by volume of sulphur and two parts hydrogen, and iron-oxide (oxidized iron borings, or, in other words, rusted iron) is an oxide containing equal parts of iron

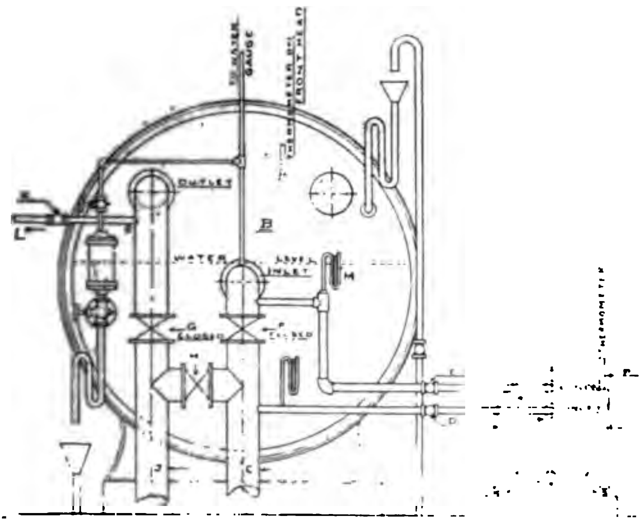


Fig. 104. Connections for Testing Wet Station Meters

and oxygen. When they come in contact a chemical reaction occurs; the two parts of hydrogen, having a greater affinity for oxygen than for sulphur, unite with the former, forming water (H_2O), while the iron and sulphur unite to form iron sulphide (FeS).

After purification for the removal of sulphuretted hydrogen has been carried on for some time, dependent upon the amount of gas passing through the boxes, the amount of sulphur contained in the gas and the amount of iron oxide contained in the boxes, the above reaction naturally stops through lack of iron oxide to continue the process. The material is then revivified by exposing it to the air, either by removing the material from the boxes and arranging it in such manner that contact with the air is obtained or, more economically, by pass-

Fig. 105. Rotary Meter, Philadelphia Gas Works

ing air under pressure through material in the box. The latter method, which is commonly employed, is known as revivifying in situ. The oxygen of the air unites with the iron to form active iron oxide again, while the sulphur is precipitated. This alternation of purification and revivification is carried on until the material contains about 50 per cent by weight of sulphur, when it is not economical to continue further and the material is discarded.

In the arrangement of purifying apparatus it is customary to have a number of units through which the gas can be made to flow in any sequence desired. These boxes are usually in different stages of foulness, or activity of the material, and any one or number may be cut out for revivification when necessary without interfering with the continuance of purification.

The iron oxide as commonly used is mixed with some form of filler, such as wood shavings or ground corn-cobs, to give the material the necessary porosity in order that the gas may pass through it, which would be practically impossible with pure iron oxide, due to its finely divided state.

After the gas has passed through the sulphur purifiers it is considered to be free from troublesome substances or impurities and is ready for distribution to the customer. It is next passed through the station meter for measurment, and thence to the storage holder and into the distributing mains.

During recent years the Rotary meter has become a familiar piece of apparatus in the gas world. The chief claims advanced for this type of meter are accuracy, and occupancy of small space for capacity, thus requiring less expenditure for housing and foundation—e. g., a wet-drum meter 16x16x16 feet has a capacity of 173,000 cu. ft. per hour, and weighs approximately 95,000 lbs. For comparison, a Rotary meter having a maximum capacity of 200,000 cu. ft. per hour has over-all dimensions of 7 feet, and the weight is about 10,000 lbs. The illustration shows a meter of the Rotary type in the meter house of the Philadelphia (25th Ward) Gas works; capacity, 175,000 cu. ft. per hour.

WATER GAS

Carburetted water gas (commonly called "water gas") is a gas produced by decomposing steam by passing it through a mass of incandescent carbon, then adding to or mixing with the resultant gas a sufficient quantity of oil to give it luminosity, or the required heating value. Steam is water vapor at a temperature above the boiling point (212 degs. F.), and is composed of two parts by volume of hydrogen and one part of oxygen. When admitted to the presence of incandescent carbon

Fig. 106. A Typical Town Gas Plant

a chemical reaction occurs in which the steam is decomposed—i. e., separted into its component parts—the hydrogen being freed and the oxygen, which is insufficient in quantity to cause combustion of the carbon, uniting with equal volumes of carbon, forming carbon monoxide. ($H_2O + C = 2H + CO$.) Two gases are therefore formed, both of which have a relatively low heating value per cubic foot when compared with the commercially distributed illuminating gas, neither of which have any illuminating value. This duel, or double, gas is designated by the name of "blue gas," to distinguish it from the mixture after the oil gas is added. The oil gas is produced by subjecting gas oil to a high temperature, which causes it to be "cracked" or transformed into a gas, composed of various hydrocarbons and other substances, similar in composition to the pure oil gas analysis previously shown. The "blue gas" and oil gas are mixed together and subjected to a high temperature sufficiently long to "fix" them into a permanent gas. The generating equipment of a water-gas plant consists principally of:

Fig. 107. Water-gas Plant for Medium Sized City

(1) Blower,
(2) Blast pipe,
(3) Generator,
(4) Carburetter,
(5) Super-heater,
(6) Seal,
(7) Oil pumps, heater, etc.,
(8) Foul main,
(9) Relief holder,
(10) Exhauster.

The blower, which is a fan or centrifugal air pump, is for the purpose of furnishing a large quantity of air for the rapid combustion of the fuel for heating the apparatus during the "blow," and the blast pipe for conveying this air under the desired pressure to the generator, carburetter and super-heater.

The generator is a cylindrical steel shell lined with refractory material, and containing grate-bars for the support of the fuel. Connections are made below the grate bars for the admission of the air blast and steam, and above the fuel bed for the passage of the "blue gas" produced to the carburetter. On the modern machines arrangement is also made for steam admission above the fuel bed and an outlet for the "blue" gas below the grate-bars, valve control being so arranged that alternate "down" runs—i.e., the admission of steam on top of the fuel bed, with consequent gas take-off out the bottom—can be made, which is a decided advantage to the condition of the fuel bed and a potent factor in fuel economy.

The carburetter is a steel shell similar in size and construction to the generator, except that the grate-bars are omitted and the machine is filled with checker work, which is composed of fireclay bricks or blocks arranged in such a manner as to afford a large heating surface, but scarcely any resistance to the flow of gas. The gas inlet from generator is at the top and outlet at the bottom. The blast pipe is connected to the top of the shell, where also are made the connections for the admission of the oil. The function of the carburetter is to mix the "blue" and oil gases.

The super-heater is similar in construction and diameter to the carburetter, but the height is usually greater. The gas inlet from the carburetter is at the bottom and outlet at the top. A valve, called the stack valve, opens from the top of the super-heater to the atmosphere, which is used for the escape of gases and products of combustion during the "blow" or heating-up process. The function of the super-heater is to "fix" or transform into a permanent gas the mixture of "blue" and oil gases.

The seal pot performs the same function as the hydraulic main in the coal-gas plant, acting as a check valve to prevent the return of gas from the relief holder when the stack valve is opened during the "blow."

The foul main performs practically the same function as the foul main in the coal-gas plant—that of conveying the gas away from the seal—except that in water-gas

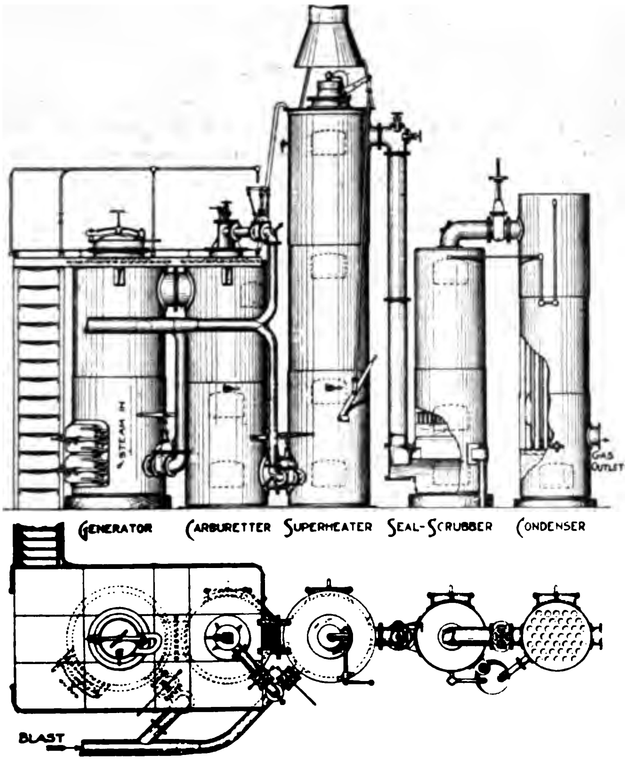


Fig. 108. Water-gas Set, Elevation and Plan

generation the gas in the foul main is under pressure instead of vacuum, and instead of conveying the gas directly to the exhauster it conveys it first into the relief holder. As in coal-gas generation, some means of cooling the gas is employed at some point in the foul main.

The relief holder is a storage tank which compensates for the intermittent process of water-gas generation, allowing the gas made in excess of that pulled by the exhauster to be stored during the "run," or period of gas making, and exhausted during the "blow," or period of heating.

The exhauster serves a similar purpose to the coal-gas exhauster, pulling the gas from the generating equipment and pushing it through the succeeding apparatus. The method of operation, however, is different, for while the coal gas exhauster maintains a constant vacuum on its inlet side regardless of the volume of gas being pumped, therefore running at varying speeds as the amount of gas being made varies, the water gas exhauster is operated at a constant speed, to suit the average make, and varying quantities of gas during a given period are taken care of in the relief holder.

In coal-gas generation the production is practically constant, i. e., gas is made continuously except at the time of charging and discharging the retorts. In water-gas generation the process is intermittent, gas being made for a certain period, during which the temperature of the apparatus is materially reduced, followed by a period of heating, during which the temperature of the apparatus is again brought up to a gas-making point.

The equipment for handling oil consists of a pump, heater, meter, and spray.

The oil pump lifts the gas oil from the storage tank, which is usually under ground or partly so, and elevates it to the top of the carburetter. As it is necessary to admit the oil to the carburetter in a finely divided state (mist form) in order to obtain efficient gasification, it is essential that the oil be admitted under pressure through some sort of spray to get the desired mist effect. It is customary to allow the oil pump to operate continuously, either using a governor on the steam inlet, which is so arranged as to maintain a constant pressure at the discharge side of the pump, or by allowing the oil to flow back to the storage tank when "blowing" the machine. This method insures the admission of oil to the carburetter at the instant it is required and eliminates any delay that might be caused by loss of prime, wet steam or other causes if the pump were started and stopped with the "run" and "blow."

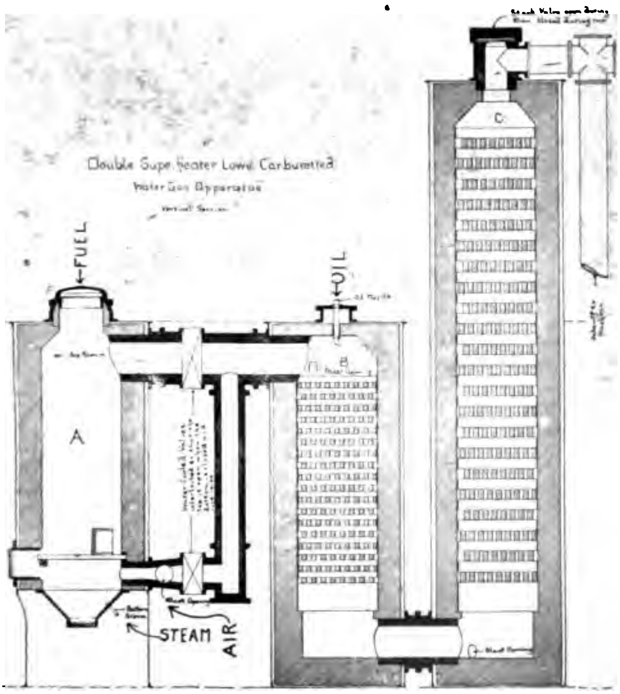


Fig. 109. Section Through Water-gas Machine

The oil heater consists of a closed tank equipped with a heating coil, through which the oil is forced before entering the carburetter. Its purpose is to raise the temperature of the oil, thereby insuring its passage through the spray in an efficient manner and the conservation of heat on the carburetter.

The oil meter is used for the purpose of checking operating results, and aids in the efficiency of the operation of water-gas generation by allowing the operator to use exactly the amount of oil desired per run.

The oil spray is connected to the pump discharge line outside of the carburetter, and extends within the shell of this apparatus several feet. The spray may be divided into three parts—the head, the shank and the cap. The head is a faced casting containing connections to the pump line and cooling water pipes. It is fitted to a companion flange on the carburetter and is held in place by easily operated screw clamps. Connections to oil and water lines are made with quick-opening unions. The shank is fastened to the head and consists usually of a piece of 2-inch pipe acting as the container of a water jacket around the smaller oil pipe, and as the holder for the spray cap. The cap is the spray nozzle, by means of which the oil is finely divided. Its design or, in fact, the design of the entire oil spray is immaterial; so long as the oil is efficiently sprayed into the machine, the spray is prevented from burning up, and means are provided for quickly disconnecting and removing it from the machine.

Operation of Water-Gas Plant

As previously stated, a water-gas machine—which is understood to mean the generator, carburetter and super-heater—may be fired up and gas made upon it within a very short period of time. Where the machine is run a portion of every day, or where even several days elapse between periods of operation, it is only necessary to apply the air blast long enough to cause the fuel to become incandescent, when gas making can be resumed. During operation, after a certain number of "runs" have been made, gas making must be discontinued and the fire cleaned. Due to the intense heat generated in the fuel bed near the grate-bars during the blast, hard clinkers are formed which, after they have accumulated, to a certain extent fuse together and retard passage of the air for combustion and steam for gas making.

Considering that the machine has been brought up to the proper temperature, the operation of gas making follows:

(1) The blast fan is slowed down; (2) super-heater, carburetter and generator blast valves closed, in the order named; (3) steam turned into generator; (4) stack valve closed; (5) oil turned on.

The length of the "run," or gas-making period, depends upon the time occupied in cooling the machine to a temperature below a point of efficiency in generation, and the length of the "blow," or heating period, upon the time required to raise the temperature again to the point of greatest efficiency for gas making. The period of gas-making is usually constant for like conditions, and will continue about six minutes. The heating period may vary in length when a heat-measuring device known as an electric pyrometer is used, but where the heat is judged by the color of the checker work in the carburetter, as observed by the operator, "blows" of constant length are usually used, except after the fire has been replenished. The average length of the "blow" is about four minutes. It is always desirable to get the oil in the machine in the first two-thirds of the "run," allowing the latter third for purging the machine of the oil gas. The quantity of oil used depends upon the quality of gas desirable.

In bringing the machine off of the "run" and on to the "blow," the oil is usually shut off at the end of about four minutes. The balance of the operation follows: (1) The blast fan is brought to full speed; (2) steam is shut off from generator; (3) the generator blast valve is opened; (4) stack valve is opened. Air is now passing through the fuel bed, which has become considerably cooled by the "run," and for a period complete combustion takes place in the fuel bed; but as the temperature increases and the fuel becomes incandescent, complete combustion is restricted to an area within the fuel bed comparatively close to the point of entrance of the air. Carbon dioxide (CO_2) is formed by this complete combustion, which, passing through the deep bed of incandescent fuel, unites with a portion of carbon forming 2CO (two parts carbon monoxide). This combustible gas passes into the car-

Fig. 111. Steam Boilers Fired by Waste Heat

buretter, when the next step in operation becomes necessary: (5) the carburetter blast valve is opened. By the admission of air into the carburetter the carbon monoxide is consumed, or changed to CO_2, with the consequent heating of the carburetter. It is not necessary to blast the super-heater on every run, as the sensible heat produced by the passing through it of the product of combustion from the generator and super-heater are usually sufficient to make up the comparatively small loss of heat in this part of the apparatus, after the machine has been in constant operation for a while.

The generator fuel is replenished at regular intervals--usually after every fourth or fifth run.

The purification of water gas is simpler than for coal gas, as no impurities need be considered except tar,

Fig. 112. California Oil-gas Plant

water vapor and sulphur, the latter being present in a much smaller proportion than in coal gas. It will not be necessary to outline the exact method of purification, as the impurities present are removed in practically the same manner as the like impurities contained in coal gas, which was fully explained in a previous section.

CALIFORNIA OIL GAS

The process of oil gas generation in the Pacific Coast states is very similar to the generation of water gas, previously explained, except that solid fuel is not used. The equipment consists of two shells instead of the three used in water-gas production. These shells are known as primary and secondary generators. The primary generator serves the same purpose as both the generator and carburetter in water-gas production. Oil

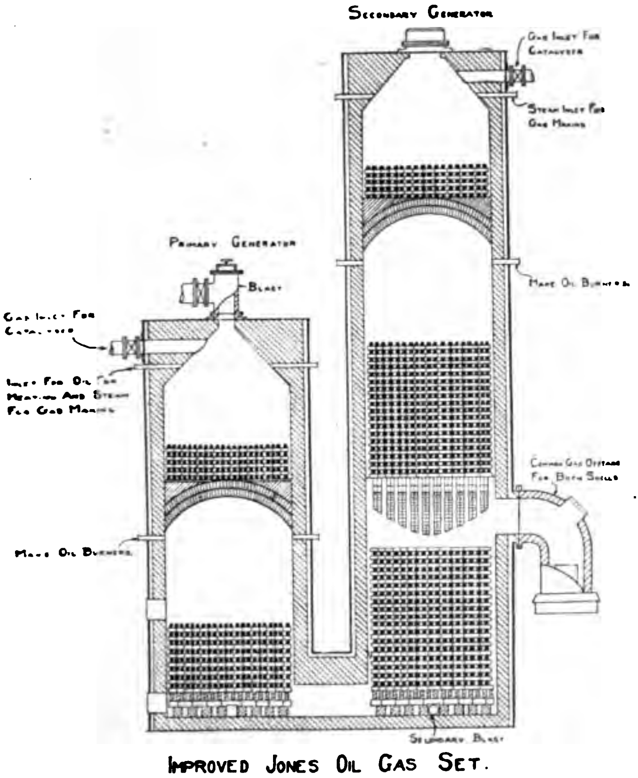


Fig. 113. Water-gas Machine Using Oil Only

and steam are admitted to this apparatus through specially designed burners, the steam being decomposed, the hydrogen being freed and the oxygen united with carbon from the oil to form carbon monoxide. The

can Gas Institute, in October, 1909, entitled
velopment of Oil Gas in California," for full
tailed information on the subject of "Oil Ga
facture."

The Tenney System of Gas Plants

The Tenney system of domestic gas manufac

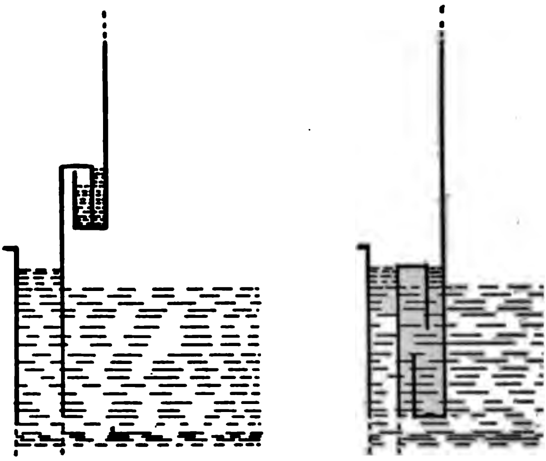


Fig. 114. Holder Cup Before and After Disen

distribution may be compared with the Pintsch
in use for railroad coach lighting throughout t

bination of the generator, carburetter and super-heater in one shell, the principle is identical. This system is especially adapted to small and widely separated towns or communities, where the cost of the ordinary methods of manufacture, storage and distribution would be prohibitive.

A full description of the Tenney process of gas manufacture and high-pressure distribution for small towns appears in a paper read by Mr. Ralph B. Wagner before

Fig. 115. Group of Gas Holders at the Works

the twenty-fourth annual meeting of the Michigan Gas Association, in September, 1915.

STORAGE OF GAS

Purpose of Holders—Where artificial gas is produced and distributed it is absolutely essential that means be provided for storing a quantity during times of light demand by the consumers for use during the times of heavy demand. In a previous section entitled "Gas Sendouts" it was shown that the use of gas by the customers is not at a constant rate, that it varies very materially during different periods of the day, and also varies greatly from day to day. The daily load may be divided in two parts; the day load, or period of heaviest demand, and the night load, or period of lightest demand. The day load may be again sub-divided into five parts—three peaks and two depressions. The peaks correspond to the meal hours and usually cover the

Fig. 116. Single-Lift Gas Holder in Steel Tank

periods between 7 a. m. and 9 a. m., 11 a. m. and 1 p. m., and 5 p. m. and 7 p. m. The depressions cover the periods between the peaks.

In the majority of instances the largest peak of the day load is during the supper hour when the cooking and lighting loads overlap, i. e., gas is used for light and fuel at the same time. There is usually one hour of the day, called the peak hour, which is the hour of heaviest demand, when the gas sendout often equals 10 per cent of the entire daily sendout, while the daily

Fig. 117. Multiple-Lift Type of Holder

load may equal 85 per cent of the daily sendout. If a supply of gas were not kept in storage the hourly capacity of a gas plant would need to equal the amount of gas sent out during the largest peak hour of the year, which would mean intermittent gas making to suit the sendout and a large investment in idle gas-making apparatus for the greater part of the time.

The storage capacity of a gas plant very seldom exceeds one-third or one-fourth the daily sendout, and may be even a smaller proportion where water gas is made. It is customary in the larger cities to have the storage holders located in different parts of the city

Fig. 118. Holder and High-Pressure Distribution Tanks

whereby a more efficient distribution of the gas is obtained.

Besides their use for storage purposes, gas holders are a source of pressure for forcing the gas through the distributing mains.

Gas Holders

A gas holder, or storage unit, consists of one steel tank inverted in another tank, slightly larger in diameter, containing water. The inverted tank, which is known as the bell, is free to rise and fall in the water, as gas is put into it or taken from it, and is equipped with suitable guide frames and rollers to hold it in place without interfering with its upward or downward motion. Inlet and outlet pipes project through the bottom of the water tank and upward to a point slightly above the surface of the water.

Gas holders may be of single or multi-lift design, single lift holders being simply a bell and tank, while multi-lift holders may consist of two or more cylin-

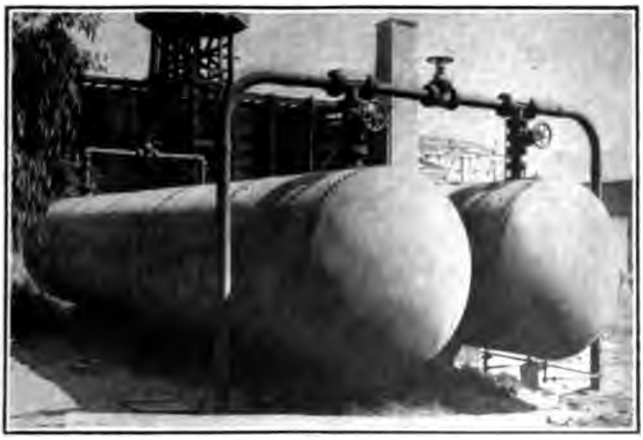


Fig. 119. Pressure Storage in California

drical sections telescoping within each other as the holder is deflated or emptied. When a multi-lift holder is being inflated, or filled, the upper sections engage the one next below in such a manner that it is pulled up as the holder fills and a joint formed at the point of engagement, known as the cup, which fills with water from the tank, forming a seal to prevent the escape of gas between the two sections or lifts.

As the gas within a single lift holder, which is wholly or partly inflated, must support the weight of the bell, or in multi-lift holders those sections also which are not landed a pressure is exerted upon the gas within the holder equal to the weight of any sections of the gas holder which are not resting on the bottom of the water tank reduced by the buoyancy of the gas.

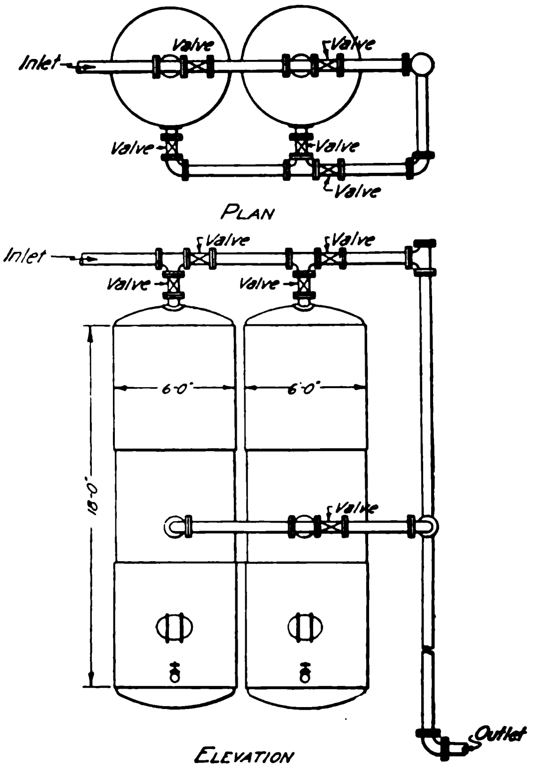


Fig. 120. Pressure Storage Tanks with Condensation Blow-off

CHAPTER IV

DISTRIBUTION SUGGESTIONS

The purpose of a distribution system is to carry the gas from the plant, or source of production, to the meter in the customer's premises, where it is to be utilized.

As the greater part of the investment of a gas company is represented by its distribution system, efficiency, permanency and at the same time economy of

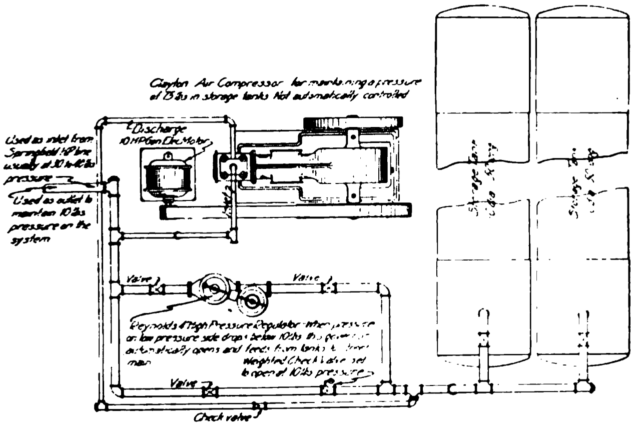


Fig. 121. High Pressure System for Small Plants

installation and operation are important factors to be considered. Local conditions influence the type of a system to be used, as there are scarcely two cities in the country which in point of layout are identical. Gas companies are dependent for the favor in which they are held by their customers upon the class of service rendered and one of the most important factors governing good service is efficient delivery of gas to the customer's premises. To insure this efficient delivery large investments are constantly being made in distribution installations or betterments which in most cases require a great many years to be returned through revenue.

Often very complicated problems are met with in distribution work where cities, by their rapid development, have outgrown or grown away from their distributing systems. Were it possible to lay out a distribution system in a new city, whose future growth could be accurately foreseen, it would be no trouble to

Fig. 122. Pintsch-gas Pressure Storage

construct an ideal system. As it is, engineers of distribution are kept busy keeping pace with developments and peering into the future, in order to maintain good service to the customer. And it is usually a phase of the gas business which is but slightly appreciated by the customer.

Kinds of Distributing Systems

Distribution systems may be divided into three classes: Those operated under low pressure, those under medium pressure and those under high pressure.

As a distinction between the classes some defined pressure range must be given each. Systems carrying pressures up to one pound (27 in. water) may be classed as low pressure systems, those carrying from one to five pounds as medium and those carrying above five pounds high pressure systems. A number of combinations of the above systems are used in various cities, most of which have been evolved as a modification of some existing system.

In the early history of the gas industry all distribution was done under low pressure, but as the business

Fig. 123. Portable Cylinders for Storage Under Pressure

developed the need of greater carrying capacity in the existing mains or larger mains became apparent, and as the former was possible by increasing pressures, the result was an evolution in distributing systems which has resulted in the high pressures so generally used today, and which has made possible the distribution of gas to small communities from a centrally located plant which otherwise would never have been supplied.

The benefits derived from this evolution in gas pressure have not been confined to the new customers obtained by supplying isolated districts. Better service has resulted from the efficient control of pressures, which has resulted in revenue from new customers and increased revenue from old ones, while installation costs have been reduced through the use of smaller and cheaper wrought iron mains instead of the large and costly cast iron pipes used in low pressure distribution.

The following is a list of the various distribution systems in use today:

1. Distributing with low pressure from a holder or holders, located at the plant.

2. Distributing with low pressure from both station and district holders.

3. Distributing with low pressures, but supplying district holders through medium or high pressure lines.

4. Distributing with low pressure, the low pressure mains being reinforced through district governors from a belt line carrying medium pressure.

5. Distributing with low pressure, the low pressure mains being reinforced through district governors from a belt line carrying high pressure.

6. Combination pressure being used. The pressure being raised at the plant to suit requirements in outlying districts, individual regulators being used on the services adjacent to the plant and along feeder mains where required.

7. Medium high pressure carried on all mains with individual regulators on each service.

8. High pressure carried on all mains with individual high pressure regulators on each service.

The above list shows plainly the evolution through which distribution systems have passed.

Each system has its special advantages provided the system is adapted to the particular city in which it is used. There can be no fixed rule as to which system is the best to apply to all cities, but due to the flexibility and low first cost No. 6 consummated in No. 7 is adaptable in most cases.

District holders are installed in advantageous geographical locations, carefully selected for various reasons, which may be: (1) Direction of growth of city;

Fig. 124. Where the Distribution System Begins

(2) increasing population of certain districts, or (3) new districts to be supplied. Primarily the purpose of district holders and boosting stations is to overcome

the effects of pipe length although the use of such holders as storage units is advantageous.

District Holders

District holders may either be filled through transmission lines which are separate from the distribution system or directly from the distributing mains. In the latter case they take in gas during times of lightest consumption, usually at night, and discharge into the system during times of demand. Where district holders are used it is necessary to have separate pressure schedules for each station.

District holder stations are equipped with necessary boosting apparatus for carrying the desired pressures upon the mains supplied therefrom, which may be low, medium or high pressure as the case may be.

MAINS AND SERVICES

The mains and services of a distribution system are comparable to the house-piping system on the custom-

[redacted]

A supply main is a branch of, or a connection between, feeder mains and is the pipe to which services are connected.

A service is the pipe running from the main to the consumer's premises, ending with the service meter.

In most efficient distribution work the supply mains

Fig. 125. A Peep Into the Underground World

are relatively small pipes connected with the feeder mains preferably at either end, and at sufficient intervals of distance to assure adequate supply to the customers. In the city of Denver, Colo., which is operated under system No. 6, outlined above, all supply mains are 2-in. wrought iron pipe, except in the business districts, and no trouble is experienced in supplying adequate pressures.

The size of gas services depends upon the pressure system used, the length and the amount of gas to be supplied therefrom, with an allowance for increased consumption and possible accumulation of foreign substances. It is customary to install pipes of a fixed size to supply buildings of the same class. Gas companies in late years have recognized the advantages of in-

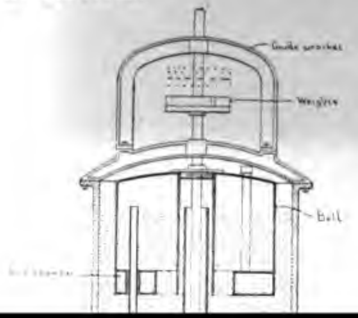
Fig. 126. Lead Caulking of City Gas Mains

stalling service pipes of larger size, and by adopting that policy at a very small advance in cost of construction have saved large sums in maintenance and renewals.

With the increasing tendency of sentiment toward the abolishment of the illuminating standard, and the fixing of a heating standard considerably lower than at present, an increase in the carrying capacity of mains and services will be made necessary. It is possible

Fig. 127. Welded Joints for High Pressure Mains

that before many years the single standard will be put into effect and it is not unreasonable to presume that the heating value of the gas may be fixed at some point near 300 B.t.u. per cu. ft. This will mean, provided the efficiency of gas consuming appliances is not increased, that the consumer in order to obtain the same heating effect as at present must consume twice the amount of gas, which will double the required carrying capacity of mains and services.



ance, or a number of appliances, with a valve located therein. At the inlet and outlet of this valve are gages to show the pressure within the pipe. A man is stationed at the valve to open or close it as the pressure decreases in the pipe beyond the valve, as shown by the outlet gage, which corresponds to increasing or de-

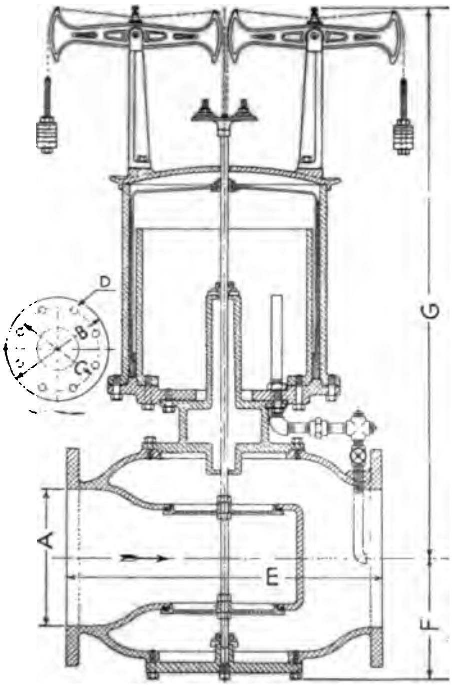


Fig. 129. Section of Automatic Governor

creasing volumes of gas required by the apparatus supplied. This arrangement would be a governor maintaining a constant pressure at its outlet side regardless of the volume of gas flowing. The man in control of the valve could carry any pressure at the outlet gage desired below and up to that shown on the inlet gage, when his control would cease due to the valve being wide open. This type of governor would be a non-automatic governor, i. e., it would supply increasing or decreasing volumes of gas as of the pressure maintained at the outlet gage.

Now suppose that more appliances should be added

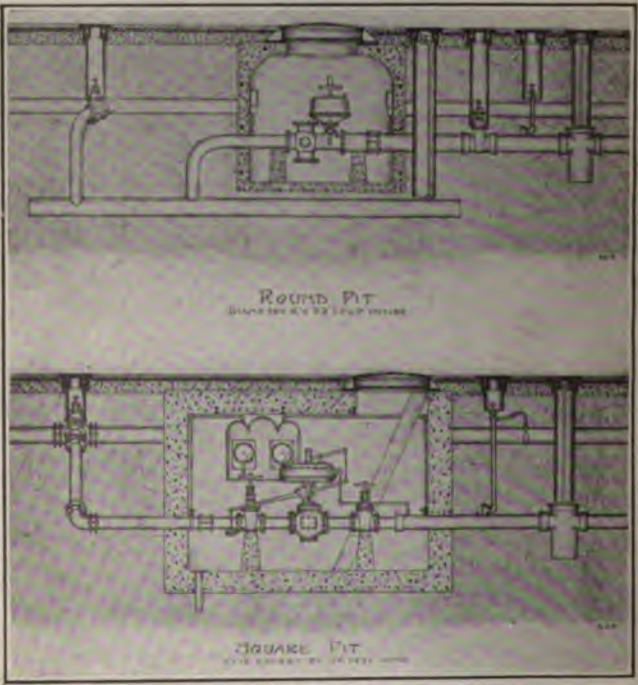


Fig. 130. Arrangement of District Governor in Pit

so that the outlet pressure as maintained by the operator would be insufficient to supply an adequate volume of gas. The non-automatic governing arrangement becomes useless until the operator determines what pressure to carry on his outlet gage in order to

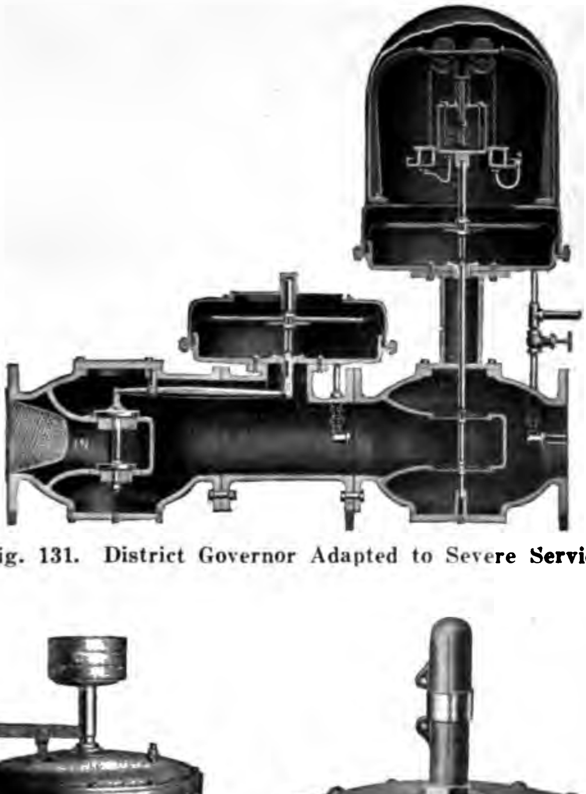


Fig. 131. District Governor Adapted to Severe Service

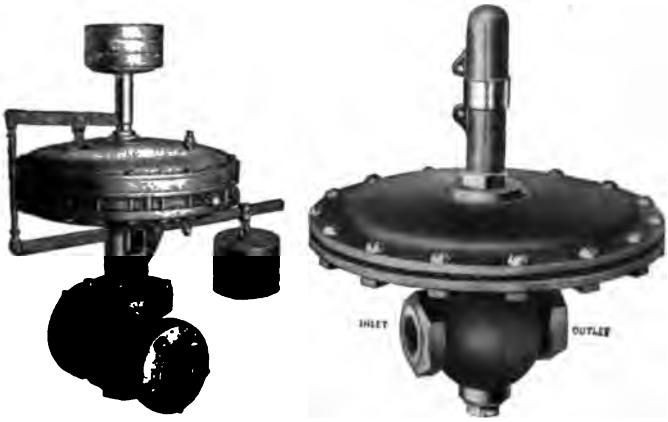


Fig. 132. Two Types of Service Pressure Regulators

supply the gas required by the changed conditions. In order to overcome this a gage is installed at the extreme end of the supply pipe, at the last appliance, a man is stationed there by a telephone who informs the operator of the pressure shown at this gage, the valve operator now opens and closes the valve to suit de-

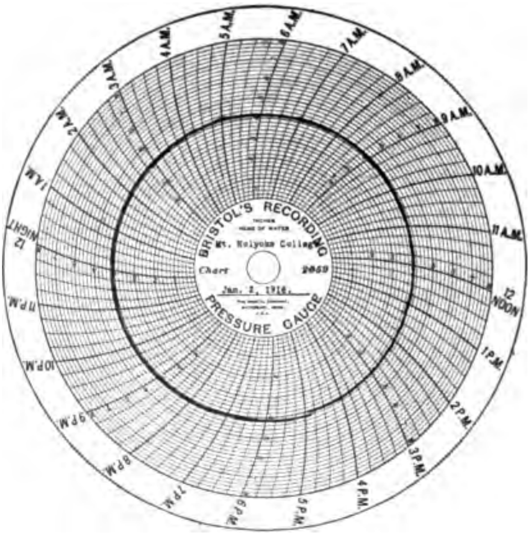


Fig. 133. Effect of Pressure Regulation

creasing and increasing pressures at this terminal gage, the gage at the outlet of the valve now shows varying pressures up to that maintained at the inlet of controlling valve as conditions of demand change as shown by the terminal gage. This governing arrangement corresponds to an automatic governor.

The above illustrations show that pressures may be governed so long as they are lower than the outlet pressure of the governing devise.

District governors are for the purpose of supplying gas from a main of higher pressure to one of lower and may be non-automatic or automatic as desired. They are usually located in manholes at points in a district selected in regard to arrangement of distributing system with the view of reinforcing pressures within the district so controlled.

Service governors are placed on each individual service pipe near the meter and are used where the pressure on the distributing system as controlled from the plant or boosting station is too high for utilization by the customer or is subject to a wide range of variations. Service governors are of the non-automatic type main-

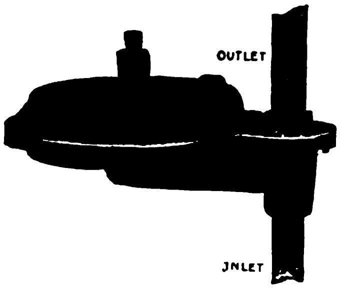


Fig. 134. Consumers Service Pressure Regulator

taining a constant outlet pressure regardless of the volume of gas flowing.

Gas Condensates

Any gas which comes in contact with water will become saturated with water vapor at the temperature the gas then possesses. As explained in the previous chapter on "Gas Manufacture," the condensation of water vapor and its removal is one of the important features of purification, but it cannot all be removed since the temperature of the gas for other reasons cannot be lowered at the outlet of the holder, which is the last place where it comes in contact with water, to a point below that which it will reach in its journey to the consuming appliance.

A unit quantity of gas may be described as being composed of a number of spherical particles called molecules. At high temperature these molecules move away from each other and the gas is said to expand. A containing vessel to now completely enclose the molecules would have to be larger than the one enclosing them originally at the lower temperature. Thus the gas has increased in volume with the rise in temperature; but the number or size of the molecules have

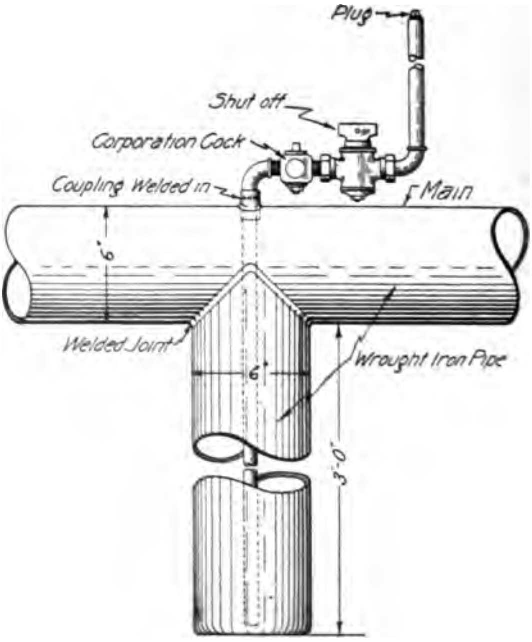


Fig. 135. Blow-off Drip on High Pressure Main

not increased. Therefore, the increase in volume is due to an increase in the spaces between the molecules. Decreasing temperature has an opposite effect, causing the molecules to crowd together, with a decrease in the spaces between them, and the gas contracts or loses volume.

The point of saturation of a gas is when the spaces around the molecules are completely filled with water vapor. The gas is then said to be 100% saturated. If pressure is put upon a saturated gas, or its temperature is lowered, the gas contracts in volume—i. e., the spaces between the molecules become smaller and some of the water vapor is condensed or squeezed out; but the gas still remains 100% saturated at the existing temperature, for the spaces between the molecules are still

Fig. 136. Drip of Ordinary Design Welded on the Job

completely filled with water vapor. If the pressure were released or the temperature increased, causing the gas to expand or increase in volume again, and considering that the water previously condensed had been removed from the presence of the gas, the spaces between the molecules would not be completely filled with water vapor and the gas would not be 100% saturated, and could be distributed without further trouble from condensation, provided its volume did not again contract to a point less than for 100% saturation

In order to make the theory of saturation and condensations perfectly clear, due to its very great importance in gas distribution, we may compare a unit quantity of gas to a certain sized sponge. When the sponge is immersed in water it becomes completely saturated (it should be noted that its size has not changed, but its weight has). If it now be squeezed in the hand, corresponding to increased pressure or decreased temperature, water is removed in proportion to the degree

Fig. 137. Hand Pump on Motor Drip Wagon

of pressue exerted by the hand; the volume of the sponge has also become smaller. Now, if the hand be opened the sponge expands to its original size, but has lost weight and is not completely saturated. It can now be squeezed without the loss of water until the same pressure of the hand is exerted as before. Had the water which was squeezed out of the sponge been caught in a vessel and the compressed sponge immersed in it at the time the pressure of the hand were removed, it would have picked up the water in expanding just as gas would if allowed to expand in the presence of water.

The important points to be brought out in the above explanation are:

(1) Gas in contact with water is saturated at the temperature it possesses.

(2) Increased pressure or decreased temperature causes condensation of water vapor.

(3) If the condensed water vapor is not removed

Fig. 138. Power Pump on Motor Drip Wagon

from contact with the gas it will be again absorbed if pressure is decreased or temperature increased.

(4) The volume of a gas is not changed by its degree of saturation—i. e., gas volume is not decreased by condensation or increased by absorption.

(5) The weight of a unit quantity of gas is effected by saturation.

(6) Water vapor will always be condensed in the distribution system unless the gas is contracted at the last point where it comes in contact with water, more than it will ever be contracted again before consumption.

sible to do so until the gas is consumed.

The condensation of vapors being direc
tionate to the amount of temperature decre
sure increase, the amount of condensate re
the gas will be greatest at the plant, pro
decreasing, until at the outlying parts of t
tion system, where temperature and pressur
constant, very little if any condensation t
The gas consumed in the outlying districts
poorer quality than that consumed closer t
due to o n of illuminants bef
reaches e s.

The gas is dependent upo
tures e utside of the pipes
In the tion mains and serv
the temperature of the ground enclosing the
mains and services are usually laid at a uni
from the surface of the ground, gas tempera
once attaining that of the ground, are fairl
The distance which the gas travels from th
for attaining this temperature is directly pr
to the velocity of the moving gas. In the cas
piping systems, the temperature of the gas
ant upon local existing conditions which
by rules of installation which
in this respect the prevention of
ture and provisions for the elimination

[redacted]

If allowed to accumulate, it will completely retard the flow of gas when its depth in the pipe equals the pressure of the gas in inches of water column. But it is not necessary for this depth to be attained before interference to gas flow begins. As the water accumulates the gas pressure tends to force it along and upward in the pipes, which causes a forward and backward motion of the water as the gas pressure and weight of water intermittently overcome each other. This causes a fluctuation of the gas pressure at the burner, which is known as a "flicker." The "flicker" gradually grows worse as the amount of water accumulates, until the flow of gas is entirely stopped. A trap or water pocket, even of small capacity, will eventually prove a source of interference to the utilization of gas.

Drainage of Gas Pipes

Any gas pipe must be laid to a slight grade, with its lowest end terminating in a receptacle from which condensation may be removed. This rule is of equal importance in the smallest house pipe and the largest gas main. This is one of the most important reasons for the preliminary inspection of gas piping by the gas companies.

The condensation receptacles are commonly known as "drips." These drips very in size proportionately as the cubical contents of the gas pipe drained and the amount of gas flowing through the pipe, and in gas-main systems the distance from the plant. Drips should be prohibited in house-piping systems except at the service meters, unless absolutely unavoidable toprevent the trapping of a pipe, as they become when once installed a source of perpetual maintenance.

The fitter should bear this in mind in cases where it is often easier to install a drip than to grade the pipe properly toward the meter. The additional cost of grading the pipe properly should not be considered, as it is usually a small matter when compared with the advantage gained in eliminating the drip. In a gas-main system, however, it is often necessary to install drips where the carrying of the grade of the pipe would entail a large expense. No drip should ever be installed where it is not easily accessible for the removal of condensation, and any expense is warranted in carrying out this rule. A drip should be provided at the outlet of every service meter, into which the condensation from the house-piping system drains. This reduces the amount of condensate collected in the

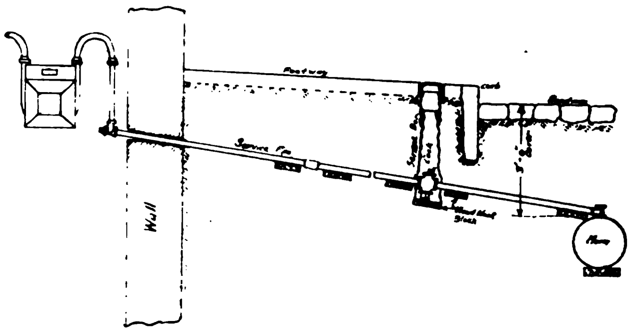


Fig. 139. Condensation Drains Toward the Main

meter, which is advantageous to the life and proper working of its mechanism.

The Removal of Condensation from Gas Pipes

If condensation is not removed from the collecting receptacles they become useless in time by becoming filled up. The intervals at which the condensation is removed depends upon the size of the drip. For house-piping systems it is not necessary to have a fixed time for this removal, but a practice should be adopted requiring the fitter to examine any house-piping drip which he encounters in his work. Any large or important drips installed on the customer's premises should be recorded and emptied at regular intervals.

Gas-main drips are recorded in a drip record book, where the date and amount of condensation removed

is entered each time the drip is emptied. These drips are separated into classes known as daily, weekly, monthly, semi-yearly and yearly drips, corresponding to the intervals between emptying, and classed according to their importance in respect to cubical contents of main drained, amount of gas flowing and distance from the plant. The daily drips are usually relatively

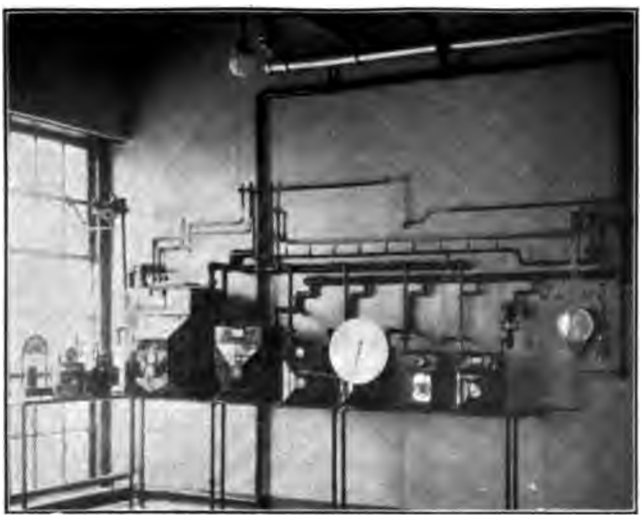


Fig. 140. House Pipe Stoppage Instruction Equipment

close to the plant, while the yearly ones are in the extreme outlying districts. The amount of condensate is recorded for the purpose of a check upon the condensation in the districts drained by each drip. As the amount should be constant over corresponding periods of two years, any abnormal change which might be due to a leak or a stoppage of the drip can be investigated.

Service drips are to be avoided unless conditions make drainage toward the main absolutely impossible, in which case they should be installed preferable outside of the customer's premises and handled in the same manner as main drips.

Great care should be exercised in the handling of condensate that none is spilled either upon the customer's premises or in the street, as the foul odor may

Fig. 141. Pump for Clearing House Pipe

be the source of annoyance to and complaints from the customers or public, which is always to be avoided.

Frost in Pipe and Thawing

Frost in gas pipes is caused by the freezing of the water vapor contained in the gas before it has time to condense, the action being similar to that which causes the vapor of clouds to be frozen and fall to the earth in the form of snow.

Frost, while at times a source of considerable trouble to gas companies, may be entirely overcome if proper precautions are used in installing or protecting the pipes.

The principal causes of frost complaints are: (1)

Fig. 142. Portable Steam Outfit for Pipe Thawing

Services running through area ways; (2) meters in exposed places; (3) risers in outside walls, and (4) exposed bridge pipes. Frost accumulations form in gas pipes in concentric rings, beginning at the pipe and continuing inward until complete stoppage occurs in small pipes. In large pipes, after a certain thickness of frost has accumulated on the inside of the pipe, it acts as an insulator and prevents further freezing. In such cases the effect produced by frost is simply a restriction of the area and reduction of the carrying capacity of the pipe.

Temporary relief may be obtained where trouble is encountered from frost stoppages by pouring or forcing alcohol or its fumes into or through the pipe, or if obtainable hot water may be poured over the surface of the affected section of pipe. The use of blow torches or flames of any kind, though sometimes practiced, is not recommended, due to the hazard attached.

The permanent prevention of frost troubles may only be accomplished by removing the cause, which can in practically all cases be done. Pipes should never be installed or meters set in places where they will be exposed to extreme temperatures, unless absolutely necessary, and then such protection should be employed as to eliminate danger of freezing gas. Exposed piping may be protected by its enlargement at least two sizes, say, $\frac{3}{4}$-inch pipe to $1\frac{1}{4}$ inch, or $1\frac{1}{4}$-inch to 2 inch, and in the case of gas mains by 2 inches in size, or by covering with hair-felt or ordinary steam-pipe covering. Meters may also be protected with some of the insulating materials. Every frost complaint encountered by the fitter should be reported specially to the foreman, who should make a thorough investigation of the cause and have a permanent preventitive change made in the installation as soon as practicable. If this is done, it will soon be found that frost complaints are a curiosity. If the cause lies with the customer, he should be induced to assist the gas company as well as aid himself in securing better service. Sometimes a riser or other piping in the control of the customer needs to be changed to prevent the gas from freezing, or a window or door in the basement needs closing up. In such cases the customer should be served with a regular form or printed notice telling him what is necessary to prevent a repetition of his complaint, and offering to do the pipe work necessary at actual cost. This notice may be worded in such a manner as to be polite, yet to create the impression that further responsibility lies strictly with the consumer, which rarely fails to bring results.

Any pipe installed under ground should be laid below the frost depth of the particular locality in which the city is located.

It is important that any gas pipe which may at any time be exposed to freezing temperatures, even though insulated or enlarged, should be provided with tees and plugs, placed in accessible places, for the admission of alcohol if required by abnormal climatic conditions.

HOUSE PIPING

Pipe and fittings compose a gas company's delivery system for carrying the gas from the plant to the customer's burner. They serve the identical purpose of the grocery man's truck, the railway freight train or the steamships, but have the decided advantage of the smaller effort on the part of the customer in securing delivery, which consists simply of the turning of a valve or cock. The efficiency in which delivery is made, which takes into consideration time and effort, constitutes the quality of service from the customer's standpoint, and often overbalances the cost of such service. The grocery man who employs rapid motor trucks, which deliver the groceries to a housewife in the shortest time after ordering, is the groceryman who prospers, even though he may charge a little more than the man who delivers his goods by wagon later in the day.

The modern restaurant man does not consider the additional cost of his gas bill over the old-time coal bill, because he has been able to serve twice as many customers in an equal period of time by the delivery system, or service, he has had since using gas, and he has been able to secure a higher class of labor in his kitchen through the conveniences obtained; consequently he has made more money and is satisfied. The housewife never throws out her gas range because the gas costs her a slight sum more than did her old coal range. She considers the value of the conveniences she has had, in the small effort expended in cooking the meals, the lack of dirt, the freedom from coal and ashes, the small amount of discomfort, and the fact that the gas is delivered to her, with scarcely any effort on her part, at any time of the day or night she desires it. Efficiency of delivery, which is analogous to good service, is the thing which all gas companies strive to attain. It can only be accomplished through the proper installation of pipes and fittings. Unless piping systems are installed properly, so that the highest efficiency is given the customer in delivery, or service, all efforts of a gas company are vain.

The pipes installed must be of a size to allow the delivery of the full amount of gas required by the consuming appliances. In deciding upon the proper size, considerations must be made for the length of the pipe and the differential pressure to exist between the initial and terminal ends. The terminal pressure must of necessity be that of most efficient utilization, while the initial is in most cases fixed by that existing in the mains or at the plant. The method of installation should be such that a maximum efficiency of service may be expected. Any method which might lead to imperfect utilization or imperfect service to the consumer should be eliminated at any cost. Satisfied customers denote perfect service, and where this is attained it means that pipes are installed properly; that they are supplying the customer with sufficient gas at any time he desires to use it, either day or night, and that no leaks exist. Upon these two things depend the efficiency of any piping system.

Pipe and Fittings

Pipe used for conveying gas on the consumer's premises are, as a rule, either made of wrought iron or steel, with screwed joints and fittings; but there is no reason, with the rapid progress made in and its adaptability, why the autogenous welding of joints should not be more extensively employed in piping new buildings. About 98 per cent of the leaks found in gas piping systems are caused by defective fittings or joints, while but 2 per cent are due to defects in the pipes themselves. It is very apparent that a piping system can be no more efficient than its fittings or method of joining. It is practically impossible, under ordinary conditions, to break a length of pipe except at the threaded joint. Therefore, if the joints are welded,

Fig. 143. Sturdiness in Fitting Design

making a continuous pipe of the entire system, it is safe to say that chances of leakage would be reduced at least 90 per cent.

Fittings used in gas work should be made of malleable iron and should be beaded—that is, reinforced by a heavier ring cast around the fitting at its face, the danger of split fittings being thereby greatly reduced. Cast-iron fittings should not be used on gas, as they are more easily broken and are more liable to contain sand-holes. There is no economy in the use of inferior material because it can be bought cheaply. No fitting should be connected to a piping system until it has first been carefully examined, and after it has been made up on the pipe it should receive another examination. This will often prevent tearing down the piping to remove the fitting after the test has been applied. Likewise, no piece of pipe should ever be connected up until it has been stood upon end and rapped with a hammer to loosen any scale or matter which might create a stoppage hazard; after this it should be held toward the light and looked through. It is also well to examine the weld along its entire length. A good pipe fitter takes pride in his work, and is not always trying to tear down a good piece of work

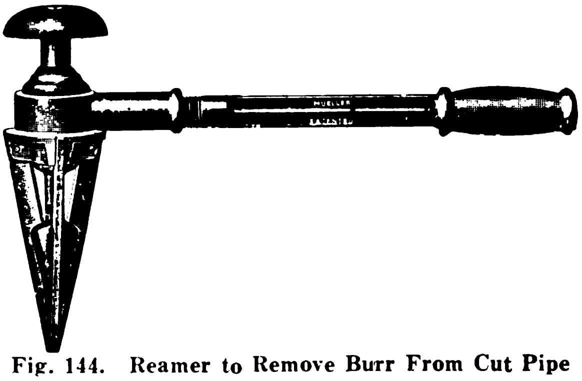


Fig. 144. Reamer to Remove Burr From Cut Pipe

on account of a piece of defective material, discovered after the job is done.

There never was a harder rule to enforce, nor one of greater importance, than that of removing the burr left by the cutting-off tool on the inside of gas pipe. It appears in every book of rules printed, yet a reamer is an unknown tool to the average gas fitter. This burr, in addition to creating a place for the lodgement of foreign substances, causing stoppages, retards the flow of gas by restricting the area or carrying capacity of the pipe. In pipes of small diameter this restriction in area is greater in proportion to the total area than in pipes of larger diameter; likewise is the stoppage hazard greater. Any fitting or joint offers a certain resistance to the flow of gas which is greater than that of the pipe itself, so that to add resistance which could be eliminated is to reduce the efficiency of the entire piping system.

No pipe or fitting which has previously been used (in other words, second-hand material) should ever be used in concealed piping. The value of new material is but slightly more, while the element of chance is reduced to an extent warrantable of the extra cost.

Pipe "dope" is used for the purpose of lubricating the surface of threads which are to be screwed together, to reduce friction, and is not for the purpose of preventing leaks. It should be used sparingly, and upon the male thread only. When used on the female thread it is pushed ahead as the joint is made up and forms an annular ring on the inside of the fitting, creating a stoppage or restriction to the flow of gas.

Permanency is a desirable feature in any gas piping system, and any cause, except natural decay, which might lead to destruction of the system should be eliminated. Pipes are destroyed by various agents, such as the action of electric currents (electrolysis), oxidation (rusting), corrosion caused by certain elements in soils, masonry, etc. One of the usual places for pipe destruction is in, or at either side of, concrete or brick walls, where the wall is subject to dampness. All service pipes or other gas pipes passing through such a wall should be enclosed by a casing of larger-sized pipe and be spaced centrally within this casing. No pipe should be laid in ashes or other soil known to contain destroying elements, unless protected by some sort of covering impervious to water (concrete cannot be classed as such a substance), and the pipe should be galvanized. Electrolysis is caused by stray currents or leakage from an electric circuit (usually in railway systems, where the rail is used as the negative conductor), and can be mitigated either by reducing the cause of the leakage, the installation of insulating joints, insulating pipe covering, or by conducting the current through the pipe in such a manner that harm does not result, by means of a connection from the pipe to the negative conductor of the source of current. It is not often that trouble from electrolysis is experienced in inside piping, but if such a contingency occurs, in which case the current would most likely come in through the service pipe, an insulating joint should be inserted ahead of the service meter and connection then made from the gas main side of this joint to the negative of the electric circuit.

When working on any gas pipes which are known to conduct electricity, a "jumper," consisting of a wire large enough to carry the current, should be connected to either side of the point in the gas pipe which is being worked upon. If this is not done and the pipe is separated, an arc will occur, which might cause a fire or explosion.

The most frequent cause of electrolysis is the imperfect bonding of the rail joints in street railway systems, which causes the return or negative current to leave the rail and seek a better conductor. A gas pipe, which is a good conductor, in close proximity to the resistance or break in the regular circuit offers a good path for the current, and it will follow it until resistance in the gas pipe or a better conductor causes it to leave the pipe, in which case a hole is burned in the pipe by the chemical or "electrolytic" action occurring wherever the current leaves the metal in the soil.

Any pipes or fittings which are exposed to moisture, so as to cause oxidation or rusting, should be galvanized, which is usually all the protection required. This should be done where the pipe must be run in damp cellars or basements, and in the Southern States, where pipes are often run outside.

MISCELLANEOUS DATA PERTAINING TO PIPES

Expansion of Wrought-Iron Pipes—The co-efficient of expansion of wrought iron, as given in Kent's Handbook, is 0.00000648 for 1° Fahrenheit, where the length equals 1. To find the expansion of a given length of pipe, the formula would be: $E = L\ 0.00000648\ (T - t)$.

L = the length of pipe.
t = Initial temperature.
T = Terminal temperature.
E = Expansion in some lengths as L.

Capacity of Pipes—The flow of gas through pipes is given in the following tables:

Cubic Feet Gas Passed in One Hour

(3 inches initial pressure; 2-10 inch drop—Denver G. & E. L. Co.)

Diameter Inches	Length in feet 10 ft.	20 ft.	30 ft.	40 ft.	50 ft.	60 ft.	70 ft.
3/8	42	30	24	21	19	17	17
1/2	85	60	49	42	38	35	27
3/4	197	140	113	99	88	81	62
1	395	280	227	198	177	161	126
1 1/4	832	590	480	417	373	339	264
1 1/2	1311	930	753	657	588	535	416
2	2397	1700	1377	1202	1074	978	760

Standard Dimensions, Capacity and Weight of Wrought Iron Pipe for Steam, Gas, Oil or Water

(Table prepared by the Metric Metal Co.)

Nominal inside diam. inches	Actual inside diam. inches	Actual outside diam. inches	Thickness inches	Outside diam. of couplings inches	Length containing one cu. ft. feet	Weight ft. of length lbs.	Length of thread inches	No. threads per inch
1/8	0.270	0.405	0.068	0.510	2500.0	0.243	9-32	27
1/4	0.364	0.540	0.086	0.720	1385.0	0.422	3-8	18
3/8	0.494	0.675	0.091	0.844	751.5	0.561	7-16	18
1/2	0.623	0.840	0.109	1.156	472.5	0.845	1-2	14
3/4	0.824	1.050	0.113	1.375	270.0	1.126	9-16	14
1	1.048	1.315	0.134	1.625	166.9	1.670	5-8	11 1/2
1 1/4	1.380	1.660	0.140	2.125	96.25	2.258	11-16	11 1/2
1 1/2	1.611	1.900	0.145	2.375	70.65	2.694	13-16	11 1/2
2	2.067	2.375	0.154	2.937	42.36	3.767	7-8	11 1/2
2 1/2	2.468	2.875	0.204	3.500	30.11	5.773	1	8
3	3.067	3.500	0.217	4.062	19.49	7.547	1	8
3 1/2	3.568	4.000	0.226	4.687	14.56	9.055	1 1-16	8
4	4.026	4.500	0.237	5.187	11.31	10.728	1 1-8	8
4 1/2	4.508	5.000	0.247	5.750	9.03	12.492	1 1-4	8
5	5.045	5.563	0.259	6.343	7.20	14.564	1 1-4	8
6	6.065	6.625	0.280	7.343	4.98	18.767	1 3-8	8
7	7.023	7.625	0.301	8.437	3.72	23.410	1 1-2	8
8	7.982	8.625	0.322	9.375	2.88	28.348	1 5-8	8
9	9.001	9.688	0.344	10.560	2.26	34.677	1 5-8	8
10	10.019	10.750	0.366	11.680	1.80	40.614	1 3-4	8
12	12.000	12.750	0.375	13.930	1.27	49.000	2	8

Approximate Discharge in Cu. Ft. Per Hour

(Straight pipe, gas 0.6 gravity, 0.5 in diff. pres.—Dr. Pole's formula)

For 1 in. diameter

Length feet	Discharge cu. ft.
50	275
100	200
150	160
200	140
250	125
300	115
350	110
400	100
450	95
500	90
600	85
700	80
800	75
900	70
1000	65

For other diameters

Diam. inches	Multiplier
½	0.181
1	1.00
1¼	1.80
1½	2.93
2	5.92
2½	10.60
3	16.50
4	34.10
6	95.00

CHAPTER V

LABOR SAVING IN THE GAS INDUSTRY

One of the most important items in the gas business today is the problem of labor. The gas industry in common with all other employers of labor is dependent upon the law of supply and demand in the matter of obtaining and handling its labor situation, which has a direct bearing upon the manufacture and distribution of gas, both in the cost of production and service and in the quality of service rendered the customer.

With due allowance made for the abnormality of the present conditions affecting labor the fact must not be lost sight of that a resumption of conditions as existing prior to 1914 cannot be expected within a number of years, with probabilities almost certain that they will never return. There are two phases to the labor problem: one is a question of cost, the other the question of efficiency. The former can be overcome by the adjustment of rates, while the latter is almost impossible of mitigation. The gas companies must look at the problem from both angles; they must consider the cost of labor and the possibility of obtaining the proper class of labor to carry on their operations. Both must be followed to the common end, conservation of man power. The gas industry is powerless if the class of labor required is unobtainable at a price within reasonable limits of the rate obtainable for their product. All gas men have wondered in the last ten years what became of the type of old gas man similar to Lloyd's Mike and Clancy. We know this type is as extinct as the prehistoric animals, but no one seems to know where they have gone. With their going we have suffered a loss that has not been replaceable in man power and which we must expect to see become more and more pronounced as the law of supply and demand operates. The alternative is labor-handled, may virtually be considered as the following:

(a) Some mechanical means for lifting coal to the desired high point in the retort house.

(b) Some convenient and certain method of weighing the coal as it passes into use.

Fig. 147. Coal to Overhead Bins Without Labor

(c) Some mechanical means of putting the coal into the retort.

(d) Some mechanical means of removing the coke from the retort.

(e) Some mechanical means of taking the coke away from the retort house.

It appears advisable where hand labor is to be reduced to reduce it to the actual minimum. In most cases the extra investment necessary is not prohibitive, for if an expense is warranted to obtain a partial saving a further expense will be advisable to obtain the full saving. This can best be done by a complete new installation of modern carbonizing apparatus. The vertical retort offers the opportunity for greatest sav-

Fig. 148. Trolley Automatically Transports Fuel

ing as the coal is fed and coke discharged by gravity. In the case of the vertical retort the fundamental steps are identical with other mechanical means in the a, b and e, but are very much simplified in c and d. Other types of carbonizing equipment that are preferable to mechanically operated horizontals are: The oven (various types) and the horizontal retort type. In either of these latter types some of the advantages of the vertical are present to a more or less extent. We believe that the full modernizing of carbonization

Fig. 149. Mechanical Handling, Screening and Loading of Coke

plants should be the aim of all gas companies and should be carried out as rapidly as labor-saving equipment is warranted.

The Doherty Fuel Economizer

Bench operation and control is an important essential in coal gas manufacture. This is aided to a large extent by the Doherty Economizer. A fuel saving is effected by this apparatus through the burning of a portion of the CO_2 taken from waste gas flues and converted to CO. The heat or energy absorbed by this

Fig. 150. Mechanical Coal and Coke Loader

process at and near the grates prevents the formation of clinker, thereby reducing the disagreeableness and amount of labor necessary to clean the fire. One man on an eight-hour shift can clean 24 furnaces, heating benches of 6s, which is the extent of labor necessary for this work in a day.

Coal and Coke Handling

A flexible means of transporting coal and coke about a gas plant is by means of belt conveyors. The cost of these conveyors will be found surprisingly small when the work that can be done with them is considered. In this day we see many of the small plants where coke is wheeled by means of trucks or wheelbarrows from the retort house to the coke pile. There are few instances where the yearly saving in labor would not pay for a conveyor to do this work. Likewise in the handling of coal from the sheds to the retort house conveyors can in most instances be made to pay a substantial return on their investment. There are a number of large firms specializing in conveying equipment and the collection and study of their catalogs will prove a good time investment for any plant superintendent. These firms maintain engineering departments for working out details on any particular problem where a lack of engineering facilities is experienced in the gas company. This service is practically gratis to the purchaser, as it is included in the overhead of the manufacturer.

Automatic Operation of Water Gas Machines

This method of operation is especially desirable where a single operator handles more than one set of generating apparatus. The flexibility and efficiency of this method are very apparent. Valves are operated by hydraulic pressure and time operation controlled by clock work in any manner desired by the operator. Further information can be obtained from the United Gas Improvement Co. of Philadelphia.

Handling of Purifying Material

In most plants the operation of changing the material in a purifier is a laborious as well as a disagreeable task. New construction work can be planned to remove all of the disadvantages of the present general scheme of purification operation by installing boxes in the open air with means provided for dropping the spent material and elevating the fresh material into the box. Revivification in situ, reversing the gas flow through purifiers, care in the manufacture or selection of material, control and efficiency of washing and scrubbing of gas before purification and temperature

Fig. 151. One Way to Avoid Carrying a Long Ladder

control in purifiers are some of the aids to efficiency of purification which reduce labor cost by the purification of a greater amount of gas per unit amount of

manifold in other work about a gas plan
handling coal and coke, excavation work, etc

Fig. 152. Illustrating Need for Mechanical I

A new scheme has just been outlined in g
icals called the Unit System of Purificati
system was designed by Charles H. Clowe
gineer for the Cruse-Kemper Co. The adv

[redacted]

of foul oxide and substituting with a container of fresh oxide, and the unit again set in operation in a very small fraction of the time ordinarily required.

Fig. 153. Much Quicker and Easier Than Using a Chisel

(3) After a fouled container is removed from the box it can be attacked in the open at leisure and spread around for revivification in the ordinary manner. (4)

After the material has revivified the containers can be filled at leisure and be kept ready for another recharge. (5) Additional units may be added similar to the sectional cabinet idea at small cost and without seriously disturbing the operation of a system. This scheme, while very new and novel in its application, looks practical and may be the best solution to the problem of purifying and purification labor yet discovered.

Handling Tar and Ammonia

The best method of handling tar and ammonical liquor around a gas plant is by the use of compressed air. With such a system a number of pumps can be replaced by an air compressor, which will also furnish air for other purposes about the plant. Tight tanks are furnished into which the tar and liquor flow by gravity and from which they are expelled by the air pressure applied. The reduction in machinery affects a saving in labor through the attention and repairs necessary where pumps are in general use. The flexibility and efficiency of such a system are also apparent.

The cost of handling ashes around a gas plant is always a considerable item of expense. Tanks equipped with elevators or with vacuum systems of conveyance are not costly and in addition to saving labor remove the unsightly ashes from their usual resting place in the plant, and the disagreeableness and damage done to machinery bearings where they are allowed to be carried about by the wind. Often ashes can be made to afford a source of revenue where the loading cost is reduced by some handling scheme.

Repair Work at the Plant

The acetyline welding and cutting torch is found to be one of the greatest labor savers about any plant. By its use repairs can be quickly and permanently made that otherwise cost immense sums for labor as well as the expense incurred by idle apparatus. No plant is too small to afford this apparatus, which can be operated by the plant foreman and will usually save its cost in the first job tackled. In the larger plants there is such a diversity of uses coming up in the everyday routine maintenance that it is criminal to be without an outfit in the hands of a skilled operator.

Arrangement of Plant

More than anything else effecting the labor situation

Fig. 154. Painters Save Time By Using Compressed Air

at a gas plant is the arrangement of apparatus and operations. Usually very little thought is given this important factor and buildings and apparatus are put in the most convenient available space without regard to their bearing or relation to other apparatus and operations. If compactness were given first consideration very often one man could do the duties of two where the activities are now far removed. A typical example of a well-designed plant is seen in the Astoria plant of the Consolidated Gas Co. of New York, where even the gas-making materials and the gas itself follow a straight direct route to their final destination in the holder.

Thawing Frozen Services

E. L. Sudheimer of St. Paul has designed a thawer consisting of a gas engine driven 20 kw. D. C. 40-volt

Fig. 155. A Thawing Outfit Avoids Digging Up Frozen Ground

generator equipped with a field rheostat for regulating voltage from 0 to 40 and 500 ft. of 300,000 c.m. cable in 100 ft. lengths handled on a steel drum and mounted on a 1½-ton trailer attached to a ¾-ton truck. This outfit may be operated independently of the electric company and is especially advantageous where the gas and electric utilities are separately operated and controlled.

[redacted]

To thaw out a frozen pipe a circuit is connected between the generator or transformer of the thawing outfit and the frozen pipe in such a manner that the current is caused to pass through the frozen part of the pipe. This can usually be accomplished by connecting the positive and negative leads to services in adjoining houses. From two to five minutes under ordinary circumstances is required to thaw out any frozen pipe. The danger of fire or explosion is nil so

Fig. 156. Typical Trench Dug with a Modern Machine

long as a perfect circuit is obtained through the gas pipe which will always exist if the pipe is intact.

DISTRIBUTION

With the increasing use of high pressure distribution, which has made possible the development of suburban districts, the use of a trenching machine has become almost indispensable. The interest in higher efficiency as related to extension work is especially directed to trenching machinery. Except perhaps in downtown districts, where pipes and other obstructions would make the use of a trencher difficult, there is no reason why such a machine should not be generally

Fig. 157. Replaces the Pick and Shovel Trench Gang

used by any company of a size to warrant the investment. The warranty of the investment would be governed strictly by the amount of extension work ordinarily carried on and the labor saving to be made compared with interest and depreciation on the investment.

Trenching Machinery

Mr. C. B. Strohn, in THE GAS AGE, gives some interesting data on trenching machinery that will be abstracted herein.

Fig. 158. Starting the Trench By Motor Truck Power

Advantages and disadvantages would be as follows:

Advantages

1. **Labor Saving**—As few men are required to operate the machine its use implies:

(a) Reduced payroll with consequent reduction in work of paymasters. One or two men operating a trenching machine do the work of 50 to 100 men trenching by hand, it is claimed.

2. **Operation**

(a) The machine may be used continuously day and night.

(b) In the event of the machine getting too far ahead of the pipe gang it may be stopped until the gang catches up without entailing enforced idleness of the gang with its expense and inconvenience.

(c) More rapid work. The speed attained by standard machines varies from 6 in. per minute to 10 ft. per

Fig. 159. Quicker and Easier Than Picks, Sledges and Bars

minute, depending on the character and hardness of the soil and the size of the trench.

(d) Backfilling is facilitated due to the finely divided condition of the soil deposited at an even distance from the trench.

(e) Tamping of the backfilling may be performed by the machine.

(f) Trenches perfectly fitted for pipe laying, due to the fact that the grade is exact as the depth of cut may be regulated. Sides are vertical and trimmed smooth.

3. Reduction in the cost of trenching.

Disadvantages

1. Ground Conditions

(a) In some places the roadside is too slanting to permit machine trenching.

Fig. 160. Ingenious Ways of Back Filling Are Possible

(b) In certain places the ground is so soft that a machine would become mired.

(c) In some places too much rock damages the machine to such an extent that cost of operating is prohibitive.

2. Liability of Breakage

(a) If a machine is in use far from the place where it is manufactured breakage causes too much delay in procuring repairs.

(b) In places where numerous gas services, water services, conduits and sewer pipes are encountered the damage to them is often great and the time and labor

Fig. 161. Tamping with Compressed Air Saves Work

lost endeavoring to prevent this damage are considerable.

The manufacturers of trenching machinery are continuously improving their standard machines and a perusal of the catalogs and literature sent out by them shows the following in reference to the disadvantages enumerated above:

Machines are made which will work on a 17 per cent grade digging a trench 20 ft. deep.

Where the ground is very soft a large caterpillar or rolling platform traction is provided.

It is claimed that any kind of rock except ledge rock may be excavated. Strong ground containing boulders can be successfully trenched. The Parsons Company show that their excavators are being successfully used in shale, hard pan, gumbo sand, gravel, clay, frozen

Fig. 162. Easy and Rapid Way to Cut Pipe

ground, natural concrete and all of the combinations and variations of these materials.

While no machinery is proof against breakage, durability and strength of construction are salient features of late models in trench excavators.

The use of an almost vertical digger boom in late models allows a maximum amount of excavation to be made on each side of a pipe obstruction.

An attempt to show present comparative costs between machine and hand labor in trenching would be rather difficult owing to abnormal and fluctuating prices paid for such hand labor. The following costs are given from the experience of the Minneapolis Gas Light Co. at a time when labor conditions were normal.

Main Trenching Labor Costs for 6-in. Pipe

Kind of soil		Hand	Machine
Sand	9	0.2629	0.1792
Clay	17	0.3504	0.1721
Clay and boulders	3	0.3240	0.1940
Sand and clay	11	0.3497	0.1322
Black dirt clay	3	0.3493	0.1901
Clay, gravel and stones	1	0.2532	0.2324
Black dirt sand	2	0.2885	0.1466
Average		0.3160	0.1780

These figures include backfilling in both items of labor. This same company's figures on all pipe laid was 0.0328 per foot for machine labor against 0.1676 for hand labor.

Interesting operating data may be secured by writing various manufacturers of trenching machinery.

The Ingersoll-Rand Co. have a portable air compressor outfit that can be used to advantage in tamping the soil back into a trench. This can be used in conjunction with an excavator or hand filling as well as for other purposes, such as calking, cutting paving, drilling, etc.

MISCELLANEOUS

Cleaning Stopped Mains and Services

The best method of cleaning services and small mains that have been filled with rust or other sediments is by use of the Wrigley sewer cleaner. This is fully described in the section of distribution maintenance, but is mentioned here as a labor-saving device, as its use will save many dollars in labor cost for service renewals.

Telemetric Gage Control of Distribution Pressure

This most efficient method of distribution operation is fully described under the heading of Pressures and Pressure Gages, but it is included here as a labor-saving device inasmuch as its bearing upon perfect service affects a very material reduction in the number of complaints of poor pressure handled by a gas company.

Fig. 163. Compressed Air Calking Saves Time and Labor

Gas Leak Detectors

There are a number of instruments for this purpose on the market the use of which saves labor in needless digging where leaks are suspected. Their cost is not prohibitive and their use is warranted in any company.

CHAPTER VI

UTILIZATION OF GAS

There have been such changes in the purposes and methods of utilizing gas in the past twenty-five years that it can scarcely be recognized as the same product

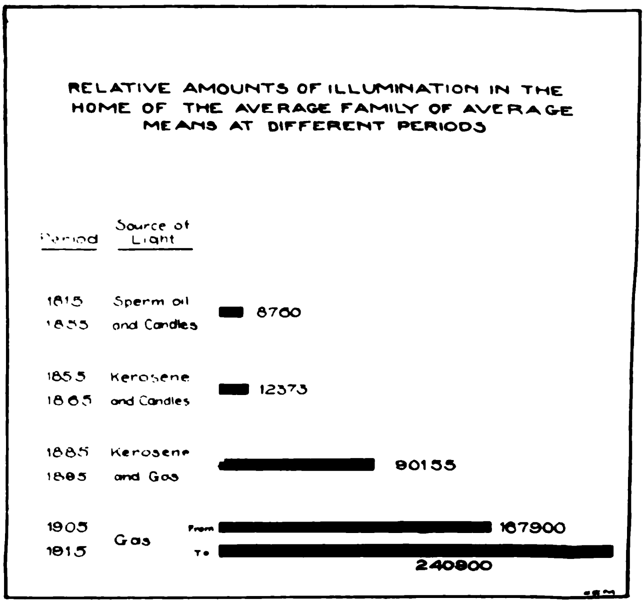


Fig. 164. Example of Increasing Unit Demand

produced and used in the early days of the gas business strictly for illuminating purposes. Such rapid progress has been made and so many new uses discovered, with the end no where near in sight, that to fully enumerate and cover this subject would require a book in itself.

No doubt there will be readers who will remember when his fitting work consisted of installing pipes for

gas lighting, putting on burners and tips and setting the meter. He may be one of the "old timers" who run the service in and completed the whole job at one time. Occasionally he connected up a gas cooker which was a luxurious appliance then, but which would not receive kitchen room from the modern housewife. To-day he is called upon to connect up the cabinet range, the copper-coiled water heater, the automatic water

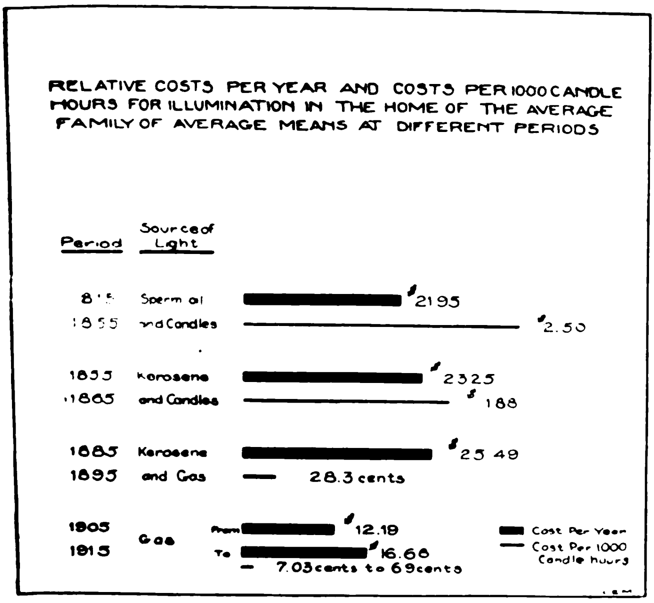


Fig. 165. Illustrating Decreasing Unit Costs

heater, the garbage incinerator, the dish washer, the gas iron, the room heaters, the gas grate, the laundry stove and the many other domestic appliances that have become indispensable to the modern household. In the industrial field he is perhaps connecting up something new every day, something which has been worked out by an expert industrial fuel engineer to fit some

Fig. 166. Recent Type of Burner Using Small Mantles

particular purpose where efficiency is desired by the customer. The installation of such things as all gas hotel kitchens with their batteries of ranges, broilers, ovens, coffee urns, steam tables, etc., laundry installations, tire heaters, enameling ovens, rivet heaters, linotype machines, metal melting furnaces, soldering furnaces, bake ovens, roasters, water heating systems, and such things as that have become so common as to attract scarcely any attention. The modern fitter is

Fig. 168. Modern Type of Bracket Gas Mantle Lamp

still called upon to install illuminating pipes and fixtures, for gas lighting is not a dead issue by any means, but on his fixtures in place of the old time tip and burner he installs a modern mantle light of the inverted type, or if the lighting happens to be for a store, factory or public building, improved gas arcs or some of the other modern types of direct, semi-direct or indirect gas lighting appliances are installed. Outside gas lighting is still extensively and efficiently used in many cities, showing progress in the face of intensive electric competition. All of which leads the gas man to rightfully believe that the future of the gas business is bright indeed.

Gas as an Illuminant

As stated by Mr. Clark in his paper, "The Developments of the Gas Lighting Industry," the Welsbach invention (the mantle light) has so cheapened gas light-

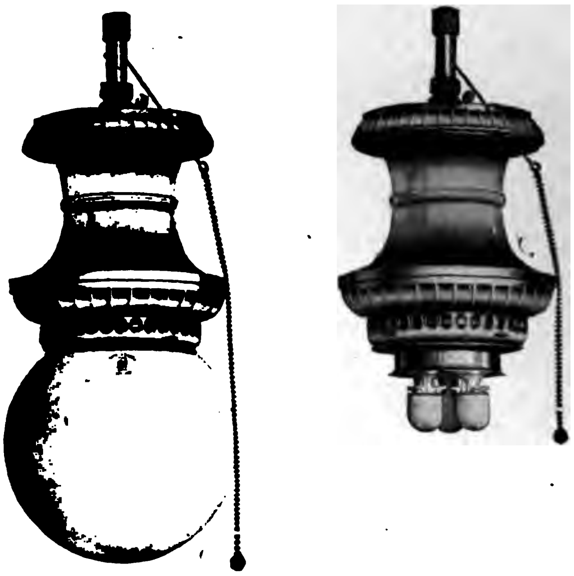


Fig. 169. Modern Gas Arc With and Without Globe

ing that in cost per unit of illumination gas has no rival except the heavenly bodies.

The modern mantle light develops 20 candles per cu. ft. of gas consumed and the open flame burner approximately 3 candles per cu. ft. The carbon filament electric lamp consumes 3.5 watts of current per candle and the tungsten filament lamp 1.25 watts per candle. With electricity at $0.10 per kw. hr. and gas at $1 per

1,000 cu. ft. the following values in illumination would be obtainable for one cent:

Gas—Mantle light	200	candles
Gas—Open flame	30	candles
Electricity—Tungsten	80	candles
Electricity—Carbon	28.5	candles

For an equivalent cost two and one-half times as much light can be obtained by the use of a modern

Fig. 170. Attractive and Efficient Porch Lamp

mantle gas light than by the use of a modern tungsten electric lamp. In the matter of advantages it is apparent that the claimed adaptability of electricity as an illuminating agent can not offset this lower cost of illumination.

Mr. J. P. Conroy, in a paper read before the Canadian Gas Association, held at Quebec August 16 and 17, 1916, made the following important statement:

"In these days we find a strong tendency among combination companies to favor electric lighting at the expense of gas lighting. This is done in spite of the fact that when electricity is used it creates a peak load on the generating system. It is this peak load that determines the size of the plant, and many thousands dollars invested in electric plant and equipment might be

[redacted]

crease the profits of the electric system by selling all of the gas lighting that it is possible to sell. The lighting load can usually be carried much more economically

Fig. 172. Semi-indirect Bowl With Gas Mantle Burner

from the gas works than it can from the electric generating system."

The residence using gas lights is always conspicuous among other residences using electricity, not because [illegible] gas light [illegible] because of the softness and [illegible] which floods every portion of the room illuminated. Where gas light is used to read by the [illegible] are conspicuous by their absence. In

[illegible] Street Lamp Automatic Lighter and Extinguisher

[illegible] other industrial lighting by gas a [illegible] which is restful to the eyes of [illegible] as well as making the dis- [illegible] more certain.

Gas as a Fuel

As a fuel gas is only in its infancy. The developments of late years have only scratched the surface. It needs but the abolishment of the illuminating standard, which is inevitable, making possible the manufacture and distribution of a cheaper gas to open up such

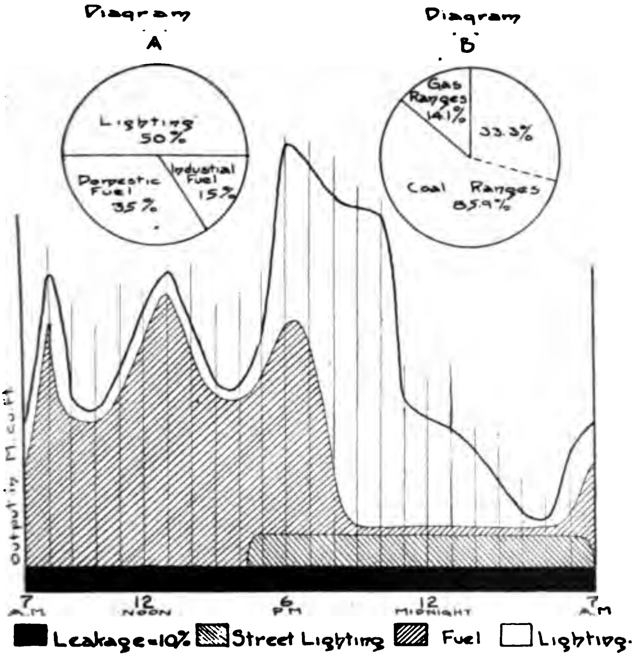


Fig. 174. Daily Distribution of Gas Consumption

possibilities in the gas fuel field that the present output will be doubled in a very short time.

Gas supplies heat only when and where it is desired. It can be used with the greatest of economy, nearly every cent expended representing useful work done. In adaptability and ease of control it greatly excells other fuel. To ignite requires but the striking of a match, the turning of a valve. As soon as the use of the gas is finished, i. e., the purpose served, all expense and waste of heat stops.

Comparison with Other Fuels

The following tables show approximate heating values and costs of various fuels:

Cost of Fuels Per Unit

1,000 cu. ft. gas contains 600,000 B.t.u. costs	$1.00
1 ton coal contains 20,000,000 B.t.u. costs	5.00
1 gal. gasoline contains 150,000 B.t.u. costs	0.20
1 gal. kerosene contains 130,000 B.t.u. costs	0.16
1 kw. hr. electricity contains 3,412 B.t.u. costs	0.10

B.t.u. Obtainable for $1

Gas	600,000 B.t.u.
Coal	4,000,000 B.t.u.
Gasoline	750,000 B.t.u.
Kerosene	812,500 B.t.u.
Electric	34,120 B.t.u.

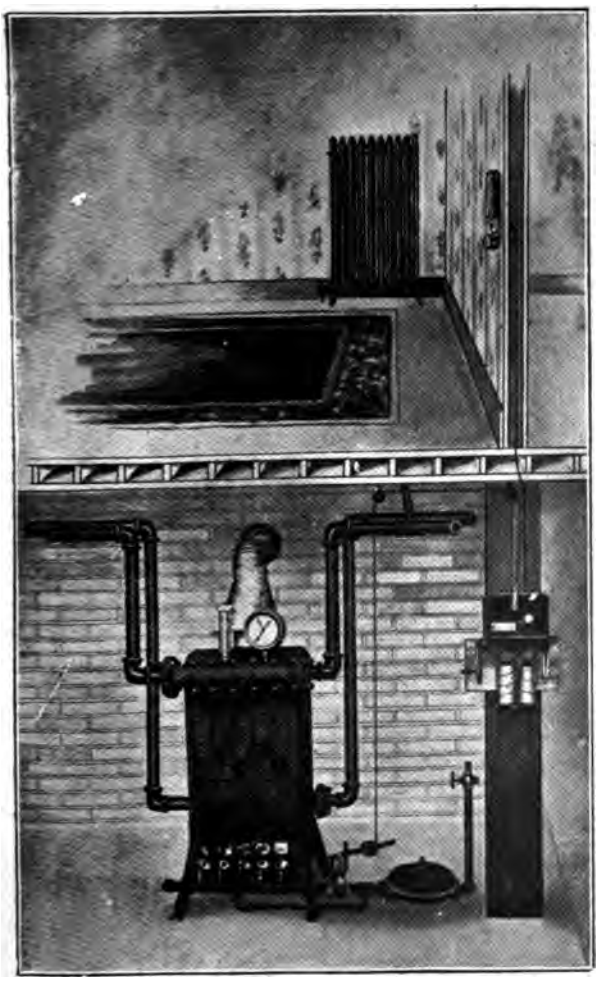


Fig. 175. Successful House-heating System Using Gas

comparison on an available heat energy basis really means nothing. The only true way of making a fuel comparison is by the cost of accomplishing the purpose for which the fuel was used.

There are a great many kinds and classes of coal used for domestic and industrial purposes from the cheapest steam coal to the expensive anthracite. With the former manufactured gas cannot compete under

value of this coal would approximate 10,000 B.t.u. per lb. of the fuel in the condition as usually sold, containing a variable proportion of moisture.

In the combustion of any fuel, either gaseous or solid, heat energy is lost with the products of combustion and as radiant heat. It is therefore an impossibility to get 100 per cent efficiency, i. e., to convert the total heat

Fig. 177. Example of Ready Adaptability of Gas Fuel

energy into useful energy, out of any fuel. The modern gas burner in general use for fuel purposes will average 50 per cent efficient, i. e., it gives up for useful work one-half the total energy contained. Where coal is used as fuel complete combustion is rarely obtained. Smoke and soot are the result of incomplete combustion and possess heat energy. They represent waste or loss of efficiency in direct proportion to the amount. Losses from radiation are greater where coal is compared with gas as a fuel chiefly because the heat cannot be concentrated. Other sources of loss are the starting up and letting down of the fire.

When comparing gas with coal in the proper manner, by cost or efficiency of the accomplished purpose, a number of things come under consideration which have no bearing upon the efficiency of the fuel in heat energy, but which are fully as important to the consumer. Some of the advantages of gas follow: (1) Cleanliness—No dirt, no soot, no ashes, the operator can wear white

Fig. 178. Hotel Kitchen Gas Outfit With Waste Incinerator

colthes and not get them soiled; the room, as well as the operator, is clean and therefore attractive to customers and others; no dirt or dust settling on the food or article produced. (2) Heat—No sweating, no heating up of the whole house or place of business, thereby driving away custom; heat always obtainable where wanted by the small effort of lighting a match and turning a valve; minimized danger of fire. (3) Effort—No fires to light and time wasted waiting for the apparatus to get hot; no coal to carry or shovel; no fire to clean or replenish or ashes to carry; no continuous sweeping and cleaning necessary. (4) Cost—No cost of handling

coal, ashes and firing; no extra labor necessary; no investment in stored coal and in storage space; no cost of cleaning and painting building; better class of labor obtainable where gas is used.

Gasoline, kerosene or other highly inflammable fuel oils have a decided disadvantage which eliminates them as serious competitors to gas as a fuel. Their inflammability makes their use except for outdoor purposes dangerous, the fire insurance rate usually being pro-

Fig. 179. Industrial Gas Fired Steam Generator

hibitive of inside use. The great number of internal combustion engines (automobile motors) in use **in the country today make the use of gasoline for any other purpose except motor fuel a negligible** quantity. **This condition to a large extent affects all fuel oils.**

Electricity while claiming a place in the list of competitors of fuel gas is really not a dangerous rival at the present cost of generating and consequent selling price of electricity energy.

Its use for heating purposes is practically **limited to isolated conditions of service where cost is an item of inconsequence. However, with the advent of cheaper**

current, which will come with modern development, it may develop into a competitor worthy of note in some classes of heating. As a general thing electricity is more efficient as a heating medium than gas where the ratio of useful heat to that available is considered, due to the lack of products of combustion. This efficiency may be assumed to be 75 per cent, against 50 per cent for gas, at which approximately 117 kw. hr. would be equal in useful heating value to 1,000 cu. ft. of 600 B.t.u. gas.

On a basis of cost for useful fuel the following are equalized selling prices.

Electric Equivalents to Gas at Prices Given

Gas		Electricity
$0.75 per 1,000 cu. ft.	equivalent to	$0.0064 per kw. hr.
0.80 per 1,000 cu. ft.	equivalent to	0.0068 per kw. hr.
0.90 per 1,000 cu. ft.	equivalent to	0.0077 per kw. hr.
1.00 per 1,000 cu. ft.	equivalent to	0,0086 per kw. hr.
1,10 per 1,000 cu. ft.	equivalent to	0.0094 per kw. hr.
1.25 per 1,000 cu. ft.	equivalent to	0.0107 per kw. hr.
1.50 per 1,000 cu. ft.	equivalent to	0.0128 per kw. hr.
1.75 per 1,000 cu. ft.	equivalent to	0.0149 per kw. hr.
2.00 per 1,000 cu. ft.	equivalent to	0.0171 per kw. hr.
2.25 per 1,000 cu. ft.	equivalent to	0.0192 per kw. hr.
2.50 per 1,000 cu. ft.	equivalent to	0.0214 per kw. hr.

Relation of the Fitting Shop to Gas Utilization

Upon the fitting shop depends to a great extent the proper utilization of gas, both as a fuel and an illuminant. The most important factor from the customer's standpoint, as well as the company's, is continuity of service. Continuity of service, which means uninterrupted service, ends when the customer is not satisfactorily supplied. In other words, bad service is coincident with an interruption of service, for continued or even frequent bad service usually ends with a discontinuation of the service by the customer's volition.

The responsibility of the fitting shop over gas utilization begins at the end of the service pipe and ends at the burner. The work is not finished nor the responsimility ended with the proper connection of the appliance. Every burner must be properly adjusted so that the most efficient combustion of the gas takes place.

While gas companies as a general rule do not assume responsibility for the conditions of the customer's piping beyond the meter, they do usually assume the right to supervise the installation of all gas piping not done

Fig. 180. Gas Fired Oven for Decorated Lamp Shades

by company fitters, the inspection of which is usually done by an employe of the fitting shop. Unless this is done perfect service to the customer cannot be assured. With it the proper installation of the customer's piping depends entirely upon the fitting shop.

The factors determining proper service or proper utilization coming within the scope of the fitting shop's responsibility are: (1) The size and condition of the service extension; (2) the size and condition of the service

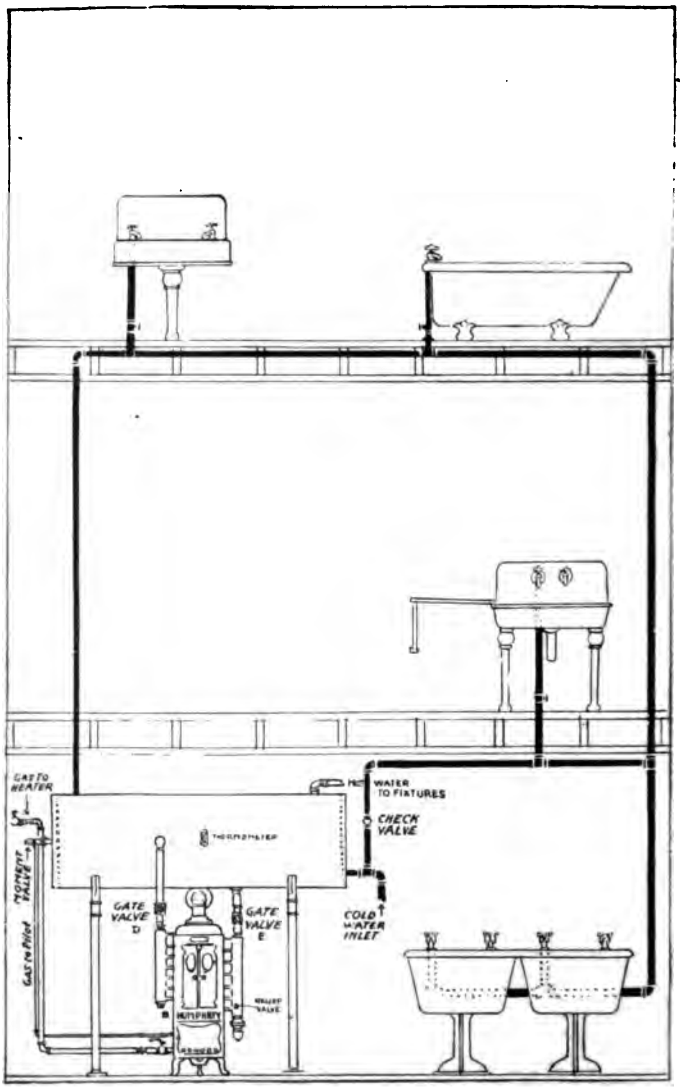


Fig. 181. Domestic Hot Water Supply, Showing Piping

regulator (if one is used); (3) the size and condition (external) of the meter; (4) the size and condition of customer's piping; (5) the method of installation of the gas consuming appliance; (6) the adjustment of the gas consuming burners.

The service extension should be of the same size as the service entering building unless more than one

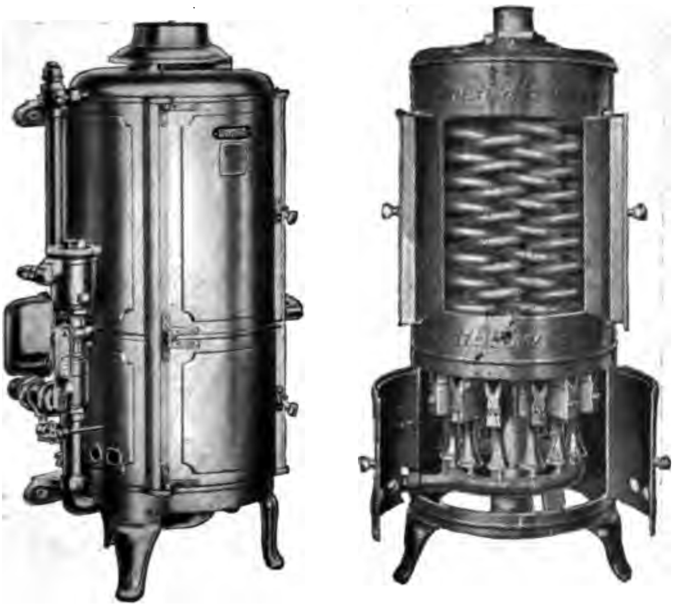


Fig. 182. Two Designs of Modern Water Heaters

extension is taken from one main service, in which case the extensions should be proportionate in size to the amount of gas to be supplied therefrom, but in no case should the size of an extension be less than 1¼-in. pipe. In case an extension is run from a service for a distance greater than 10 ft. a cock should be installed at the point of leaving the main service. All service extensions should be graded to the main service, unless absolutely impossible and tees with accessible plugs for cleaning purposes inserted at proper intervals. The service regulator should be of the proper size to supply the required amount of gas at the desired outlet pressure and the outlet pressure should not be less than 3½ in. nor more than 5 in. of water column. The meter should be of a size to supply the desired amount of gas with a differential pressure between inlet and outlet of

faction of the customer, and to the elimination of all hazards. The adjustment of the burners of the consuming appliance requires no little skill on the part of the fitter and consists in the proper mixture of gas and air being obtained to give perfect combustion, with the resultant aid to utilization. The proper adjustment of a burner is obtained when the flame is composed of short cones having a greenish color and when the flame is almost on the point of popping back into the mixer.

Fig. 184. Tempering, Annealing and Small Enameling

It is usually not practicable to adjust a burner as delicate as this unless the pressure range at the burner is small or automatically adjusting air mixers are used.

Some Don'ts

Gas companies often distribute pamphlets or cards to the customers containing pointers for gas utilization something like the following:

Keep range free from grease. Soda is effective to use for this purpose.

Don't use blacking on the burners.

Wipe out oven at least once each week.

Burners popping back and lighting in mixer (indicated by reddish flame and roaring sound near valve) are not necessarily in need of adjustment. Turn out burner and light again, holding match an inch from burner.

Small flashes of red flame from burner do not require

Fig. 185. Gas Heated Industrial Furnace in Operation

attention. They are caused by dust entering the mixer.

Before lighting any of the burners it is always well to try all the gas valves to be sure they are closed and that there is no gas in the range.

Both parts of the double burner may be used at the same time or separately.

Don't open pilot burner for oven until match is lighted and you are certain that all valves are closed.

Always open lower oven door before lighting oven burner.

If match is blown out while lighting a burner turn off valve before getting another match.

Never leave range until sure that both oven burners are lighted if both are to be used.

Before using the upper, or baking oven, it should be lighted for about 15 minutes, as pastry and many other things may be spoiled by putting in a cold oven. After

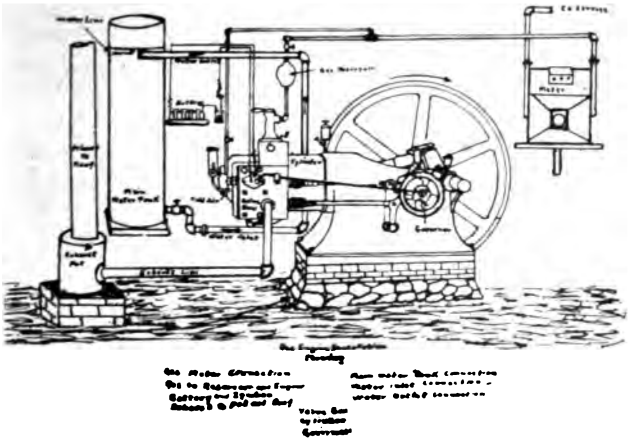


Fig. 186. Sketch of Gas Engine Piping Arrangement

the oven is thoroughly heated the flame should be turned low or one burner turned off entirely. Anything requiring extra browning may be placed in the lower oven, under the flame for a minute or two.

When cooking is going on in either baking or roasting oven both doors should be closed to confine the heat. Great capacity and economy are secured by baking and roasting at the same time.

Never light the top range burners until ready to use them, and turn them off as soon as through. Don't leave a burner lighted because you intend to use it soon.

Turn it off and use another match when ready. Always remember that matches are cheaper than gas.

Don't use the giant burner when a smaller one will answer. Learn to use the simmering burner as much as possible, especially to keep things boiling after once started.

Don't use a burner turned on full if it will do the work turned on half.

Turn out oven burners several minutes before baking is finished.

Don't use covered roasting pans in gas range ovens. They require 20 per cent more gas.

At least once a month flush water heaters thoroughly by closing stop cock between heater and tank and opening faucet at the bottom of heater, draining off five or six pailsful of water; or attaching a hose and letting it run ten minutes. Do not forget to open stop cock when through.

Don't heat more water than you intend to use or for any length of time before it is needed, as it cools rapidly in the tank after the heater is shut off unless the tank is well insulated.

Be sure that the heater is connected to the outside of the building by a vent pipe containing no dampers. This vent pipe does not make the heater burn any better, but it prevents poisonous products of combustion, which differ from those given off by a gas range, from escaping into the room and becoming a menace to life and health.

Fitters should familiarize themselves with these directions and call the attention of customers to the value of carrying them out, always remembering that the policy of all well organized and regulated gas companies is to teach the customer to conserve instead of to waste gas. A $2 per month customer all the year around is of more value to the company than a $5 per month one for two months out of the year.

CHAPTER VII

EMPLOYES

The employes of the fitting shop, exclusive of foremen and clerks, may be divided into eight classes: (1) Complaint Men, (2) Inspectors, (3) Measuring Men, (4) Fitters, (5) Meter Men, (6) Special Men, (7) Shop Men, and (8) Helpers.

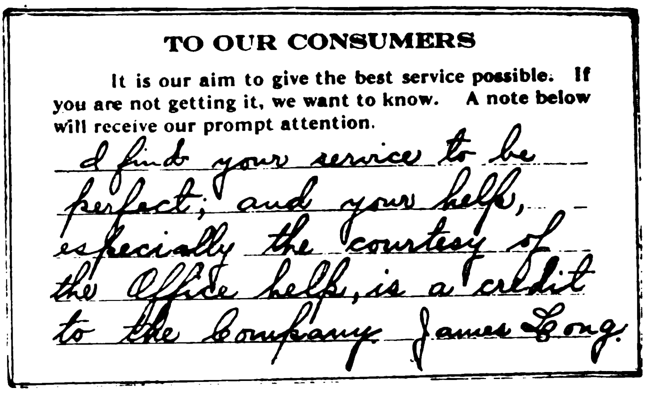
Complaint work may rightfully be called the most important work handled by the fitting shop, as it has to do entirely with the service given the customers. The employes selected to attend to complaint work must, therefore, be men of exceptional ability, carefully chosen by their qualifications fitting them for this position.

The inspectors pass judgment on the work done by fitters not employed by the company, and in some cases inspect all work done by company fitters; but there are doubts as to the wisdom of the latter method, as it has a tendency to disrupt harmony in the fitting organization. The inspection of company work can best be done by the foreman or an assistant having supervision over the men. The inspectors need have no qualifications not possessed by the fitter, as either must know thoroughly the difference between right and wrong in gas fitting.

The measuring men, where a system of separate measuring and installing is employed, receive all fitting orders before they are given to the fitter. They locate the position of appliances, risers and meters, and decide upon the way the pipe is to be run, and measure up, drawing a sketch to accompany the order or otherwise identifying the plan of installation, so that the fitter receiving the order will be able to install the job without trouble or loss of time. The measuring man turns in with the order a list of the material requirements, which goes to a shop man for assembling.

The fitters install all piping and connect all appliances, setting the meters necessary on any job attended to by them. Their necessary qualifications are high.

The meter men should set all meters not requiring any considerable amount of materials or time. In most cases their work would consist of resets; that is, the setting of meters where one had previously been installed, returns and changes. Their work, while important in the sense that all work done by the fitting shop is important, does not require the degree of skill and ability necessary in some of the other classes. Speed and carefulness are the most important qualifications necessary, as the meter man must handle a large



TO OUR CONSUMERS

It is our aim to give the best service possible. If you are not getting it, we want to know. A note below will receive our prompt attention.

I find your service to be perfect; and your help, especially the courtesy of the Office help, is a credit to the Company. James Long.

Fig. 187. What Courtesy to Consumers Brought

number of orders each day and the correct report of execution is absolutely necessary to the company. Speed and carefulness are also conducive of satisfaction and safety to the customer.

The special men may handle most any kind of work not coming under the head of other classes, and that of any other class in emergencies. Such work as replacing defective parts of appliance, tracing meters and piping, investigations, giving estimates or advice on piping jobs, putting up flue-pipe, installing lamps, room heaters, etc., may be classed as special work. In any large shop it will be found economical to employ a man, or number of men, as the case may require, to take care of the miscellaneous or special work, which leaves the men of other classes free to attend to work of perhaps greater importance.

The shop men, which includes machine men and all laborers employed within the shop, cut all pipe to length and screw the fitting thereon as instructed by sketch or otherwise, tie the jobs into compact bundles, and otherwise facilitate the work of the fitter by having all material ready to go out with each order.

The helpers are the apprentices, and give aid to the fitter or other employes whenever needed. In some shops where the measuring system is used the old-time regular helper with each fitter is dispensed with, in some cases no helpers at all being employed, the fitters doubling up on jobs which one man is unable to handle. In other cases a minimum number of helpers are employed, who assist the fitters having jobs requiring the services of more than one man. The latter method appeals as the most economical and also affords a reserve to draw upon for new employes in other classes. The helpers should be chosen with the latter scheme in view, and should therefore pass within certain specifications as to their embryo ability and future use in higher capacities. After being carefully selected, they should be passed through a course of instruction while serving as apprentices in order to fit them for other positions.

Qualifications and Selection of Employes

Much depends upon the judgment of the foreman in the selection of new employes for the fitting shop. The fact must not be lost sight of that an expense is attached to the training of green employes, which will be lost if the judgment of the selector is at fault.

Diamonds in the rough often develop a flaw in the polishing process, but experts never polish a worthless stone.

In selecting employes from a number of applicants, too much care cannot be exercised. It is not enough that the applicant apparently is possessed of all the qualifications necessary in the fitting shop employe. His character and life away from the shop must be looked into, and especially his habits. He may be a wanderlust, trying to secure employment long enough to get him to another town or city. This class should be avoided, as it is time, effort and money thrown away to attempt to train them. Married men are usually preferable to single men, as they possess an incentive which inclines them to steadiness and longer periods of employment, although there should be no bar to single men if they come up to requirements. The element of chance, however, of the latter staying with the company long enough to recompense it for the cost of training is greater than with the former.

All applicants for employment should be compelled to make written application on a form provided by the company, giving at least two responsible references. Letters of reference from former employers in the possession of the applicant are usually worthless. An employer of standing always prefers to recommend a former employe by personal letter to a prospective employer after application for a position has been made to the latter. The written application is in many ways desirable, as it gives the foreman a chance to verify past records of employment, character, habits, etc., and to judge of the applicant's education by the handwriting, grammar and spelling used, and from the record of education, which the application form should provide for.

Almost as great care must be exercised in choosing the experienced fitter as in the green man, for, while the fitter will not require an expense for training, he may cause expense in other ways. The most desirable way of securing fitters is by the method of promotion, and the prudent shop foreman will always have plans laid out ahead to tide him through the busy season.

A good way of securing "diamonds in the rough" for the fitting shop is to watch the laborers of other departments, particularly the street and production departments. By co-operation with the heads of these departments, it is not a difficult matter for the shop foreman to secure a list of likely candidates for promotion, whom he can watch for awhile before making selections. Inter-department promotion, giving the present employes preference over others, is always productive of satisfaction and efficiency. It is a part of human nature to resent the presence of outsiders, more especially if the outsiders take superior positions. Therefore, a better feeling will prevail among employes if they know they are to receive credit in the way of promotion for meritorious work. A vacancy in any department of a gas company should be accompanied with an analysis of the payroll lists before outside help is employed.

As the company is dependable to a great extent upon the fitting shop for the friends or enemies it makes through orders handled, great care should be used in chosing the men who represent this department. A man must be endowed by nature with certain qualifications, without which he is totally unfit to become a fitter, regardless of the amount of training received. Among the important qualifications necessary in a fitter are the following:

Temperament

He should have a good disposition and a pleasing manner. He must not be excitable, nor apt to lose his temper or presence of mind under any circumstances, as he will be called upon at times to face provoking situations as well as dangerous predicaments. He should not be a man to jump at conclusions nor pass snap judgment upon any condition of his work, but should investigate thoroughly and satisfy himself of the exact conditions before proceeding.

Personal Appearance

The fitter need not be an Adonis, neither a Beau Brummel, but he must be enough of both to avoid any semblance of repulsiveness to the customers. Even a man who works for a living in the manner a fitter does can have a fairly dignified appearance. It cannot be expected that a fitter do his work properly and be dressed up in clerical garb, neither can it be expected that he be clean at the time; but the man with proper regard for his personal appearance will avoid extremes. He will come in contact with people of refined and even touchy natures, and it is desirable to avoid offending them as much as possible. The suit of overalls is just as honorable a garb as the frock coat, but it mustn't be kept from the laundry tub too long or it loses a great deal of its honor. The subject of personal appearance is a touchy one to dwell upon and is very liable to offend, but its importance in connection with the meeting of gas company representatives and the public makes it obligatory to include it as one of the important qualifications of a fitter.

Manners and Conduct

Good manners denote good breeding and is an attribute which will do much toward maintaining friendship with the customer. The conduct of the fitter toward the public whom he meets must always be manly. He should always remove his hat when entering and while working in a private residence, in a business place where ladies are present, or in an office. He must not be talkative, speaking only when addressed, when asking questions concerning his work, or in reporting conditions and giving instructions concerning the installation and appliances. He should avoid conversation on any subject not pertaining to company business, and should give information regarding the business of other departments only upon request, and then only so much as is necessary. It is better to refer the customer to the proper authority of the company than to take any chances in giving wrong information. This can and should always be done in a manner not offensive to the customer. In talking, use good language, never indulging in slang words or phrases, and be careful to choose words not antagonistic to the customer. He must always keep the interest of the company at heart, but remember that as a representative of the company his duty is to make and retain friends for them. This he cannot do if the customer is antagonized by a disagreement. Tact and diplomacy must often be used in preventing arguments.

The fitter with good manners will be as noiseless as possible and do his work with little fuss and flurry. He will try to avoid making any more dirt than is pos-

Fig. 188. Uniformed Meter Readers in London

sible, and will clean up what he does make, or at least offer to do so. The customer is usually much impressed if, after the completion of a job, a request is made for a broom and dust-pan. It is not often that the fitter has to use it, but his willingness invariably leaves behind a friend. In muddy weather the shoes should be well cleaned before entering a house. Usually a housewife considers the tracking up of a floor a capital crime. If an endeavor is made to show consideration for the wives of the customers much has been done toward creating a feeling of good will toward the company in the customer.

Honesty and Sobriety

Little need be said on these dual requirements, which are of equal and absolute importance, as the first offence should warrant instant dismissal from the service of the company. The fitter has access to the property of customers and also handles tools and materials of value belonging to the company; therefore, dishonesty, which is usually a natural instinct not easily overcome, cannot be tolerated. The danger attendant with the use of liquor by men working with gas, as well as the embarrassment to the company of having a report of such coming in against an employe prohibits the toleration of this vice.

Workmanship

An applicant, even though endowed by nature with all the other qualifications necessary, to be of value to a gas company must possess mechanical ability of no small degree. The work done by gas companies on the consumers' premises is of a very diverse character, requiring not only a knowledge of pipe fitting but of other mechanical features as well. Skill comes with practice, but real ability is inherited; therefore, if a man possesses no natural mechanical ability he is worthless material for the fitting shop. Mechanical ability can only be denoted by trial, the old adage of the impossibility of reckoning the distance a flea can jump by his looks fitting the case exactly. We have all seen men take hold of a tool and use it as if it were a part of himself, while others, even after long experience, handle their tools as clumsily as a schoolboy, never seeming to get used to them. A short trial with a good experienced man will usually bring out the dormant mechanical ability if there is any to bring out; if not, training is useless. Clumsiness in the beginning must be overlooked, but improvement should follow rapidly in the right kind of man. After the helper has proven his right to be trained, by showing mechanical ability, his training should begin in earnest.

A fitter must be careful and thorough in his work, doing it properly even at the expense of time. It is better to do one job well than any number of botches. The latter will invariably come back for attention, providing a source of perpetual maintenance, continuing so until changed properly. Any work done must be done permanently, the real fitter never hangs his pipe up with string or wire, for he knows it won't stay where he left it. Carefulness is the art of never taking a chance, and there is no reason for taking a chance in any phase of gas fitting work. Taking a chance in the gas business has landed many men in different places, especially the hospital. The usual form of taking a chance, in other words, carelessness, is testing for leaks with a flame. Don't do it. Carefulness should be a predominating virtue.

A fitter should never leave a job uncompleted unless absolutely necessary, and then only after satisfactory explanations are made to the customer. If the whistle happens to blow before the last piece of pipe is up it should be unheeded. There are exceptions, where work is being done in an unoccupied building or is of such a character that finishing is not absolutely imperative, where this rule can be waived, but in the ordinary routine of fitting shop work it should be rigidly followed.

Workmanship demands that the premises or property upon which work is being done be restored to as near its original character as possible. This means the replacement of walls, floors, moved material and the cleaning up of dirt or litter made.

The gas company fitter has as much to learn, his work is as difficult and of as great importance as most of the trades. He must therefore consider the time required to become a master workman and not become discouraged if promotion does not come as rapidly as expected. An apprenticeship in a building trade usually covers a period of three to five years at a wage smaller than any paid in the gas company fitting shop. After that the tradesman can work at his trade, if there is any work to be done. His wage when he works may be higher than the gas company employe, but in most cases the gas company fitter works twelve months out of the year, so that he is considerably to the good over the tradesman at the end of the year. Gas companies usually have no fixed period of apprenticeship, the period depending, as it should in all cases, upon the apprentice himself.

Education

Education is a very necessary qualification of a fitter, as it is today in every class of work that counts. Education is almost as free as the air and those who are without it owe it all to themselves.

A fitter should have at least the equivalent education received in the eighth grade of public schools. I would consider that much necessary and more proportionately increasing the value of the man and his chance of promotion.

A gas company order becomes a permanent record after the fitter has duly executed, filled it out and signed it. It is, therefore, necessary that the writing, spelling and grammar be intelligibly and well done. The public must also be met and talked to and a favorable impression can only be made by being able to talk correctly. In addition the fitter has measuring, estimating and calculating to do requiring the use of mathematics, all of which depend upon education.

Knowledge which will prove of value to a fitter is contained within the elementary section of this book and should be studied. In addition it is to be recommended that one of the several correspondence courses carried on by the gas associations be taken up. A word to the foreman will bring all the necessary instructions of procedure in taking up a course, or he will otherwise give aid in helping any employe to better his education.

Not enough importance is attached to the training of the fitters by the average gas company of the country. Much benefit would result thereby, both to the company and the individual, if this training were systematized and regular examinations held to determine the rating of the employes.

Training of Employes

After the applicant has passed the necessary qualifications for employment and is accepted his education or training should immediately begin. It is assumed that the new men will be started at the bottom, this

Fig. 189. Training Women Campaign Crews

being the only way to assure harmony in the organization. There is nothing more prone to disrupt an organization than the promiscuous advancement of men without regard to ability or length of service.

The most valuable men to an organization are those who have grown up in its service and have reached the top by steady strides. These men are permeated with the spirit of the company and are the main standbys in cases of emergency or stress of any kind.

Under a previous head mention was made that experience is without question the best teacher. However, we cannot afford to lose prestige through the mistakes of our men. They must be taught to avoid these mistakes, but the teaching must not interfere with the work of the company. Because of this, and also on the score of economy, the educational work in a large organization can, with advantage, be conducted in a place set apart from the actual work of the department.

In this more or less theoretical education there are two avenues of procedure: (1) Entirely by lectures, reinforced with demonstrations, embracing all phases of the work, and (2) by specific schools of instructions wherever possible. It is to be understood, however, that all methods used for educating the men must be further assisted by their gradual development while engaged in the actual work of the fitting shop. They must be put under trained men as helpers, and when they qualify as fitters they should be closely watched by foremen in order to help them over the rough places.

The size of the company is the fundamental determination as to whether the definite school of instruction is possible, but wherever there are any number of men doing the same class of work there the individual school of instruction offers the greatest chance of success, since it instructs men without interfering with shop routine. Lecture courses are ideal for instruction in work which does not require mechanical skill, but where mechanical skill is necessary the school of instruction is the place to acquire it, because there the men have the chance to actually do the work under a competent instructor.

In smaller companies the lecture course reinforced by concrete examples and actual demonstrations where possible, provides the best method for this work, although the lecture idea cannot develop the thoroughness of mechanical training which is gained by the school of instruction.

In the consideration of the establishment of a definite school of instruction, at the outset it must be clearly understood that the success or failure of the enterprise rests largely upon the man appointed as operating head or instructor. This man must be of the highest type and should preferably be one who has risen from the ranks through conscientious and faithful service. He

Fig. 190. Use of Demonstration Meter in Training Employes

should have executive ability and the talent for teaching others, and must be vested with absolute control of the school. Only by having such a man and giving him this authority will the school be successful.

He should report directly to the department head and not to any assistant head, since the proposition requires careful watching to prevent discord between the shops and the school and to insure the full benefit of the school being obtained by the fitting organization.

Education by Means of Lectures and Demonstrations

The Pacific Gas and Electric Co. use the lecture-demonstration scheme as follows: They maintain a night

Fig. 191. **Employes' Instruction Meeting Room**

school to which all employes are eligible, they joining of their own volition, but having once joined they must attend regularly and take every examination.

The work is taken up several nights each month, when a certain portion of the work is covered by lectures, explanations and practical demonstrations of the work covered by the lecture. After several lectures and demonstrations covering a particular portion of the work, the men are then given questions to answer. Should the percentage of the answers sent in be very high, the work is passed on to the next subject, but should the percentage be low the same ground is covered again.

These practical demonstrations have proven to be surprisingly beneficial to the employes of this company. Frequently a subject is given to all the men with a request that they send in a written answer, although it is not obligatory on the part of anyone to do so. The

Fig. 192. Salesmen Instruction Class at Indianapolis

answers are then carefully compiled and such of those who did very well are commended, while those who did not do so well are brought together and the subject thoroughly discussed.

In Des Moines, Iowa, where the company is smaller than in San Francisco, there is a definite educational scheme which will be cited to serve as a possible example to those of like situation where a few men may eventually do all classes of work.

There they have an educational class which meets monthly and in which all of the men take an active part. The particular object of this class is to make the employes in all departments as familiar as possible with the work in all other departments, and incidentally specifically to instruct the group, the work of whose department is being developed at the meeting. In addition each group in the shop force has weekly meetings under the guidance of their shop foreman, in which specific instructions and suggestions are given and the men are encouraged to take part in these discussions.

In Denver, Colo., the educational scheme is on much the same order as that in Des Moines. Meetings are held once each month in the demonstration hall at the main office, where lectures are delivered and demonstrations made by some department head on subjects of importance to the men. The men are encouraged to ask questions freely and join in a general discussion after the lecture. Question boxes are maintained at the various shops where the men are requested to deposit questions on any subject pertaining to the gas business. The boxes are opened at the monthly meetings and answered by the head of the gas department.

Employes of the fitting shop, gas meter shop and trouble department attend these meetings, and while attendance is not compulsory a record is kept of the names of all employes of the departments attending and absent. These records show that 90 per cent of the total number of employes is the average attendance at the meetings.

The Westchester Lighting Co. of New York, which is composed of a number of small properties, uses the lecture and demonstration scheme. The employes of their properties, which are situated close together, meet collectively and alternatively in the different towns when lectures are given and demonstrations made by a department head. These lectures are afterwards compiled, well indexed, distributed among the properties in such a manner that the employed may have access to them.

In the foregoing instances the lecture idea is clearly

set forth and that these accomplish great good goes without saying. In these companies the size of the organization does not permit, neither does it warrant, the expense of a school of instruction. The one possible

Fig. 193. Reference Books in the Engineer's Office

objection to this method of education, when it is held outside of working hours as it usually is, lies in the detaining of the men without pay, even though it be voluntary on their part. However, this may, after all, be more of an imaginary evil than an actual one. In Denver we have never had a complaint from the men and they really take a great interest in the meetings.

In some large companies employes' meetings are regularly held for the instruction of the men. The Philadelphia Gas Works requires their distribution employes to attend meetings according to a prearranged schedule. In the fitting department the meetings are usually held each Monday morning before the men leave the shop and lasts for about an hour, but meetings are occasionally held at night, for which the men are allowed a bonus for attending. The subjects discussed at these meetings include the explanation of new rules and new features connected with the work, the discussion of errors made since the previous meeting, study of the rule books, etc. When a new appliance is placed on sale specialists from the appliance department attend the meetings of the fitters for the purpose of explaining their construction, installation and adjustment.

Education by Schools of Instruction

In several of the large cities the idea of the school of instruction has been greatly developed, that of the Consolidated Gas Co. of New York City being probably the most complete example of its kind in existence. This school is entirely devoted to the fitting branch of the organization and occupies an entire floor in one of the shop buildings.

THE NEW YORK SCHOOL OF INSTRUCTION

By the New York method the applicants for employment as helpers are first sized up and if they are satisfactory are sent to a district shop where they work for a couple of weeks in order that the superintendent may more completely judge of their characteristics. While in the shop they are put on all classes of work and are also sent out in the district as helpers. If they are of sufficient intelligence and show an aptitude for the work they are eligible for the first or elementary course given at the school, their names being placed at the bottom of the list of those waiting to go to the school. The system of instruction is graduated from elementary work to the more complicated, which calls for thorough mechanical training.

An instructor, with numerous assistants, all expert in the business, handle from 30 to 50 pupils daily, keeping a record of their progress and reporting each day to the main office, from where, in turn, this information is sent to the different shops concerning their own men. In every study the students actually perform the me-

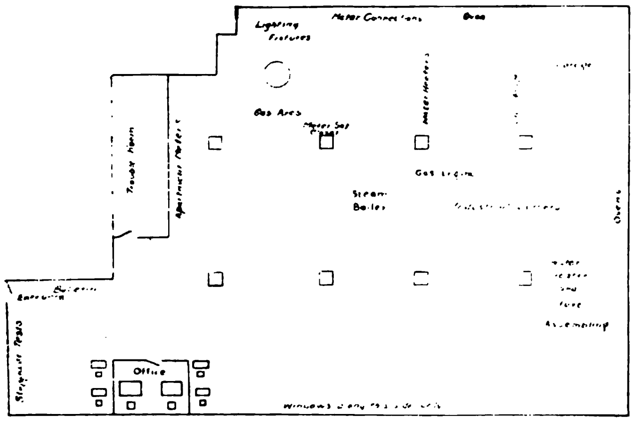


Fig. 194. Floor Plan of the Fitters' School at New York

chanical work which is called for. The day is divided into two sessions, morning and afternoon, different subjects being taken up at each, the classes being made up of those whose turn it is to attend the session.

When a man first goes to the school he is taught indexing, or the reading of meters, and is given a rating in this subject, and returns to the school until he attains proficiency in this branch, when he receives the O. K. of the instructor. The instructor will not pass a man in any subject unless he is satisfied that he is competent to perform the work in the district, and before being completely passed and given a second O. K. in a later visit to the school he must correctly answer ten written questions pertaining to the particular subject he is taught.

As soon as a shop is notified that a man has received an O. K. in a certain class of work in the school he is allotted similar work in the district, but is accompanied

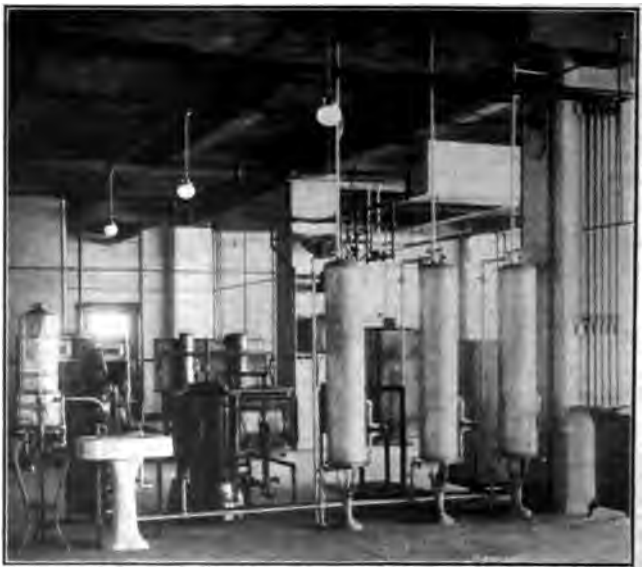


Fig. 195. Water Heater Instruction Outfit of the School

by a district foreman, who reports upon his competency under conditions as met with in the district.

After the man has worked in the district until proficient and when all the men before him have qualified for a higher grade of work, he is again sent to the school to qualify in the higher grade. In this way men having a knowledge of the work are always available.

The expense of the school is large as the employes are paid their wages in full, together with traveling

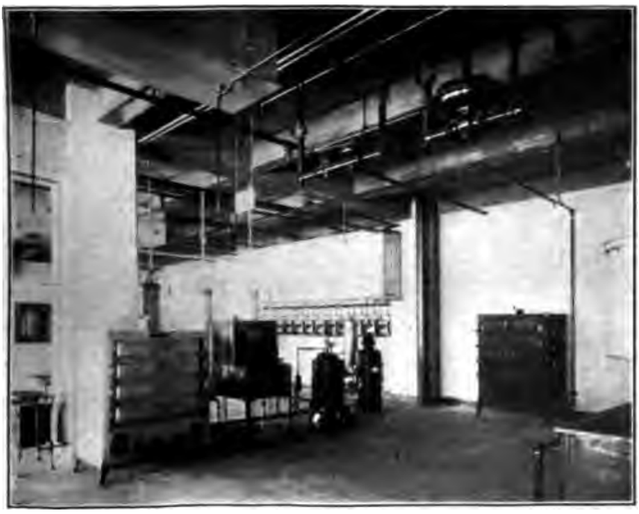


Fig. 196. Gas Ovens and House Piping Instruction

Fig. 197. Gas Stove Assembly Instruction

expenses to and from the school, but the results obtained in efficiency and loyalty have more than justified the outlay.

Some of the subjects upon which instructions and demonstrations are given in the school are as follows:

- Locks and unlocks
- Complaints
- Indexing
- Burners
- High bills
- Leaks
- Stove measurements
- Stove sets
- Meter measurements
- Meter sets
- Stove repairing
- Industrial appliances

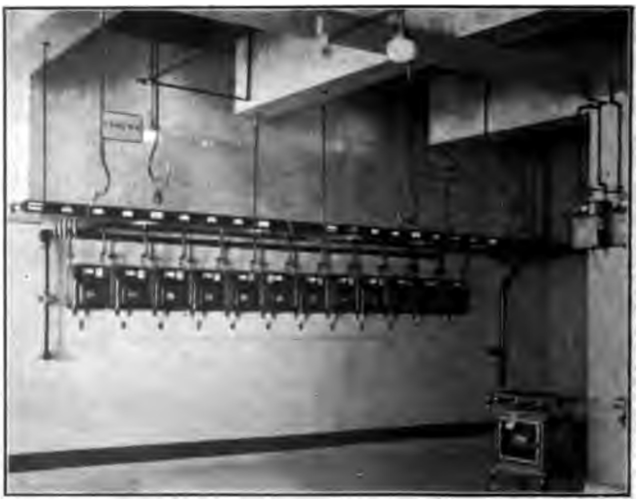


Fig. 198. Meter Reading Equipment and Stoppage Test

Actual work tickets are used in dealing with these subjects.

In addition to this work the men are taught to write their reports briefly and intelligently, and are also tested for their sense of smell, a defect in this being sufficient to bar a man.

[redacted]

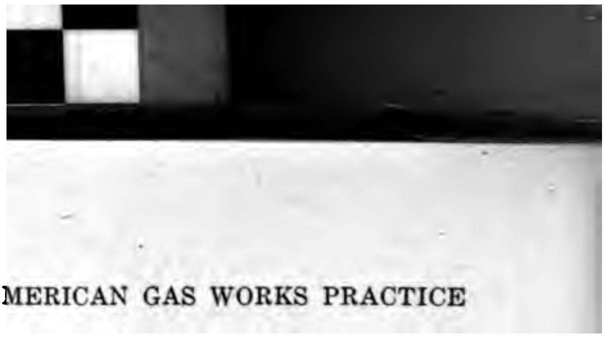
TRAINING SCHOOL AT BALTIMORE

The Consolidated Gas, Electric Light and Power Co. of Baltimore conduct a training school for the instruction of its distribution men on the third floor of the main distribution building, which is in charge of a practically experienced man.

Employes are taken from the various departments at schedule times, in numbers which do not seriously interfere with operations in those departments. When new men are employed they are at once enrolled. The period of time covered by the course depends upon the progress made by the individuals. Those who do not fulfill requirements are not retained in the employ of the company.

Fig. 199. Installation Instruction School at Baltimore

All periods of instruction are held in the day time, the company paying the salary of the employe while engaged in school work. Field work or work done in



THE CHICAGO FITTERS' SCHOOL

The fitters' school of the Peoples Gas Light and Coke Co. of Chicago occupies a building devoted entirely to this work. In this building are reproduced all classes of complaint causes; here are all styles of ranges and water heaters for connecting and adjustment; lamps of all kinds for hanging and maintenance; automatic

Fig. 203. General View in the Baltimore School

water heaters, hotel and restaurant appliances, meters of all sizes, etc.

There is always one instructor at the school who is an experienced gas man and he carefully watches each individual student. For special courses special instructors are obtained.

The method of conducting the school is in brief as follows: A man makes an application for a position with the company either as a fitter or as a helper. If for a fitter, and if his general appearance is favorable, he is first sent to the school and is given some actual mechanical work to do. He may be given a water heater or a range to connect, running the necessary fuel line and setting the meter. He may be given one appliance to connect and several to adjust, or some difficult job for which it is necessary to cut pipe. He is also given certain educational tests to determine his

Fig. 204. Burner and Water Heater Adjustment in Baltimore

ability in reading, writing and his knowledge of simple mathematical problems. The primary object is the determination of his mechanical ability and general characteristics.

If the man applies for a position as a fitters' helper he is given the same series of questions to answer and various other tasks of a very simple nature are performed by him, the object being to determine his willingness to work at any task given him as well as his dexterity along mechanical lines. These and all other men who attend the school for any reason have their sense of smell tested, since a developed sense of smell is necessary for a man handling gas.

By means of these various examinations of applicants many undesirables are prevented from obtaining positions with the company and causing trouble later. Not only is the company thus protected, but also the customer and incidentally the man himself is protected.

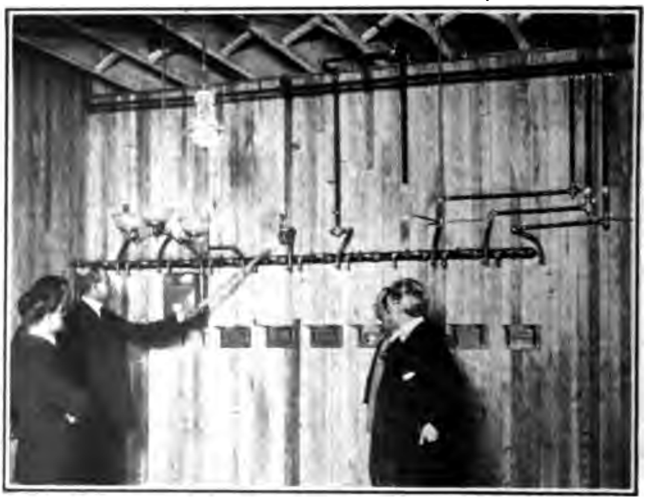


Fig. 205. Baltimore Instructor Illustrating Meter Connections

In conducting the courses of instruction an effort is made to prepare the men for the seasonable work of the company. Thus, in the early spring all the fitters and helpers are instructed on appliance installing. For some of the men it is simply a review, while for others, in some phases, it is new ground. The men actually connect up appliances, running the fuel line, setting the meters, and making out the necessary tickets. They are drilled on rules and are given pertinent instruction regarding their conduct on the customers' premises. In the early fall similar classes are conducted in lamp work and later in the fall on complaint work. All men, whether fitters or street men, who are expected to act as complaint men, are drilled at the school. By means of trapped services and risers, leaks, poor supply, binding meters, etc., these men are instructed or reviewed in this particular branch. At other times classes are conducted in range adjusting. Helpers are trained for fitters and fitters are reviewed in their weak points.

Fig. 206. House Piping Stoppage in the Baltimore School

Another phase of the adaptability of the school lies in the testing of all men who are to be raised in rate or position. These tests are conducted along certain prescribed lines and the men are required to be familiar with all work up to the grade to which they are to be advanced. If a man fails to qualify or is weak in some particular item a report is sent to the shop, and if the ideas of the shop and school differ the matter is discussed between the division superintendents and the school and a decision reached.

Many conditions of service are faithfully reproduced at the school and where a new cause of a complaint is discovered attention is called to it at the school and if possible the condition is reproduced.

The men stay at the school for varying lengths of time, depending upon their efficiency, when they are sent for instructions, but only one day is spent in testing a man. When the examination is that of an outsider applying for a position, the day is spent on his own time. The company men, however, are carried on the school roll.

The method of operation differs from that used in the New York school, caused by the difference in organization and manner of conducting the work, but the result obtained is the same, being the increasing of efficiency of the daily work of the men by teaching them the requirements of the individual gas company.

The foregoing descriptions are given to show what means are being employed by some of the small, medium and large companies to carry out this idea. It is just as important for the manager who has only one fitter to train that fitter to be an expert gasman as it is for the manager controlling one hundred fitters to so train them that he has one hundred expert gasmen. There is no distinction and no dividing line between the importance of fitters in any sized company and the educational scheme devolves itself into the question of how far the company can afford to go. When a company is so large that proper training or instruction cannot be given by the manager or department head then the expense of a regular training school is surely warranted.

Discipline

Discipline is the enforcement of rules and methods. It seems almost needless to say that rigid discipline is an absolute requirement in any well organized fitting shop. Every company has certain rules concerning the handling of work which vary according to particular local conditions. The wisdom used in making these rules and the extent to which they are enforced meas-

Fig. 207. Representatives Should Make Good Impression

ures the degree of discipline maintained and to a large extent the class of service rendered the customer.

Rules should be as few in number and as simple of understanding as is practical; so few and simple, in fact, that the fitter can memorize them all without trouble. There should be no "blue laws," but every rule should be of importance and absolutely necessary. Should a rule become unnecessary or obsolete through any cause it should be immediately repealed and the fitter so notified. In the same manner, when new rules become necessary, due notice should be given them. Where printed rule books are used, revisions should be made at stated intervals. When important changes of rules are made the knowledge should be conveyed to the fitter in a meeting held for that purpose or in regular meetings, if such are held, giving him the reason such changes are made necessary, and the information should be posted on a bulletin board for a reasonable length of time.

There is a difference between the rules and the methods used in doing work. A rule is a law concerning some very important part of the work which is intended to be particularly brought to the attention of the fitter. Methods are the ordinary and lesser important ways of doing work, which can be only right or wrong, and which are supposed to be known to all experienced fitters and to be taught the new men by means of systematic training.

The rules and methods adopted as the laws of any company should be rigidly enforced and all violations punished. When a man wilfully breaks a rule or disobeys an order he places himself in the identical position of the man who wilfully breaks the law. In the latter instance he is liable to arrest and imprisonment, in the former he should be liable to discharge. Leniency, however, may be shown for the first offense. In all cases of violations the offender should be given a fair and impartial trial, with his foreman as the judge, but in no case should a violation be overlooked. There should be no appeal from the judgment of the foreman unless the case should be of such a nature as to cause the foreman himself to seek advice from his superior.

The merit and demerit system which is used in some organizations is to be recommended. By means of such a system meritorious work as well as demeritorious is kept track of, the one counteracting the other, so that a complete record of every fitter is always at hand. This record, while a means toward the promotion of the worthiest man, is also an aid to discipline by causing the men to strive to keep their records clear of demerits. If the system of instruction and training is as it should be there will be no excuse for the violation of any rule

Fig. 208. Employes Have Good Working Conditions

and every doubtful circumstance will be placed before the foreman for his decision before action is taken.

It should not be construed from the foregoing that it is impossible to break a rule. All rules, as well as all laws, may be legitimately broken in some extreme cases, but the case must be an extreme one and the breaking done by someone in higher authority than the fitter, unless it be an emergency requiring prompt and decisive action. In cases of emergency the fitter should use his best judgment and immediately thereafter notify his foreman.

Promotion

Every fitter, and in fact every gas company employe, looks forward to promotion and is entitled to do so provided he conducts himself in a deserving manner. If he does not conduct himself in such a manner he should

Fig. 209. Employes' Lunch Room in a Gas Office

be disposed of to make room for a more worthy man. It must be thoroughly understood that a man's promotion depends entirely upon himself. He should so conduct himself that he is ready when the call comes to step up and take his place in the ranks ahead. Every man has a fighting chance to go up, but it is necessary in this day and age to fight for that chance with the best offensive weapon known—ability. He should at all times prove his worth to the company, and his right to occupy a higher position with it, by doing everything—and more—asked of him.

The man who does only what he is told usually does not get very far in any line of business. It is the man who uses his brain, as well as his hands, who has initiative and originality and who is always on the job and ready to go, who gets to the top of the ladder. Ambition is productive of promotion and without it a man is useless to himself or the company. The am-

Fig. 210. Gas Company Employes Enjoy a Banquet

bitious man is always looking ahead and is busy fitting himself for a higher position, while at the same time he is doing his work well and ungrudgingly in the position he occupies. One of the best ways of winning promotion is to understudy the man just ahead. Getting to the top of the ladder consists of climbing a number of steps one at a time. Some men have gotten to the top by jumping several steps at a time, but this method must be attendant with luck or uncommon ability, for a slip means a landing further down, probably at the bottom, with a good bit of the wind gone, making the next upward climb more difficult than at first. As the ladder is ascended the climb becomes harder and the hazard greater. Extreme caution must be exercised and every atom of strength conserved to continue, but when the top is reached there is usually a platform to sit down and rest, and this platform may have a railing around it. Similarly the upward climb in any vocation is attendant with increasing hazards in the way of responsi-

Fig. 211. Program Cover of Company Engineers' Club

bility. If the man is incapable of assuming these responsibilities when he reaches them he inevitably falls. Responsibility is very often the extreme test of a man's ability which decides his future career. If he has contracted the habit of looking forward and anticipating the responsibilities ahead before assuming them he is forewarned and therefore forearmed, and the chances are very much in his favor.

The ambitious and prepared man will not be afraid to ask for his chance when the opportunity arrives in the way of a vacancy up ahead. Often the mere asking has decided in favor of one of a number of equally experienced men. In a large machine shop were a number of skilled machinists, some had been working in the shop for a great number of years. Among them was a young man about 25 years of age who had been there about a year. While he was the youngest man

Fig. 212. Gas Company Athletic Team at Rochester

in age he was also the youngest in the service of the shop, but was as skillful as any of the others; however, not any more so. The day came when the foreman of the shop was promoted to another position. The young machinist promptly applied for the vacant position and in due time received it. Some of the older men were much surprised and disappointed and decided to ask the superintendent for his reasons in disregarding seniority. The superintendent informed them that the new foreman was the only man who asked for the position and he considered, therefore, that he was the only one who desired it. The young man would not have been promoted, however, had his qualifications not been worthy. His asking had simply cast the deciding vote and broken the deadlock which existed among a number of equally deserving men.

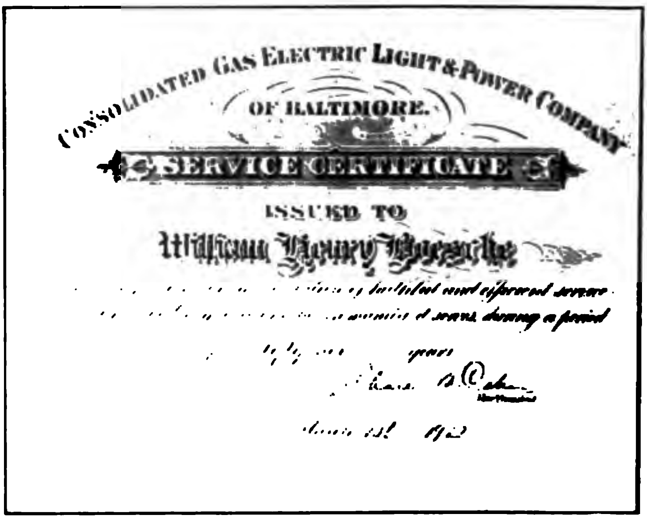


Fig. 213. In Recognition of Long and Loyal Service

All companies should practice a merit system of record for keeping track of their fitters, thereby grading each man according to his worth, so that when a vacancy occurs the men of highest grade in the class below the vacancy are in line for promotion. This method might consist of a card record of each employe of the fitting shop, starting at the time of his employment. The cards should be classified into the various grades of work done by the shop, such as complaint

[redacted]

work, fitting, meter setting, etc., the importance of the work regulating its grade. Each class of work, in addition to carrying with it an individual importance should have a separate salary limit proportionate to its importance. The card record would, in fact, be a history of the individual, and on it would be recorded date of entering the service, date of all changes of rate or position, all meritorious and all demeritorious acts, and a record and the grade obtained in periodic examinations as a part of the educational scheme of training.

Fig. 214. Regular Monthly Employes' Club Dinner

Length of service, punctuality, steadiness, class of work done, amount of work done, behavior, obedience of rules, and every other act or deed of especial importance should have a value of a certain number of points, according to importance, either as merits or demerits. A certain predetermined number of merits should qualify the employe for examination to a higher grade. And if the examination is satisfactorily passed and no vacancy exists in the higher grade, the grade of examination is added as additional merits which count in the employe's favor as against employes of the same grade who have also passed the examination. In this manner a number of qualified men are always ready to fill vacancies in any branch of the fitting shop and it simply becomes necessary for the shop foreman to consult the record cards to find out which employe is to be promoted. It prevents the promotion of untried and unqualified men, the promiscuous promotion of any of the men and induces harmony and contentment. The

Fig. 215. Saxophone Band of Detroit Gas Men

men all know that promotion depends entirely upon themselves and that to lead their class they must work up to it. They know that they are surely going to get their chance if they are deserving of it. It prevents the burying alive of a man and if worked out on a larger scale, that of interdepartment promotion, may be the means of an ideal company organization.

Several gas companies have systems along the lines of the above mentioned. The Peoples Gas Light and Coke Co. of Chicago and the Rochester Railways and Light Co. claim great success for the scheme. It is a subject worthy of the consideration of all companies, for there is nothing of greater importance or conductive of a more perfect organization than the judicial promotion of employes.

Compensation

Undoubtedly the subject of wages is the most important phase of any industrial scheme and the one over which most of the labor discussions take place.

Fig. 216. Gas Company Orchestra at Pure Food Show

The stock in trade of a man who works for a living is his labor and he has a right to expect a fair return for his efforts. The amount of compensation paid the fitter in return for his labor is subject to local standards, which in turn are governed considerably by the size of the company, so that no attempt can be made to decide upon what should be considered a fair wage. This subject is best left to the judgment of the companies themselves, who know by their balance sheet, better than anyone else, just what they can afford to pay. However, a living wage at the beginning of a man's employment is only just and proper and that his pay increase with his worth to the company is no more than could be expected and is conductive of a contented organization.

The question of working time and time off is another feature which must be largely guided by circumstances and environments. It is, however, a well-known fact that long hours are not productive of greatest efficiency. A man is but a human machine and cannot work indefinitely. A nine-hour working day should be of suf-

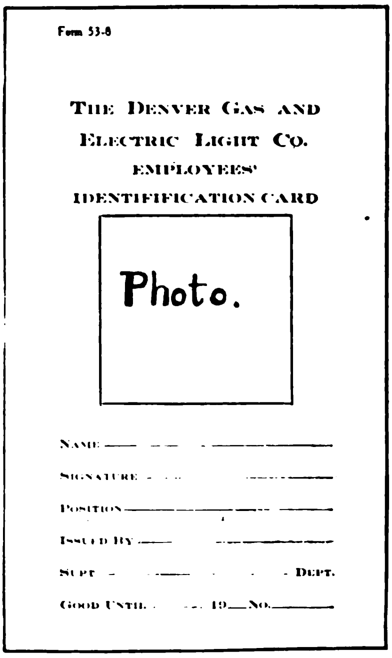
ble amount of work. While it is true that the "piece-work" system is apparently productive of an increased amount of work per dollar invested, when the quality of the work done is weighed against the cost, the company loses. When a fitter does "piece-work" he is working against time, everything else is forgotten and neglected. Anything that takes time, which can be left undone, is going to be left undone. We cannot blame the fitter for this, and no system of inspection will overcome it, but it is not the kind of work a gas com-

Fig. 218. Campaign Crew Is Thus Illustrated on Circular

pany can afford to do and expect to give its customers the best service in the world. Many a dollar has been spent by companies straightening up the improper work done during a period of compensation by "piece," yet there is something so alluring about the prospect that other companies will persist in trying it. A fitting shop is not a factory where speed is everything. Quality counts in the gas business and anything detrimental to quality must be sacrificed.

Identification

Proper means of identifying employes of the fitting shop who must have access to the customers' premises cannot be overlooked in well organized companies. Just what system of identification is employed is immaterial so long as it accomplishes its purpose, which is the


Form 53-8

THE DENVER GAS AND ELECTRIC LIGHT CO.

EMPLOYEES'

IDENTIFICATION CARD

Photo.

NAME

SIGNATURE

POSITION

ISSUED BY

SUPT DEPT.

GOOD UNTIL 19 NO.

Fig. 219. Identification Card at Denver

safe-guarding of the customer's property from unauthorized persons posing as gas company employes and the ready admittance, without loss of time, to the employe having business on the customer's premises.

One of the most common means of identification, and perhaps the most inefficient and easiest duplicated by those of dishonest motives, is the nickel-plated badge

[redacted]

or shield, having the company's name and the employe's number inscribed thereon. It is remarkable how unsuspecting the public usually is and how easily it is to

Fig. 220. Identification in Newspaper Advertisement

gain admission to their houses on a pretext to read the meter or inspect something or other. Every once in awhile there are epidemics of petty thefts perpetrated by crooks in the guise of gas men, during or after which we warn the public to admit no one on any gas company business unless they can be identified by showing their badge. We don't stop to think how easily it is for the crook to either counterfeit our badge or obtain one which has been lost or stolen.

The public often, however, becomes unduly suspicious, especially after having once been imposed upon, and a badge on a bonafide gas man fails to gain admission. Some means of positive identification which

Fig. 221. The Company Executives Also Recuperate

cannot be duplicated under ordinary conditions is therefore needed.

The fitter with his tools and materials or with a company vehicle hardly ever needs a passport to the customer's premises, but the measuring man, the inspector, the special or complaint man and the meter reader should be provided with such an article of as near an undisputable kind as can be adopted.

The uniformed employe is perhaps the best solution of this problem, although it does not entirely eliminate the danger of counterfeiting. However, the thief hesitates to adopt a garb which, directly after the commission of the crime, would make his apprehension most certain by its conspicuousness.

The Denver Gas and Electric Light Co. uses an identification card, contained within a leather pocketbook suitable for carrying orders, which contains the employe's photograph, his name, position and the signature of the head of his department. The only chance of deception here is for the crook to obtain a blank card, which he would have to have printed as all the company blanks are well guarded, have his own photograph pasted thereon and forge the superintendent's name. It would avail him nothing to try to pass himself on a lost or stolen card as the photograph of the rightful owner would prove the deception. I believe this form of identification card offers an efficient method for the smaller companies, where the uniforming of all employes would hardly be warranted, and would prove much superior to the more generally adopted badge.

Welfare and Pensions

By means of these items much can be accomplished toward the creating of a permanent force and for this reason should be strongly advocated. The workman becomes more loyal if he knows that he will be taken care of if he becomes injured or sick, and that after years of faithful service his declining days shall be free from want.

In some companies welfare is in the form of a blanket insurance, either accident or life, or both, while in others the insurance is carried by the company itself, a small sum being taken from each pay check, proportionate to the amount of the check, or all the expense being borne by the company.

The Peoples Gas Light and Coke Co. of Chicago has a most complete welfare and pension plan. A staff of competent physicians is maintained, under the direction of a chief, who represents the highest type in the medical profession. These physicians examine every applicant for employment, attend the injured employes and visit the sick. Injured men of all classes are paid full time. Those employes who are paid by the day receive full time for seven days in case of sickness and half time for a period of six months. Salaried employes are paid full time for a period of six months and longer at the discretion of the officers of the company. In the matter of death benefits, if the deceased has been in the employ of the company for a year and leaves dependents, a year's salary is given to these dependents. If there are no dependents, funeral expenses up to $100

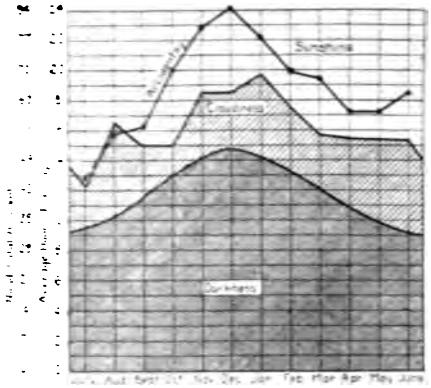


Fig. 222. Good Illumination Keeps Down Casualties

are paid. Their pension plan is as follows: For each year of service there is made to the employe, placed upon the service annuity roll, an allowance amounting to 2 per cent of the average monthly salary received by such employe during the five years immediately preceding retirement. All the expenses of these benefits are borne by the company.

The Consolidated Gas Co. of New York and the Rochester Railways and Light Co. have mutual benefit societies, while the Denver Gas and Electric Light Co. has both a mutual benefit society and workmen's accident insurance, the former being optional and beneficial in case of either injury or sickness, while the latter is compulsory to all employes except bookkeepers and clerks in the office, and is beneficial only in case of injury while on duty. The expense of both are borne by the employes, a proportionate amount from each pay check being set aside into a general fund.

Bonuses

The payment of bonuses to fitters should be in the form of a reward for information or acts of value to the company and not a part of their regular work. The

Fig. 223. Emergency Cars Promptly Remedy Trouble

selling of appliances or the giving of tips which result in sales, instrumentality in the connection of unused appliances or any means whereby gas consumption is increased, proof of gas steals, etc., should be rewarded. The receipt of these bonuses, in addition to his regular salary, will make the fitter more alert.

Bulletins

The use of a bulletin board in the fitting shop of any company is to be recommended. Upon this board should be placed all new rules or changes in rules, announcements, and any information which might be of value to the fitters. Verbal information is often misunderstood, or forgotten, while if written on the bulletin board, and left on for a reasonable length of time, a thorough understanding by all is assured.

The printing of a monthly bulletin devoted to articles of interest to the fitting organization will prove valuable to the larger companies. In this bulletin might be printed information that is intended for the general use of the organization and not coming under the head of specific orders, local news of the fitting shop, personal items concerning the fitters, acts of merit worthy of special mention, articles on special installations or conditions which might be gotten up by the fitter doing the work, announcements and a question box.

There is no doubt that such a bulletin would interest the fitter and aid the company in cementing the bond between them. A number of the larger companies are now getting out such a bulletin, which is, however, more in the nature of an interdepartment periodical. In the writer's opinion, one devoted entirely to the fitter would be more valuable and appreciative to him, as the reading matter could be more detailed and specifically interesting. There is no doubt that a nominal subscription price to cover the expense of publication would not prove objectionable.

Social Welfare

Much good-will results from organizations among the fitters devoted to social purposes, since it awakens a spirit of unity and co-operation among the members. Such an organization goes far toward removing differences existing between individuals and has a tendency to cement the entire organization into a homogeneous whole.

The encouragement of athletics among the fitters with the organization of baseball and basket-ball teams is recommended. The employe engaging in athletic sports will keep himself in good physical condition and therefore be of greater value to the company from a working standpoint. A man in any walk of life left to his own devises in the way of amusement will often go astray, while those surrounded by good environments are safeguarded to a great extent. While we usually only claim one-third of the fitter's time, the work done during that third is often disadvantageously influenced by what he did during the other two-thirds.

We are indebted to a great extent for facts and suggestions used in the foregoing to Mr. C. E. Reinicker of the Peoples Gas Light and Coke Co. of Chicago, who in

Fig. 224. Such Protecting Devices Prevent Injuries

a paper read before the American Gas Institute in 1914 ably covered the subject of training of distribution employes.

Safeguarding Employes

The invention of the slogan, "Safety First," and its adoption by all progressive firms and corporations, has prevented more bodily suffering, and saved more lives and limbs than has been caused and lost through the European war. When the employer awoke to the fact that his employes were the most valuable assets of his business, he immediately set about to conserve their lives and healths. That the effort has resulted in efficiency and increased profit is proof that it should be continued and improved by all employers.

The gas companies were quick to see the ultimate good that would result from these safety first methods and adopted them. That it has paid is proven by statistics on record. The injury of a trained workman, be he a fitter or a stoker, means that he must be replaced with a less skilled man with a consequent decrease in efficiency. Most of the larger companies maintain bureaus or departments of safety, under a competent chief, who is continually devising ways and means of safeguarding the employes.

While the work of the fitter is not particularly hazardous, it may become dangerously so at times. He is working with a fluid that, under favorable conditions, is not dangerous, but which may, as the result of acciproves a serviceable instrument for this purpose. The operator should then kneel and place the ball of his palms upon the small of back with the fingers reaching around the body, just below the floating ribs. The arms should be held perfectly rigid and artificial respiration produced by throwing the weight of the body steadily downward upon the ball of the palms, at the same time squeezing inward with the fingers. This forces the air from the patient's lungs. By relaxing the pressure upon the body the air rushes into the lungs, producing a com-

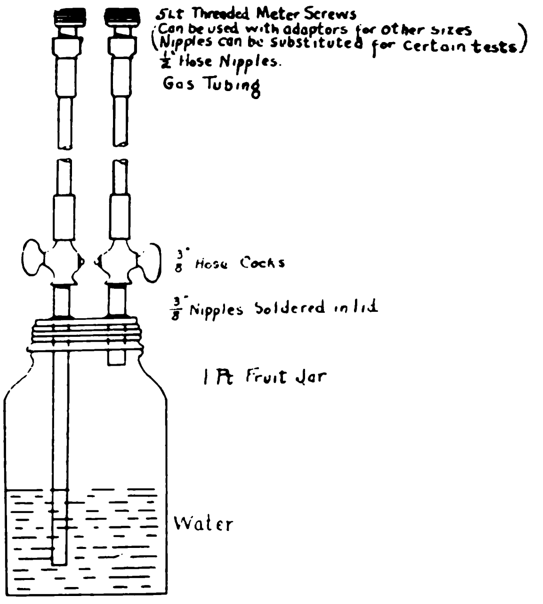
Fig. 225. Exhalation Position in Asphyxiation Treatment

plete inhalation. The exhalation and inhalations should be produced at the rate of eighteen times per minute, until the patient shows signs of life or until no signs are shown after working at least two hours, or until by absolute tests made by a physician the patient is pronounced dead.

In all cases of asphyxia a physician should be immediately called, and before his arrival first aid means resorted to.

(1). If the patient is but slightly overcome with gas, have him sit in the open air, well wrapped up. Exercising reduces the strength. Do not let him go to sleep.

(2). If considerable gas has been inhaled and the patient is still conscious, place him flat on his back, keep warm, give cup of strong black coffee, Weiss beer,



TEST BOTTLE FOR GAS LEAK DETECTION.

Fig. 226. Better Than Matches in Testing Leakage

soda water or bromo-seltzer. Induce belching or vomiting.

(3). If the patient is unconscious first take him into the open air, loosen clothing, keep warm, start artificial respiration immediately. When consciousness returns, if a physician is not present, give teaspoonful of aromatic spirits of ammonia in a glass of water or the remedies prescribed in case (2) above. If the jaws are set slip knife handle or stick of wood between back teeth as a gag.

Above all things keep th patient warm with blankets, coats or water bottles. If he vomits clear mouth and throat with the finger. A few drops of ammonia on a handkerchief held before the nose often aids in resuscitation. Do not give intoxicating liquors in any form. Persons accustomed to the free use of intoxicating liquors stand less chance of recovery from asphyxia. Do not give up until the patient is fully recovered or rigor mortis actually established, proving death.

The following precautions should be taken to prevent asphyxia: (1) If leak is in house open doors and windows before beginning work. (2) If there is a moderate amount of gas in air do not allow workmen to remain over five minutes in its presence. (3) If these is a large amount of gas in air, a respirator should be used. (4) On any class of work known to be hazardous at least two men should be employed. (5) In atmospheres containing gas even in moderate quantities the men should work in relays, with a force outside of the dangerous place sufficiently strong to rescue those within. (6) Remember that an ounce of prevention is worth a pound of cure, and that asphyxia is often produced through carelessness.

CHAPTER VIII

MANAGEMENT

The working organization of gas companies is usually divided into four general departments: production, distribution, office and commercial. The executive

GAS COMPANY ORGANIZATION CHART

- General Mgr.
  - General Supt.
    - Engineering
    - Transportation
    - Production
      - Yard work
      - Engine room
      - Night
      - Retort house
      - Assistants
    - Distribution
      - Fitting shop
      - Meter repairing
      - Storeroom
      - Complaints
      - District stations
      - Street work
      - Pressures
      - Condensation
      - Dist. maint.
  - Commercial Mgr. — Commercial
    - Salesmen
    - Service superv'n
    - Floormen
    - Appliances
  - Auditor—Chief Clerk — Office
    - General books
    - Vouchers
    - Reports
    - Auditing
    - Consumers' book
    - Contracts
    - Cashiers
    - Orders
    - Meter reading
    - Bills
    - Collecting
    - Payroll
    - Filing
    - Credit
    - Claims
  - Purchasing Agt. — Purchasing
  - Dept. Mgr. — By-product sales
  - Dept. Mgr. — Advertising

heads are: a general manager over all departments, a general superintendent over the production and distribution departments, an auditor or chief clerk over the office department and a commercial manager over the commercial department. Each of the general departments may be again subdivided into as many departments and sub-divisions as the size of the company and the efficiency of operation warrant. Each sub-division would have a foreman in charge who is directly responsible to the head of the department and who in turn is responsible to the head of the general department.

It is customary for the general superintendent to have two superintendents under him, in charge of the production and distribution departments respectively. The production superintendent, who is usually stationed at the plant, has under him various foremen, such as for the retort house, the yard, the engine room, night foreman and such assistants to himself as may be necessary. The distribution superintendent has supervision over the foreman in charge of the fitting shop, street work, meter repair shop, holder stations, complaint work, store room, etc.

In the office under the auditor or chief clerk may be various departments, such as general bookkeeping, customers' bookkeeping, meter readers, orders, claims, contract appliance, cashiers, collectors, credit, filing, payroll, vouchers, etc.

The commercial manager has charge of the commercial end of the business and is over the salesmen, service supervisions and office floor men, and may have joint authority with the head of the office department over some departments.

In addition to the above outline there may be other departments operated independently of either of the four general heads, such as engineering, purchasing, transportation, by-products sale, advertising, etc., whose heads are directly under the general manager. The transportation and engineering departments may, however, be under the general superintendent but independent of his two superintendents, while advertising may be under the commercial manager.

It is found that efficiency is promoted to a great extent by dividing a company into a number of parts,

may be too small to employ a num
foremen, but the only limit to the r
foremen it can employ is the number
for most efficient operating. It is
that a man can only serve one mast
should be compelled to serve. One
for any unit, but the foreman of t
have a "boss" who does not exist a
composing the unit is concerned.

The above is not a standard outli
pany organization, as each company
own local conditions, but is assumed
pose of showing the different activiti
ried on in all companies. While the
may have a number of men compris
smaller companies may have one ma
combined activities of a number of t
In either case, however, the activity
portance.

Relation of Fitting Shop to Other De

The fitting shop is closely relatec
other departments of a company th
other departments or sub-divisions..
tion department is so closely affiliat
eral departments as to be practicall-

The service which is given the customers is dependable upon the fitting shop to a great extent, while the attitude of the customer toward the company is influenced by the work done by the fitters, who are often the only representatives of the company known to the customer. Therefore a company is usually judged by the quality of work done or efficiency of its fitting shop rather than the way its gas is made, its mains laid or its books kept.

The fitting shop must be in harmony with the other departments if results are to be obtained. A representative of the commercial department, the contract or order departments has no right to promise execution of an order without first consulting with the fitting shop, who usually have their work laid out ahead of them in the most efficient manner and who are not always able to execute an order without timely notice. On the other hand, the fitting shop should make every effort to aid the department receiving an order in carrying out the customers' wishes, and above all things keep any promise or appointment made. Without perfect harmony, which is the understanding of each other's position and methods of operations, friction between the fitting shop and other departments, which is detrimental to both the customer and company, cannot be avoided. By arrangement with the fitting shop representatives of the commercial department may often clinch their sale by having the customer connected at a set time instead of in regular turn, but the wise representative will be reasonable in his requests for such service, reserving them for cases of absolute necessity. There is nothing more productive of discontent and inefficiency on the part of the fitting shop than the making of "rush orders" out of every order received from the customer. The modern fitting shop with its intelligent, well-trained men understands the position of the customers and their customary desire for immediate service, and they also know that it is the company's desire to furnish them service at the quickest possible time, as the revenue dates from time of execution and not of issue of order. Therefore, no time is going to be wasted unnecessarily by the fitting shop in the execution of any order, but allowances must be made for the varying number of orders handled from day to day. The number of men constituting the fitting force is practically constant and is based upon average working conditions, while the number of orders handled may be 100 per cent greater one day than another. Compensations must therefore be made by the use of time, and this should be thoroughly understood by those taking the customer's order.

The fitting shop harmonizes with the bookkeeping department when it furnishes them with a complete, clean and legibly written, executed work order. It aids the meter readers by setting the meters in accessible places, the complaint men in the manner of installation, the meter repair shop in the care exercised in handling, choosing locations and setting meters, the street department in the prompt report of irregularities in service or pressures, the storeroom by the conservation of material and the proper handling or requisitions, the transportation department by the proper care of equipment, the commercial department by satisfactory installations and the report of prospects, and it aids the company by doing all these things and more satisfying the customer by perfect installations and courteous treatment.

Gas Companies and the Public

The elements which conduce to the ideal relations as between the gas company and the public are: (1) Confidence on the part of the public, (2) good service on the part of the company, and (3) trustworthiness on the part of the one in charge of the operation of the company.

Gas companies are but the servants of the public, and as such must serve them in the best possible manner. The confidence in which any servant is held by his master is governed entirely by the class of service given. Likewise the number of friends or "boosters" a gas company has depends entirely upon the company and the quality of service rendered. Upon these friends or customers depend the amount of gas sold and revenue received thereby.

The public supports the gas company by its patronage and is therefore entitled to primary consideration from every employe from the general manager down. Its rights, which are good service, should be the first thought in the mind of everyone, and no complaint, no matter how trivial, should be allowed to remain unattended to over night unless at the order of the complainant himself. The wishes of the public, which are the companys' orders, should be handled in a prompt and business-like manner productive of satisfaction to the customer. If necessary to set a time limit on an order it should be executed at that time if it takes every employe of the company to do it. Broken promises are productive of more enemies than bad gas. Often the customers will overlook an interruption of service as being accidental, but they rarely forgive the breaking of an appointment.

Tact in handling the public is a necessary attribute to any gas company employe coming in contact therewith. Good nature, good manners and courtesy, not overlooking personal appearances, go a long way toward creating a lasting impression. It should be borne in mind by every such employe that the public judges the company by the representatives whom it comes in contact with. If that representative happens to have a "grouch" on, the company loses a friend, even though its service is first class and its policy of the highest order. It is to be understood that the public is composed of people of all kinds of temperaments, some of whom may be very unreasonable at times, but it should be remembered that the best employe and the one worthy of promotion is the one who can handle such cases by thinking of the person only as a prospective or present customer, as the case may be, who in his own mind has a real grievance, and with an unruffled temper adjust whatever differences may exist. It may

... third time even become a ...nency and good service" should be ... gas company.

Relation of the Fitting Shop to the ...

Every pipe and fitting constitut... system of a gas company and use... conveying the gas from the holder... located on ground owned by the pu... or right to use this ground is merel... or alleys in which the mains are l... public or taxpayers. The city is s... of the taxpayers' property. The s... are located on individual property o... over which the company exercises... the terms of a contract. The hous... ances for using gas are located up... by the consumer.

The entire work of the fitting s... the property or premises of the pub... carrying out the desires or orders... made known to the company in a ... manner.

While the duties of all gas ... primarily for the purpose of ... manner, many of them are ... contact therewith. However, the ... in contact with the ...

orders and rules of the company, in which case the proper instructions should be given or reference suggested to the person authorized by the company to give such instructions or issue the necessary order to conform with the customers' wishes. A point blank refusal shows lack of tact on the part of the employe and is never necessary. Tact or diplomacy is a very important and necessary requisite of every fitting shop employe, who must forget self in his desire to serve both the public and the company and so retain amiable relations between them.

The fitter is most often the representative by which the company is judged. It therefore behooves him to bear in mind that the company is dependable upon and has confidence in his ability to cause this judgment to be most favorable. The customer in passing judgment not only considers the class of work done or service given, but the actions and manners of the man doing the work as well.

Organization of the Fitting Department

Too much importance cannot be placed by gas companies upon the organization of the fitting shop. From the foreman in charge of the shop down to the helpers, all men employed should be of the highest class obtainable at the salaries which the company can afford to pay. If it pays to employ high class salesmen in the commercial department to sell gas appliances—and no one doubts the wisdom of doing so—it should pay to employ high class labor to install these appliances. The salesman, after he sells the appliance, receives his commission, his interest ceases and he is out of the deal so far as benefit to the customer and company is concerned. The fitting shop, by its method of installation or manner of doing work, greatly influenced by the impression made by the fitter upon the customer, has much to do with the prospect of the appliance remaining in service and becoming a source of profitable revenue to the company. The sale of an appliance in itself means but little to any company;

it can mean nothing more than the profit made from the selling price after the salesman's commission is deducted. This profit, as shown on the monthly report, is never a large item, and is often a debit instead of a credit. The company's revenue depends upon the amount of gas consumed by the appliance, and in order that the maximum amount of gas will be consumed the appliance must be satisfactory to the customer. It cannot be satisfactory unless properly installed, and it will not be properly installed unless the organization of the fitting shop is high class.

A large sum of the company's money is invested in the appliances, meters, pipes and materials handled and used by the fitting shop. That they are handled carefully and used economically means dollars and cents to the company. A three-cent fitting thrown away or left lay on each job doesn't mean much to the individual job, but collectively 100 jobs equals $3, or the fitters' daily wage. A broken casting on a range caused by carelessness means not only the expense of repairs, but annoyance and delay to the customer and loss of the fitter's time in getting a new range or part. A meter is a delicately adjusted measuring instrument. Improper handling or setting may injure it so that it registers incorrectly. This improper registration may be favorable or unfavorable to the customer, but in either case it is unfavorable to the company. A fast meter, making high bills, is just as much to the detriment of the company as one registering but part of the gas used. An injured meter must be returned to the shop and repaired, which necessitates unnecessary expense. Waste of material is a crime which is never committed by the first-class fitter.

The conservation of time and material, which is measured in profit to the company, can only be accomplished through a perfect organization. While the shaping of this organization may be due to a great extent to the manager or superintendent, the direct responsibility rests upon the foreman in charge of the shop. Upon his efforts depend those of the men in his charge, and through his ability as an organizer the perfect machine is obtained which works without a knock.

LARGE COMPANIES

In large companies it is practical to have the organization divided into classes corresponding to the kind of work done, such as measuring men, fitters, helpers, meter men, repair men, complaint men, special men, inspectors, shop men and drivers. By this method greater efficiency is obtained in all classes of work through the fact that all the men become expert in their particular branch of the work done by the fitting shop and by the expediency with which the orders may be handled through the method of separation and classification. The time consumed in setting a meter, attending to a complaint or inspecting a job is relatively slight when compared with doing a fitting job, therefore, if the orders are given out promiscuously to the same man, delay in executing the former orders, which are the most important, is occasioned while the fitter is doing a fitting job. If he does not execute the fitting job in its geographical order, time is lost on the road. Different handling and transporting are also required. Time is money and one way to overcome time and make money for the company is to quickly get from one job to the next. The man setting meters spends but little time on each job; he can therefore attend to a great many orders in a day if furnished with rapid means of transportation. The fitter spends most of his time on the job, therefore it is not so important that he move as quickly from one job to another as it is in the case of the meter man. The complaint man must move faster than either, as his work is of the greatest importance of any handled by the fitting shop.

It is economical for any company to classifiy its fitting work where there is enough of each kind of work to keep a man going at top speed all day.

In order that the men do not become stale from long-

Supervision.

The man selected to the responsibl man of the fitting shop must be a ability to handle the men in his ch the orders given him by office in an He must be a man among his men, an mechanic and be possessed of a fair tion.

Above all th s he must be able to alwa perfect organizatio exerc liscipline and preve disconte fair and impartial should not e to reward merit n deserving o cri ism. He should alw self in such a manner that he will and be held in respect by all his men be a despot and should encourage between himself and the men on ma to the work, but he must not in any allow familiarity. The right kind of a able to get 100 per cent out of his men ing to the whip, by the use of the spur—

The second most impo is practicability. It is n nical man, but of absolute imp practical man. He must be an

Practicability is as essential to the fitting shop foreman as it is to the master mechanic in a railway shop, the master bricklayer or the master plumber. Either must actually graduate from the journeyman or workman class before he may efficiently qualify as a foreman to direct others. It would be both embarrassing to the foreman and detrimental to the company for a workman to ask advice or instruction from his superior and not receive them because the foreman was not practically educated in the many phases of the work under his supervision. While practicability is essential to the foreman in judging the class of work done, it is also necessary in judging the amount of work to be expected from the men. An incompetent foreman will not be able to appreciate a good day's work nor to recognize a poor one. It is not always the job which shows up biggest in amount of pipe run that is the most difficult or important. If a foreman, therefore, judges work by the looks of it the men are not going to receive the just credit which they deserve and the company will lose money in the end.

The foreman must be willing and able at all times to answer questions and give instructions in all matters pertaining to the work in his charge, as well as upon the general subject of gas and the practice of other departments. As an instructor he should possess an elementary knowledge of subjects discussed in the first part of this treatise, all of which will prove of value to himself and the men. It should be his object to encourage learning and study among the men by helping them in every way possible to obtain knowledge. Education of the men helps him as well as themselves and the company derives benefit through the fact of possessing a body of intelligent, competent men. A certain amount of education is a necessary requisite of a foreman; he cannot have too much, but he must have enough. He need not be an engineer, but if he is so much the better. He will seldom run into any work requiring the actual skill of a trained engineer, but he will every day run into problems requiring ordinary technical knowledge. He should know why gas flows through the pipes and how to figure the flow; why they must be of a certain diameter to pass a given volume; why the increasing of length must be accompanied with an increase of diameter or pressure; why the pressure at the top of a ten-story building is greater than in the basement. He should know what to do in case his men become overcome with gas and how to apply first aid in case of accidents. He should be able to write legibly and converse intelligently and be able to figure estimates closely. How often have we seen a competent pipe fitter possessing all the requisites of a good foreman held back by the lack of education —in most cases the man's own fault. In this day and age of night and correspondence schools the uneducated man either has not been properly encouraged or lacks the energy and ambition to educate himself and thus fit himself for promotion. This is the age of education; without it a man is handicapped; the world wants and demands trained men.

The foreman of a large shop must not be handicapped or entangled with clerical work which keeps him in his office. He should spend practically all of his time on the outside, where the work is going on. This is the only way that he can know what kind of work is being done. He should make it a point to visit all of his men at frequent intervals, dropping in upon them unexpectedly while in the midst of their work. He should see all of the work possible, especially the most important classes, and thus act in a measure as an inspector. Of course, in large shops he cannot see all the work, but he can see enough, chosen at random, to form his conclusions as to the general class of work being done. Where the shop is too large to allow the foreman to visit his men often enough or see enough of the work to serve as an average sample, an assistant foreman should be employed, serving in the same capacity as the foreman. It is found advisable and can be recommended in the large cities to have a number of shops in different parts of the city, each supervised by a separate foreman and all under a general foreman, the duties of the general foreman to be similar to those of the individual foreman.

The clerical work of a fitting shop should consist of a chief clerk and as many assistants as necessary. The chief clerk, in the absence of the foreman or assistant foreman, should be superior in charge of the fitters and all men employed in the shop department. It would be his duty to handle the orders, giving them out to the men, and otherwise handling the inside

Fig. 227. Making a Good Impression

work under the direction of the foreman. It is advisable that a chief clerk be a fitter promoted to that position, as the practical knowledge of fitting work will prove of great benefit. The foreman should keep himself posted as to the orders in the shop and in the hands of the men and personally oversee every completed order turned in. He should be furnished with a list by the chief clerk every morning and noon of the orders given out, showing the address, nature and fitter's name and the time when execution is expected, arranged in geographical order. By means of this list the foreman can plan his visits and inspections. It is absolutely necessary that a foreman be provided with means of rapidly traveling from job to job. A light automobile runabout is to be recommended for this purpose.

As the foreman of a fitting shop is continually meeting the public and as his position demands a good impression, personality is of vast importance. Appearance and manners are of equal and primary significance, while conversational ability and tact cannot be overlooked.

The fitter who reads the foregoing advisory qualifications of a foreman may think that the target is too high to hit. It takes high aiming to hit it, but high aiming will hit high targets, and it is not beyond the average fitter to score a bull's-eye. They say "everything comes to him that waits," but it doesn't. Today the good things have to be gone after. The competent foreman is an exemplary character, but the logical way to select him is from the ranks of the fitter. The fitter who strives to stand out from the rest of his work, appearance, actions and manners is the one most likely to be chosen. It is up to him and to no one else whether he fills the requirements or not.

RECORDS

There seems to be no specific reason why the ultimate adoption by all gas companies of standardized work order forms and methods of handling fitting shop work cannot become a reality, instead of an ideal possibility. It is in no manner the assumption of an impossibility to say that this can be accomplished through the co-operation of the gas companies and the degree of receptiveness in which they are willing to be placed.

It is safe to say that there is no class of work containing as many diverse methods of operation as gas company fitting work. Hardly any two companies use the same work order forms and methods, although there is a growing tendency on the part of controlling or operating syndicates to effect a standardization among their companies.

It must be admitted that local conditions have a bearing upon the method of doing work, while the size of the company also wields an influence of some extent, but these influences are of such a character that they should not effect a general scheme of uniformity, which could take minor conditions into consideration. The proper and safe method of running gas piping, the care and handling of gas meters and the proper installation and adjustment of consuming appliances are of the same degree of importance to all companies and cannot be influenced materially by local conditions. Means toward the end of obtaining these results with the greatest efficiency is the object of this article, which while attempting to deal with the subject from an efficient standpoint, also deals with it from the standpoint of dollars and cents, as efficiency can only be measured in the ultimate cost of results.

Forms and Methods

The standardization of work orders and forms among gas companies would without doubt prove of immense value, as perhaps one-half the present forms in use could be eliminated through judicious and systematic consolidation. But this standardization cannot be effected without being accompanied with a standardization of methods in doing the work, the two being complementary of each other.

The efficiency of operation of a gas fitting shop depends primarily upon two conditions, namely, cost of operation and quality of service. It is right that a gas company should desire to carry on its operations as cheaply as possible, but in doing so the service rendered the customer must not be sacrificed. If one gas company can maintain a quality of service equal to 100 per cent at a cost of operation fifty per cent lower than another, it is reasonable to believe that the other company can do the same by changing its methods of operation to conform with the first. Let us go on further, then, and predict that by the adoption of the one best way of operating a fitting shop that all companies will be able to maintain 100 per cent efficiency both in service and cost.

Standardized methods, such as are herein recommended, must not be confused with standard practice. Standard practice very often proves a stumbling block, which retards progress, and consists of doing things a certain way because it has always been done that way. If a better way is found to do a thing, which will result in efficiency, it should be adopted even though it is strictly against any standard practice then known. When something new is discovered in gas manufacture it is not long before all companies fall in line and adopt it. The same thing can and should be done in the fitting shop and would be if just a little more attention were paid to this important part of the gas business. By the adoption of standardized methods, uniform practice is obtained which consists of the one best and most efficient way of doing fitting shop work, but which is subject to changes as newer and better methods are discovered. However, the best existing practice should always be the standard practice adopted by all companies. As previously stated this can only be accomplished by co-operation among the various companies and the promulgation of any new and efficient methods discovered by any of them.

No forms or methods, however, should ever be adopted until by trial it has proven superior to that which it is to succeed.

Even in the rules by which the installation of gas piping is governed a wide diversity occurs. One company allows 70 ft. of ¾-in. pipe as the maximum length, another 50 ft. One allows 12 openings from a certain size riser, another 8, while a third allows 15. There is only one law governing the flow of gas in pipes, and the gas made is all of practically the same quality, so why should not one standard set of rules for the installation of piping be adopted by all companies? With this object in view the Bureau of Standards is now at work upon a National Gas Safety Code, certain sections of which will appear later in this book as they are finally completed.

As before mentioned, the size of the various companies may influence the methods of operation to some extent as, for instance, in the smaller cities the duties of one man may combine a number of activities which in the larger cities are the separate duties of a number of men. However, there is no reason why the work should not all be done a uniform way, the only difference being that in some cities it is done on a larger

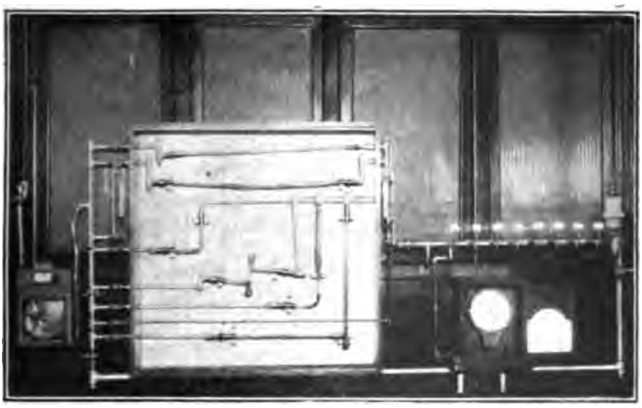


Fig. 228. For Instruction in Faults of Fitting

scale than in others, but the general system can be made adaptable to cities of any class.

Methods of Handling Fitting Jobs

The fundamental purpose of a fitting shop is the cutting, threading and installation of piping to convey gas from the company's mains to the gas consuming appliance. There are two generally adopted schemes in practice for the achievement of this purpose. (1) Cutting and threading on the job. (2) Cutting and threading in the shop, following previous measurement. Exponents of the former system claim time saved over the latter in the one trip necessary to complete the job. This would be its only redeeming feature were it carried practically as it appears theoretically. Objection-

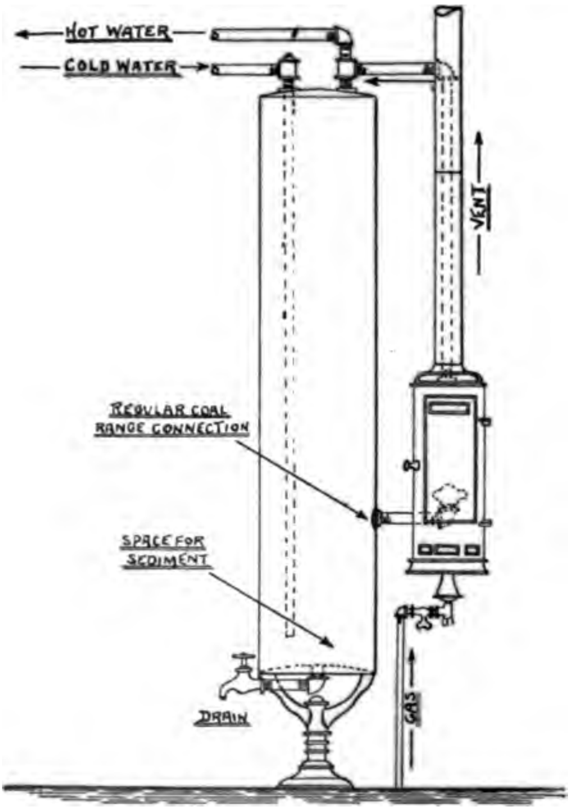


Fig. 229. Good Example of Instruction Sketch

able features are the fact that the pipe is cut and p up one piece at a time, requiring numerous trips fr the wagon to the house which is annoying to the cu tomer, the length of time spent on the consumer's pre

Form 291. 500M-P 7-13

Date Meas'd ______ By ______

Material used for ______ Order No. ______

Premises ______ Sets in ______

Name ______ Part Supplied ______

Meter No. ______ Size ______ Index ______

For Clerks { Credits Taken | No. ______ | Amt. ______

Tabulated by ______ Date ______ Class ______

Inspected by ______ Date ______

☞ **Put all sketches on reverse side.** ☜

Finished By ______ Date ______

MATERIAL RETURNED

	Hose Cocks	Service Cocks	Caps & Linings	Lead Conn.	Valves.
Size					
Quantity					
Rec'd By					

Fig. 230. Fitter's Material Record Card

ises, which is also objectionable and the uncertainty of having the required material on hand. A shortage of material results in one of two things, an improperly installed job or loss of time and delay in getting the required material to the job. The fitter who has cutting tools and vise with him will never be the accomplished and expert workman that he will be who knows that every piece of pipe is cut to measure and must fit, and who in measuring a job knows that a mistaken measurement means delay and censure. The latter method breeds carefulness and skill to a degree never attained by the former class of fitter, with the result that a better class of work is obtained.

Two separate methods may be used in the system of prior measurement. In one the fitter installing the job measures it himself, in the other one man measures the job, another cuts and assembles the pipes and fittings, while a third completes the installation. The latter method is the most systematic as it requires the use of a sketching or identifying scheme that must be thoroughly understood by all the men, which automatically eliminates any rule-of-thumb methods. The prior measurement plan has many advantages in its favor. In the first place, the measuring, cutting and installing can each be done by one man without assistance, unless the job should be of an extraordinary character. In wagon fitting two men are essential or time is wasted. The measuring man arranges all details as to location so that no time is lost by the installing fitter once he is on the job. The measuring man, using a motorcycle, may get all appliance and fitting orders directly from the office several times a day and turn in a measurement card with the order to the shop almost as quickly as it ordinarily reaches the shop from the office if unmeasured. By the use of a motorcycle very little time is consumed going from job to job. The work is better done and less annoyance is caused the customer by the smaller period of time spent on his premises. Conditions will be absolutely known and thus assurance be given the customer that all materials required will be delivered with the appliance and installing fitter. One measuring man can measure up as much work as five fitters can install, while one shop man can cut, thread and assemble as much pipe as ten fitters can install.

From a cost standpoint the following comparisons show the advantage of the measurement system, assuming that a fitter can complete four jobs per day:

Comparison of Methods

	Measuring method	Wagon method
10 Fitters at $3.00	$30.00	....
2 Measuring men at $3.00	6.00	....
1 Cut out man at $2.50	2.50	....
1 Delivery man at $2.50	2.50	....
1 Helper to deliver	2.00	....
12 Fitters at $3.00	...	$36.00
12 Helpers at $2.00	...	24.00
Total cost of 48 jobs	$43.00	$60.00
Cost per job	0.90	1.25

The vehicles used as conveyances for doing this amount of work would consist of two motorcycles and one delivery truck for the measuring method and twelve wagons or trucks for the wagon method.

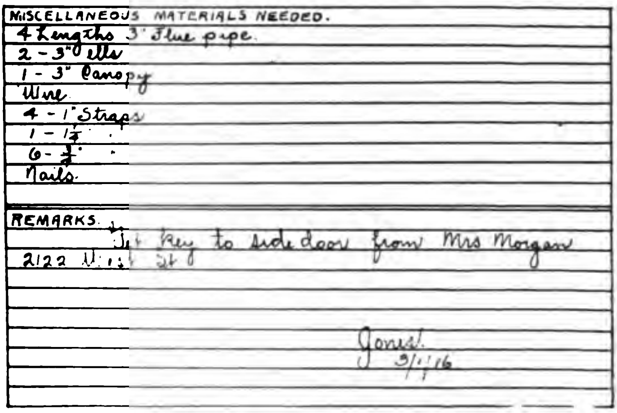
It does not seem as though the wagon method of fitting can be recommended for any size of plant. In even the smallest size plant it should be much more satisfactory for the fitter to previously measure up all of his work. There is only one disadvantage in this method, which, however, is reduced to an almost neglible extent in the larger companies, it delays the installation of the job one-half day.

With the use of the measuring system a decided advantage is found in the keeping of storeroom records which often amounts to a very material saving. The wagon fitter must carry a supply of all kinds of material [illegible], as he never knows exactly what he will need, [illegible] must requisition to an open account.

The measurement system demands the workmanship of intelligent trained men, as a form of sketching and recording of pipe and materials must be used which is legible to every man employed in the shop.

System of Measurement

Some one distinctive method should be employed which combines simplicity with practicability; something which can be deciphered at a glance by the trained fitter, without the use of a code book. An ordinary blank or cross-section card of a standard size, or one


MISCELLANEOUS MATERIALS NEEDED.
4 Lengths 3" Flue pipe.
2 - 3" ells
1 - 3" Canopy
Wire
4 - 1" Straps
1 - 1½" "
6 - ½" "
Nails.

REMARKS.
Get key to side door from Mrs Morgan
2122 [illegible] St

Jones.
3/1/16

Fig. 231. Requisition for Material

containing space for the order number and fitter's name, may be used for the recording of the sketch, measurements and material requirements.

The first thing the measuring man should do is to locate the position of appliance to the absolute satisfaction of the customer. If the appliance is located on a floor above where the pipes are to be run, a feeler bit should be run through the floor three inches from the wall and on a line with the opening in the supply pipe of the appliance. This locates the riser pipe, and the next thing in order is to locate the position of the meter. When the best position has been chosen, an outline as near the exact size of the meter as possible should be drawn on the wall with white chalk. The two terminals of the house pipe are now located and sketching may begin. The fitter should stand with his face toward the meter outline (in practice this may be imaginary) and draw all pipes running parallel with the wall upon which the meter sets as horizontal lines

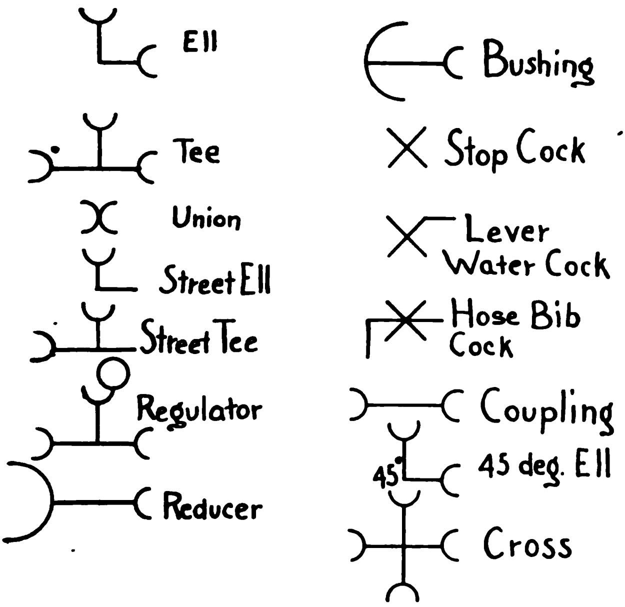


Fig. 232. Symbols on Back of Fig. 231

either to the right or left of the meter, as the case may be. Pipes running directly away from the line of vision should be shown as diagonal lines of 45 degrees angle, running toward the top of the sketch and inclined toward the general direction of the appliance, which would be either to the right or left of the meter. Pipes running in a direction toward the fitter or away from his back should be shown parallel to those running away the sketch is finished, the ben

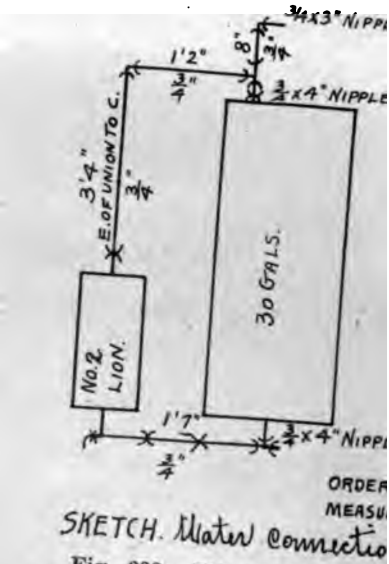


Fig. 233. Fitter's Sketch o

accurately located, after w
taken. As is seen by the accomp
fitting is represented by a simpl
measurem

representing only one meter and appliance, the most difficult kind of an installation may be as readily sketched and measured and be as legible to the installing fitter. By always assuming the position of the measuring man to be facing the front of the meter when sketching, no trouble is experienced by the fitter in laying out his pipe preparatory to beginning work. On jobs where this rule or method cannot be followed, as in water-heater installations or jobs where there is no meter, the direction of vision should be identified in

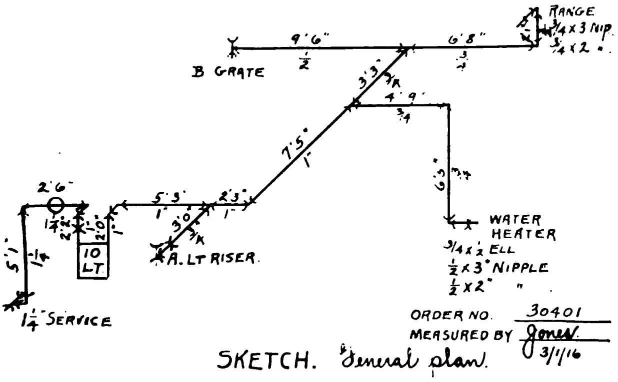


Fig 234. House Piping Sketch, Using Symbols

some manner by the measuring man so that it is plainly understood by the fitter.

A good system of symbols to use is that adopted by the American Gas Institute for use in sketching and identifying pipes and fittings in cast iron mains, but which are just as adaptable, with a few minor changes and additions, for screw-pipe work.

All measurements should be taken from center to center where possible to do so, and should be considered as being such unless otherwise marked. Sketches should be drawn as near proportionate in scale as possible. While it cannot be expected that they be drawn to actual scale, yet they can be drawn in such a manner as

the installation. The back of th
show any information which
installing fitter.

Any walls or floors through
must be plainly marked at the e
ity of getting through at that sp
by the measuring man. Where
risers are to be connected togeth
should be marked with chalk
etc., and a corresponding letter
at the point of connection. If a
a number of floors, this should b
by light horizontal lines marked
etc.

As previously stated, maximum
in fitting shop work by a system
dividing the work into a number
men doing one kind of work. In
is enough of each kind of work to
it, it is advisable and economica
The ordinary shop will therefore
following activities: Measuring,
delivery, complaint work, meter
inspection and special work

In the subsequent chapters
this method of classification of wo

Handling of Appliance...

These orders, which should have a space provided wherein the order clerk marks when wanted, should be delivered to the shop twice daily, at noon and at 5 p. m. The work received at noon, unless marked "emergency" or for a subsequent time, are given to the measuring men, to be measured in the afternoon for installation the following afternoon. Those received at 5 p. m., unless otherwise marked, are measured the following morning for installation the succeeding morning. The measuring men should call at the office each day at 11 a. m. and 4 p. m. to receive orders for and measure any emergency jobs which must be installed the afternoon or morning following receipt of the order.

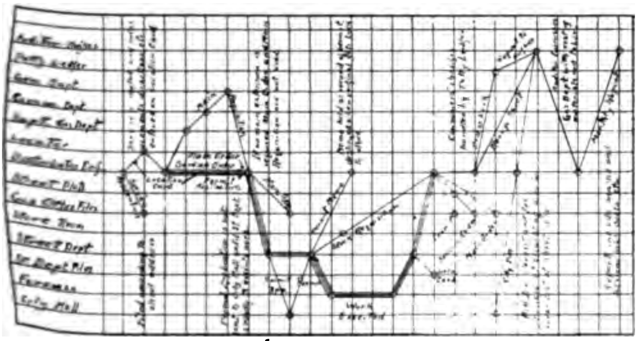


Fig. 235. Route Traversed by a Shop Order

The orders, which should be in duplicate, as they are received by the shop, are separated, the original being given to the measuring man and the duplicate, or shop copy, placed in a box containing his name against the return of the original order. Upon its return accompanied with the measuring card, the shop copy is transferred from the measuring man's box to a shopman's, and the original and measuring card given to him for assembly. The shop man uses the original order as a material requisition, keeping all of his orders, when through drawing material, in a box in the shop. After the pipe is cut and assembled it should be tied into a bundle with an address tag attached and the order and measuring card returned to the clerk, who distributes the same to the fitters, again transferring the shop copy to the fitter's box receiving the order. The storekeeper, in the meantime, while giving out the material required on the job, should charge out the appliance, if one is called for on the order, and get it out ready for delivery, or in certain instances might mark on the order, "get appliance at office." If a meter

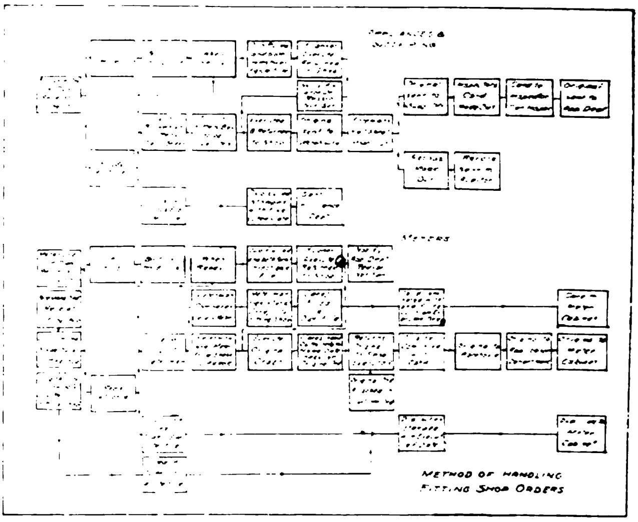


Fig. 236. Handling Fitting Shop Orders

is required on the order, this is also gotten out and put with the rest of the material.

A delivery truck may be used to advantage in delivering the appliances, piping and meters to the premises of the customer. The delivery man must of necessity be accompanied by a helper to help unload the appliance and he may be used, when his time is not entirely occupied in delivery work, in doing some fitting work himself.

The delivery system must be so arranged that no delay is occasioned the fitter in waiting for his material. The fitter may travel from job to job by street car or bicycle, as he has nothing to carry with him except his bag of tools. It should be noted that this method provides a very substantial saving in vehicle investment, operating and maintenance, over other methods. The above system, with minor modifications to suit local conditions, is adaptable to and will prove economical in any city.

Service Extensions and Meter Headers

All extensions of services, except those requiring excavation, and all meter headers should be the work of the fitting shop. The street, or gas service department, should only run the service in from the main, through the wall of the building, at a point as near the proposed meter location as is practical, and there stop. The fitting shop takes it from this point and connects to the meter.

The word "service extension" should be applied to all gas piping between the point where the underground piping enters the building and the meter cock. Literally speaking, a meter header is a part of a service extension, although in fitting shop parlance, the extension ends at the first opening of the header. A building service is another form of service extension, which is sometimes installed by outside gas fitters and is used to connect various meter headers to the common service pipe.

In doing work connected with service extensions a distinction must be shown between those entirely upon the premises into which the underground service enters and those supplying other premises from a common service. It is customary to take separate contracts, known as extension contracts, for the latter, the orders for which are issued by the office and come to the fitting shop for execution upon a regular service order.

The ordinary service extension connecting the underground service with the meter usually needs no separate order, as the modern company should compel the location of its meters in close proximity to the end of the service pipe, in which case the order to install a meter is sufficient to cover all the work of supplying gas to the meter inlet.

The work of installing a meter header should, however, be covered by a separate order which may be a regular appliance and fitting job form. As a meter header must usually be constructed before any orders for meters are issued, it is imperative that some order be used to carry the material and labor charges. Furthermore, if these charges were distributed over the different meter orders a complexity of storeroom accounting would occur.

Both service extensions and meter header work may be handled by the fitting shop in the same manner as any appliance or fitting order, by previous measurement and cut-out, except that where an order requires a considerable amount of work, or, if any danger is involved, a helper should accompany the fitter during installation.

The Handling of Meter Orders

Nothing is of greater importance to a gas company than its meters. The net earnings of the company is dependent to a large extent upon the accuracy of meter registrations, the facility in which meter orders are handled and the correctness of reports and records thereof.

Nothing short of the best methods known are proof against errors and inaccurate reports occurring occasionally to the disadvantage of the company. Meters may even be set and lost to the records for indefinite periods unless good systems are used.

The fitting shop is not alone responsible for the errors which might occur, as efficient office methods are just as essential to a good system as shop methods, and the same standard of perfection should be maintained in one as in the other.

The two most important considerations connected

[redacted]

with the handling of meter orders by the shop are: (1) The speed in which the executed order reaches the office, and (2) the accuracy and completeness of the data shown on the completed order.

The first item is important inasmuch as revenue commences with the installation of a meter, and ends with its removal. The record of this installation or removal should appear upon the consumer's ledger as soon as it can possibly be entered there. In the case of an installation, so that the customer can be billed at the regular time and in the case of a removal, so that he can receive his final bill promptly. Even the prompt execution and delivery to the office of change meter orders are important, as all meters, except routine maintenance, are changed for a cause of which the office should have immediate record. The importance of accurate and complete records on the executed order is too apparent to warrant a statement of reasons.

The handling of meters by the fitter does not require the degree of mechanical skill necessary in some of the other classes of work, but what is lacking in mechanical requirement is compensated for in the speed and accuracy made necessary. It is recommended for all companies having enough meter work to keep one man busy, to make of it a distinct work, separate from fitting and other work handled by the shop, except those meters required on piping installations handled by the regular fitters. A conveyance of special design should be used which is both conducive of careful handling of the meter and of speed in executing the orders.

A system must of necessity be used in the shop which differs from that used in other classes of work, as every meter and order must be safeguarded against the possibility of loss or error. Some very elaborate systems are in use, but in most cases they carry with them so much duplication that the possibility of errors is often enhanced instead of diminished. A system combining simplicity with efficiency is to be desired.

The following simple system may be found worthy of consideration: All meters sent from the repair shop to fitting shop are provided with tags, tied to one screw, showing company number, factory number, size, maker and index. The clerk giving out the meter and the fitter receiving same compare the tag with the meter, after which the tag is removed and filed against the fitter, serving as his receipt for the meter. The shop copy or duplicate of the set order is also filed against the fitter. It is seen that both the meter and order are safeguarded against loss by the fitter.

The fitter, having set the meter, fills out the order on the job and returns it to the shop, after which the shop copy is pulled from the fitter's file, stamped completed, dated and filed by order number, or geographically. The original completed order is compared with the meter tag and if found to correspond is sent to the office, the tag being returned to meter repair shop for filing by company number.

In the case of return meters the tag is made out in the fitting shop showing in addition to the meter data the address removed from and attached to the meter before it is sent to the repair shop. This tag remains on the meter, receiving record of test and repairs, until it again returns to the fitting shop for resetting. The original order is compared and filled out by the fitter on the job, and returned to the shop. After comparison with the meter and tag it is sent to the office, the duplicate or shop copy pulled from the fitter's file and filed in the same manner as the set order.

On a change meter order the set and returned meter would show on one order. The method of handling the order being the same as a set and return.

Handling Complaints

Nothing is of greater importance to a gas company than the immediate and permanent alleviation of all complaints, no matter how insignificant they may appear. Complaints are the ripples on the sea of good service which may develop into waves of dangerous proportions when fanned by the winds of inattention or incompetency.

It is beyond reason to expect that complaints can be entirely eliminated, as nothing earthly can be of an

Year	Total		Correct Meters, Number	Fast Meters		Slow Meters	
	Number	Per Cent Error		Number	Average Per Cent	Number	Average Per Cent
1872	202	0.32 F	81	87	4.30	32	9.55
1873	238	1.18 F	95	100	5.43	40	6.61
1874	285	0.57 F	131	101	4.76	51	6.22
1875	314	1.33 F	142	123	5.99	39	8.17
1876	381	0.74 F	179	148	5.19	53	9.17
1877	257	0.28 F	125	93	4.79	34	11.00
1878	343	0.63 F	180	111	5.34	44	9.51
1879	193	0.64 F	91	83	5.00	18	16.20
1880	122	0.52 F	52	48	4.54	22	6.59
1881	141	0.33 F	72	41	5.68	28	6.44
1882	127	0.43 S	62	41	4.10	21	11.30
1883	38	2.76 S	15	11	4.25	12	13.12
1884	176	0.58 F	100	51	4.22	25	5.02
1885	139	0.08 S	74	44	5.09	21	11.50
1886	124	0.79 S	64	38	4.55	22	12.43
1887	94	0.62 F	63	23	4.29	8	5.69
1888	182	0.82 F	109	56	5.22	17	8.71
1889	179	0.05 S	121	42	5.65	16	15.41
1890	218	0.60 S	134	64	5.32	20	23.60
1891	230	0.41 S	144	52	4.74	34	10.03
1892	344	0.41 F	190	105	5.67	49	9.28
1893	527	1.23 F	284	197	5.10	46	9.30
1894	604	0.99 F	327	217	4.70	55	8.56
1895	957	0.40 F	549	301	4.73	93	9.72
1896	1200	1.22 F	602	477	4.87	113	8.41
1897	443	1.36 F	220	183	4.98	31	12.39
1898	537	1.10 F	248	235	4.97	42	15.65
1899	473	0.64 F	225	199	4.64	49	13.52
1900	633	0.74 F	298	258	4.81	77	10.75
1901	940	1.86 F	413	456	4.76	71	7.89
1902	990	1.60 F	394	479	5.18	117	7.53
1903	1195	1.28 F	535	541	4.84	119	10.07
1904	1204	1.69 F	521	578	4.93	105	8.87
1905	746	2.29 F	324	359	5.31	63	4.40
1906	416	1.82 F	178	212	4.82	25	7.40
1907	354	1.64 F	148	177	4.46	29	7.74
1908	432	1.65 F	199	201	4.37	32	5.81
1909	411	1.78 F	180	189	4.87	42	5.40
1910	325	1.38 F	136	158	4.58	31	9.27
1911	452	0.59 F	236	152	4.50	64	6.70
1912	440	1.26 F	225	175	4.60	40	8.33
1913	352	1.14 F	195	129	4.30	28	7.07
1914	286	0 76 F	169	86	5.12	31	7.98

Fig. 237. One Company's Experience with Meters

everlasting character, but it is within reason to expect that complaints can be materially reduced by exercising advanced methods of workmanship, in all installation work done by the company, and in the manner of handling the complaint when it does occur.

A complaint must be handled in the same manner as a bodily ailment. We are all aware that serious illness often results from the neglection of apparently inconsequent ailments, which if attended to in time and in the proper manner, by the removal of the cause, results in complete recovery, with no serious effect. By the same analogy we would employ an expert physician to diagnose the cause and prescribe the proper remedy for its removal.

Complaints oftentimes originate in the minds of the customer, but the fact must not be lost sight of that even these are of the utmost importance, as some cause must have originated the idea in the mind of the customer. This class of complaint is often the hardest of any to "kill," as the remedy must exist in convincing the customer beyond the reason of a doubt that his service is what it should be and what he expects it to be. Particular imaginary complaints require particular remedies, but they all should result in the removal of the cause.

Nothing is more detrimental to service than inattention or temporary relief. Any means are warranted to eliminate either. It is never impossible to effect a permanent repair, and temporary means of relief should only be employed until permanency can be established

Whether complaints shall prove a serious detriment to a company depends greatly upon the men employed in handling them—from the clerk who receives them to the men who execute the orders. The most trivial complaint may make an enemy for the company if incompetently handled. It is therefore necessary, in perfecting an organization for the handling of complaints, that great care be taken in choosing the men and standard of requirements adapted to which they conform.

A disputed question has arisen in combination companies, selling both gas and electricity, as to the advisability of maintaining one complaint department to handle combined gas and electric complaints, or whether each kind of complaint may best be handled by its individual department. The principal objection to the

Infractions of Gas Service Rules

No.	Subject	First Inspection	Second Inspection	Third Inspection	Fourth Inspection
1-	Records and Reports	2	1	-	-
2-	Testing Facilities	4	5	-	-
3-	Request Tests	1	-	-	-
4(a)-	Refunds for Fast Meters	19	15	6	1
(b)-	Charges for Slow Meters	-	-	-	-
5(a)-	Service Test Record	-	-	-	-
(b)-	Meter Test Record	35	16	2	-
(c)-	Meter Record	19	8	2	-
(d)-	Tabulation of Meter Tests	34	19	7	1
6-	Bills	1	2	-	1
7-	Complaints	7	8	5	1
8-	Interruptions of Service	-	-	-	-
9-	Definitions	-	-	-	-
10-	Meter Testing Equipment	9	11	-	1
11(a)	Method of Testing	6	4	-	-
(b)	Installation Tests	10	9	3	1
(c)	Allowable Error	-	-	-	-
(d)	Prepayment Meters	-	-	-	-
12-	Periodic Tests	10	5	1	-
13-	Referee Tests	-	-	-	-
14-	Calorimeter Equipment	6	6	2	-
15-	Heating Value	16	8	2	-
16(a)	Test for Hydrogen Sulphide	7	2	-	-
(b)	Total Sulphur Requirements	6	2	2	1
(c)	Hydrogen Sulphide Tests	25	15	3	-
17(a)	Pressure Variation	1	3	1	1
(b)	Pressure Surveys	27	17	2	-
18-	Record of Interruptions	3	1	-	-
19-	Extension of Mains	1	1	1	1
	Totals-	249	157	38	8
	Infractions Per Inspection	3.3	2.7	2.1	1.6

Fig. 238. Effect of Repeated Inspection

combination shop lies in the fact that it eliminates to a great extent the specializing that is necessary in the proper handling of either complaint. The gas complaint bears no resemblance whatever to the electric complaint, and in most cases is a more difficult proposition, which requires different tools and different methods of safety precautions.

The theory of the combination gas and electric department is that complaints of either character in the same vicinity may be handled by the same man, thus effecting a saving in labor. Another apparent advantage lies in the fact that either of the two kinds of complaints may predominate in number, in which case the men may be switched from gas to electric, or vice versa, as conditions might warrant. If two separate organizations, in which different men handle the different complaints, are to be maintained within the combination department, economy cannot be practiced as it could if the gas complaints were handled by the fitting shop.

Gas distribution work is particularly affected by seasonal conditions, which make the fitting shop particularly adapted to the handling of complaint work. The spring and summer is the time of heaviest appliance and installation work, with a smaller number of complaints, while the fall and winter is the heaviest in complaints and lightest in appliance and installation work. Therefore, the fitters may be switched from complaint to fitting work or from fitting to complaint work, in a manner to suit existing conditions. In this way both maximum economy and efficiency are obtained.

Another advantage in favor of the latter scheme is in the fact that the fitting shop is in most cases prepared to carry the complaint to a thorough completion, which consists in the entire removal of the cause. If piping work is necessary it can be expeditiously done, or if the remedy consists in changing a meter or regulator, that may also be done with minimum delay and inconvenience to the customer. Another favorable point is that the foreman in charge of the fitting shop must of necessity be an expert gas man and a specialist in all branches of gas company work affecting the safety and service given the consumers. It cannot be expected that the foreman of a combination complaint shop would be a man of the same qualifications. He would undoubtedly be a man of high calibre, but the old unsettled question arises as to

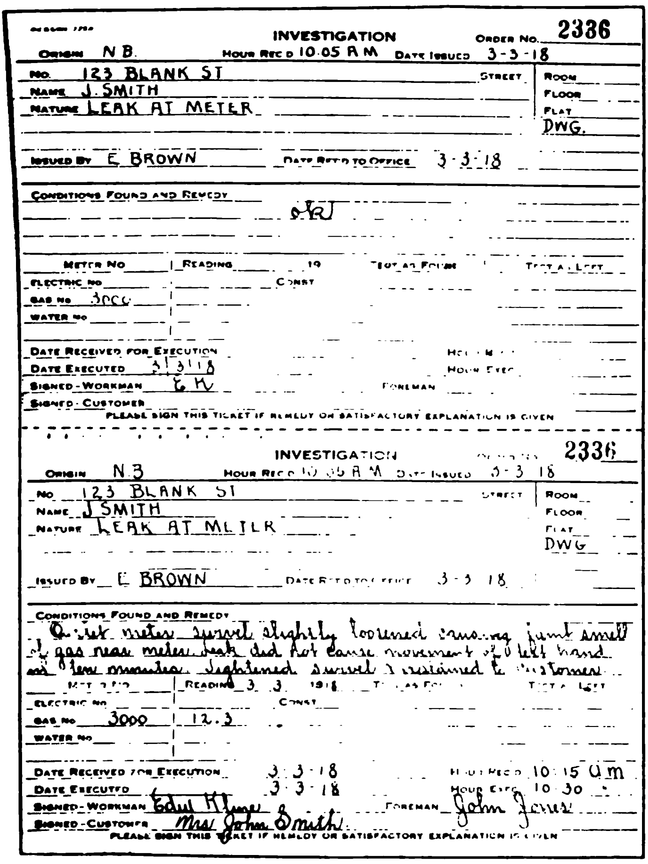
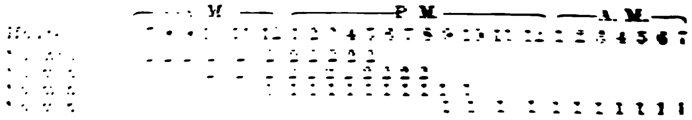


Fig. 239. Inspection Report on Complaint

whether a man may be a good gas man and a good electric man at the same time.

Gas companies should be prepared to handle complaints at any time of the day or night. Where a company is not large enough to require a man or men on duty during the whole 24 hours of the day, a telephone can be installed in the residence of one of the men and he be subject to call after working hours. This fact may be made known to the customer by a suitable legend printed on the gas bill. In the larger companies the complaint force may be divided into squads in such a manner that some one is on duty at all times during the day and night. Local conditions must govern the number of men comprising the complaint force and the number on duty at any time. The following diagram is given to show how the men may be arranged in regard to numbers and time:



In this diagram it is assumed that there are six complaint men working on ten-hour shifts. It is seen that the number of men on duty at one time is in direct proportion to the possibility of complaints coming in. The men going off duty can always be held over if necessary. By the study of any particular local condition a schedule may be arranged which will suit the needs of the company.

To avoid annoying the customer, no more men should ever be sent on a job than are absolutely required to do the work. In order to help the fitting shop in this respect, all information possible should be obtained from the customer by the clerk taking the order. From this information the foreman can judge what is needed in the way of men and equipment, and should be able to complete the order on the first trip in practically all cases. Numerous trips to the customer's premises, often by different men who, being unfamiliar with the conditions, require explanations from the customer, go a long way toward creating a feeling in the customer's mind that the company service is woefully inefficient.

Owing to the dangerous nature of some complaints, as well as to their detrimental effects upon good service, all orders should be transmitted to the operating force at the shop as speedily as possible after their receipt. This should be done by the use of the telephone, a telephone order being used at the shop for transmitting the complaint. After execution, the telephone order containing the report made out by the fitter and the customer's signature showing that the complaint was satisfactorily attended to should be pasted to the original order made out by the office and preserved as a record.

The fitters attending to complaint work should be explicitely required to report any condition existing on the customer's premises that would be conducive of a repetition of the complaint, such as piping too small or improperly installed, meters exposed to extremes of temperature or damage, etc. In cases where the faulty workmanship lies within the responsibility of the company, elimination of the fault should be accomplished as soon as possible. Where the fault lies with the customer, he should be properly notified to remedy the same at his earliest convenience.

Handling of Miscellaneous Orders

Under this heading would come all work not previously classified, such as repairs to appliances and the delivery or installation of heaters, lamps and small appliances not requiring a fitter. In the larger shops there will usually be enough special work in the nature of repairs, etc., to require the services of one or more men. The delivery of appliances not requiring the services of a fitter to install may be best handled directly from the office.

General Importance of Forms and Reports

Upon the completion of any kind of an order it becomes a permanent record of the company. It is therefore of the utmost importance that the completed form contain all information that could possibly be of any future value. Too often the otherwise good fittter turns in his report as "O.K. John Jones," and while the foreman may accept John Jones' O.K. as proof that the job was satisfactorily completed, other departments interested in the order may not know him so intimately, and the O.K. simply signifies incompleteness in the order. The proper report upon an order is of practically the same importance as the proper execution of the work. The incomplete O.K. upon an order simply signifies that the fitter has been imperfectly trained. The fitter should bear in mind that too much information cannot be written upon the order. If the front side of the form does not contain enough space for all the information that the fitter considers of

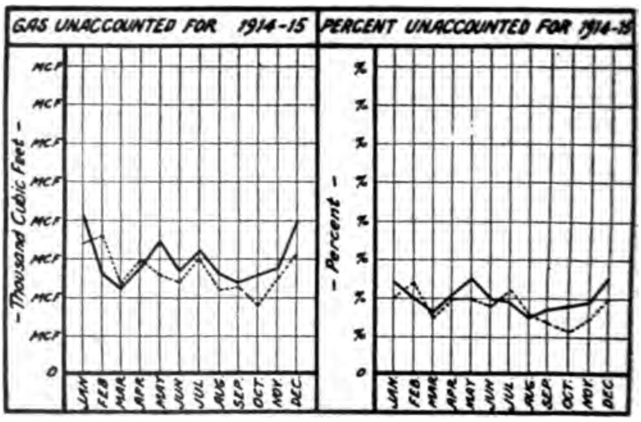


Fig. 240. A Convenient Form of Record

value, there is no objection to using the reverse side or even of permanently attaching an extra sheet of paper. However, forms if properly gotten up by persons familiar with the practical side of the gas business will contain spacing for all information desired, and will not require of the fitter a lot of clerical work of no value to any one.

Too often forms are gotten up by incompetent persons and changed to new forms adopted at the whim of anyone desiring to do so. This is wrong, and results in a large expense in printing and stationary. Before the adoption of a form of any kind it should be given the most careful consideration by everyone interested in its use. Even the fitter himself often has valuable ideas on the subject that should be considered. The adoption of uniform forms, which could be the result of study by gas association committees and capable representatives of all the companies, is to be looked forward to as an ideal condition.

SMALL COMPANIES

In general the only difference existing between large and small company shops is the combining of activities in the latter. The work is of the same relative importance to either, as is also the qualifications of employes. Good service is as much of an asset to a company selling 30,000 cu. ft. of gas a day as it is to one selling 3,000,000 cu. ft.

Supervision and Employes

The foreman of the small shop is often the meter repairer, storekeeper, street foreman and sometimes even the gas maker. He is therefore usually what would be called an all-around man. While his qualifications must be high, he is not the high-class specialist that will be found supervising the larger shops. The greatest fault of the small company lies in the fact that the foreman's knowledge is too often of a local nature, instead of general. He must usually fight his own battles, devising ways and means of doing things as he is able to. Sometimes we find some novel and original ideas worked out in the small properties that are the inventions of necessity, some of them are quite efficient in their way, but too often suffer by comparison with those adopted through the wider experience of the large companies. It would undoubtedly prove of benefit to any small company to send their foreman to a large company for at least two weeks each year, there to see and learn all that he possibly can of the methods employed. If the foreman is of the right stuff he will come back chock full of efficient ideas which he will proceed to put in force and the company will profit thereby.

The fitters must of necessity be handy men like the foreman, able to do any kind of work encountered. There is no reason, however, why the work cannot be done in the same general way as it would be done in the larger shop, the same rule applying to setting meters, installing appliances, piping houses, complaints, etc., and the same class of workmanship could be expected.

Consolidation with Other Departments

In the small companies there may be no separation into departments, or the company may be divided simply into three general departments: Manufacturing, Distribution and Office. The Distribution department would embrace the fitting shop, meter repair shop, street work, storeroom and often meter reading and delivering of bills. One foreman, or at most two, usually handle all distribution work.

Reading Meters and Delivering Bills.

The reading of meters and bill delivering very often proves a serious handicap to the efficient operation of the small shop. Where a number of fitters or helpers are required on this work for a part of the time each month, it means that the shop must either work short-handed during this period or be overstocked with labor during the rest of the month. Neither condition is efficient, and this practice should only be employed by those companies who have not enough customers to keep one man busy reading meters and delivering bills continuously.

Forms and Reports

These items are of the same importance to the small company as to the large one, and should receive a like consideration. The forms in all probabilities could be fewer in number, but should follow the same general outline, and require the same attention from the fitter in the matter of detailed report thereon.

CHAPTER IX

THE FITTING SHOP

The logical place for the gas fitting shop is evidently in a location as near the center of population of the area covered by the distribution system as possible. The time spent on the road by the fitter is always a waste for which the company must pay out money and receive none in return. The more that this wasted time is reduced, the more useful work the company will get

Fig. 241. Floor of a Fitting Shop

out of its men and the more efficient the operation of the shop will be. Whether the shop be located at or near the office, at the gas works or in a suitable building elsewhere, are minor details so long as waste of time is reduced to the minimum.

Location

Other features to be considered in choosing a location for the fitting shop are: (1) Valuation of property or rental of; (2) proximity to associated departments;

(3) facilities for delivery of materials and (4) facility for handling transportation equipment.

In most cases the ideal location of the shop is at or very near the office. With the object of attractiveness, as well as to best serve its patrons, the office is invariably located in the center of the business portion of the city, which is also usually the hub of population. Except in the small properties, it is quite out of the question to locate the shop here, due to the high rental, or high value, if the company owns its own office.

It is desirable to have the fitting shop, storeroom and meter shop located in the same building, as the former must draw all materials used from the storeroom and meter shop and is dependent upon their proximity for a large measure of its efficiency. As the meter shop is a place of disagreeable odors and the storeroom one demanding warehouse facilities, a location which is suitable for an office is unsuitable for a building housing the combined activities of the gas shop.

A site should therefore be selected as close to the main business district as possible, but far enough removed therefrom that objectionable features will not exist.

Such a site can usually be found in the warehouse district of the city, and it is desirable that the building used should be occupied entirely by the gas company. It is desirable to obtain a building located on or near a railroad switching track which will greatly facilitate the delivery and unloading of materials, especially those coming in carload lots, such as meters, appliances and pipe. The building should be easily accessible for wagons and trucks and the locality provide street or alley space for parking the vehicles when the fitters are in shop. The building should not be so situated that difficulty is encountered going to or from it, such as railroad tracks to cross. Often in such cases, where the distance is not an objection, serious delay is caused which greatly impedes the work of the shop.

In some cities the gas works affords an ideal location for the shop building, but this is the exception rather

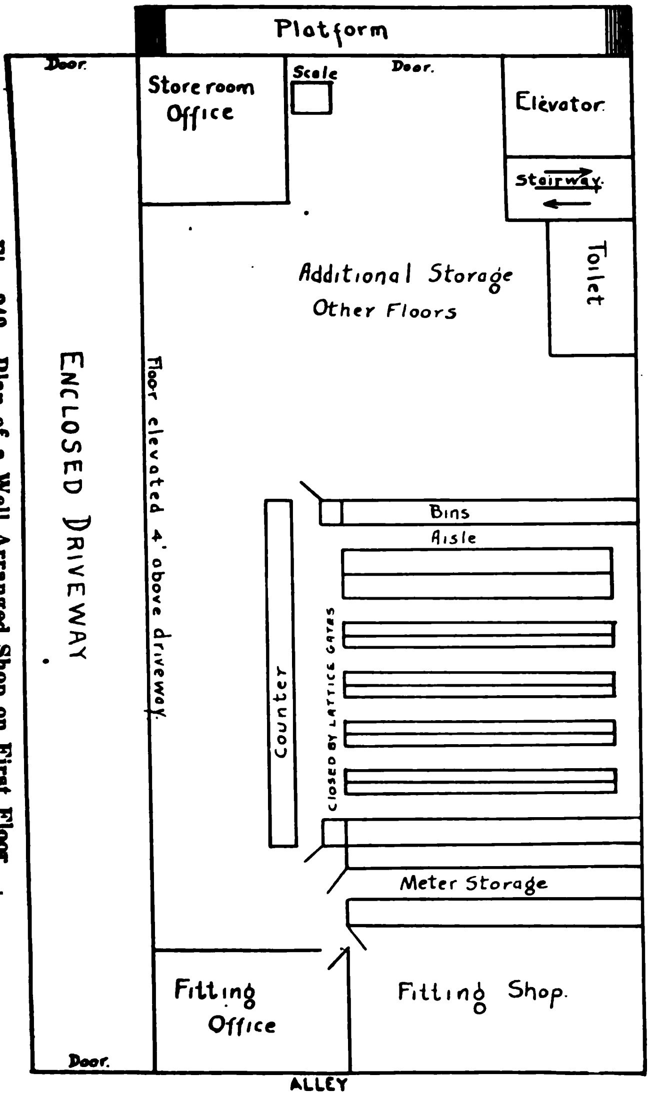


Fig. 242. Plan of a Well Arranged Shop on First Floor

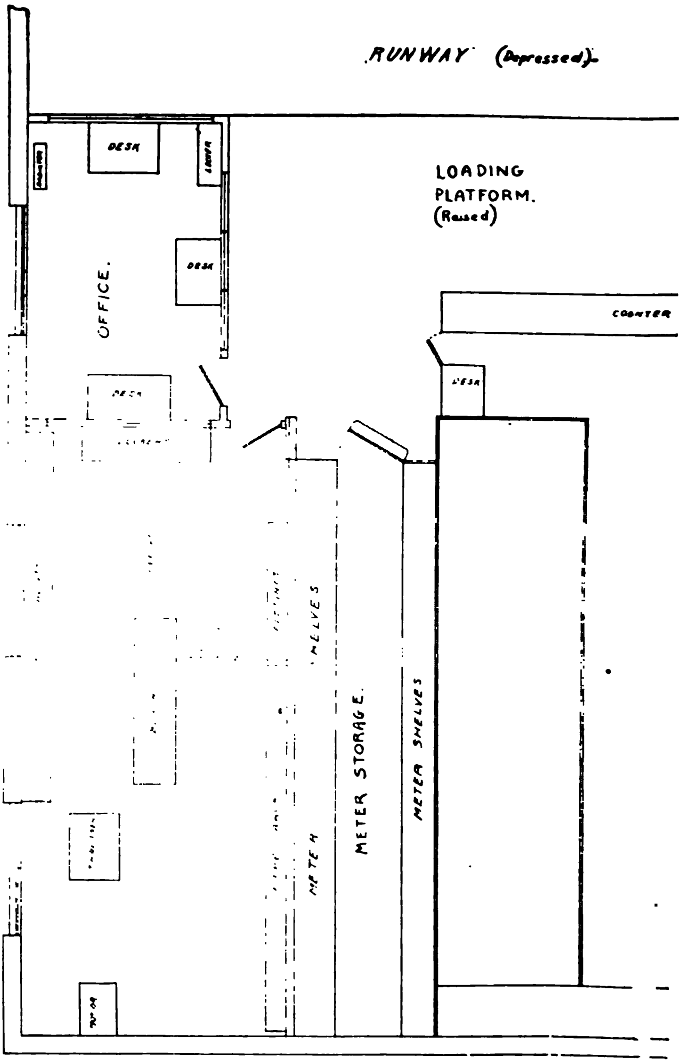
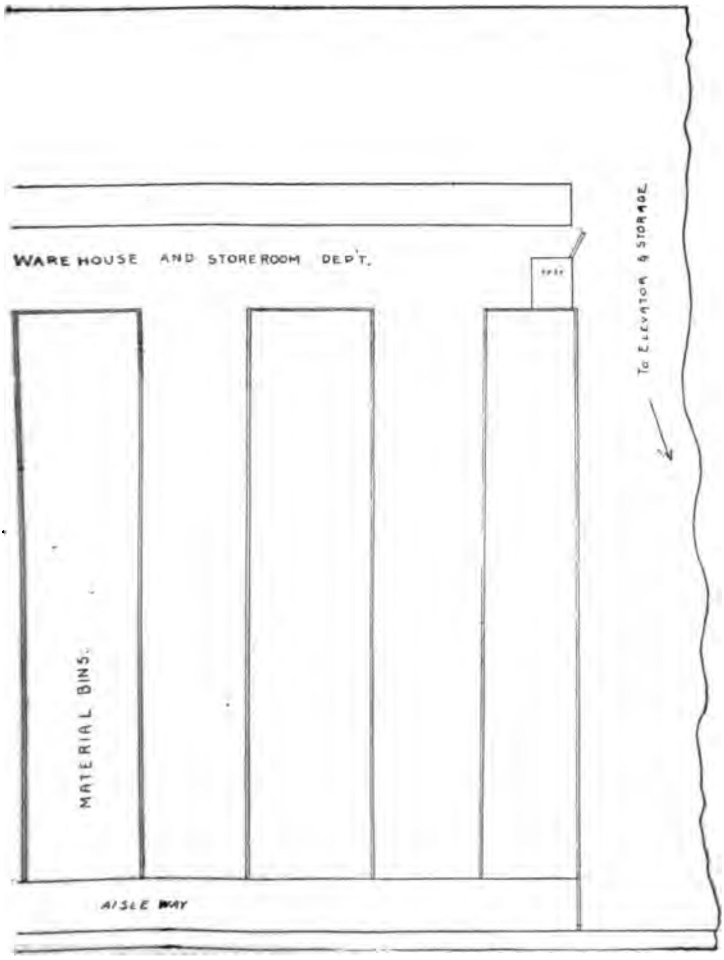


Fig. 243. Another Arrangement of



Fitting Shop Located on Upper Floor

than the rule, as the plant is more often located in an inaccessible place, which would be disadvantageous. When no objections appear, however, the shop located at the plant offers many advantages which conduce to economy and efficiency.

The Building

A suitable location having been selected a building must be decided upon which will fulfill the conditions needed in a shop or storeroom. The size of the building and number of floors is of course dependent upon the particular local conditions, but certain requirements are demanded in any. As the materials stored and handled possess great weight the construction of the building, in regard to the load it will safely carry, must be a primary consideration. It should contain a full finished basement, for the storage of pipe and heavier fittings, and an elevator.

The top floor should be occupied by the meter shop and provisions made for good ventilation and light. This is best effected by the use of combination roof ventilators and skylights. Certain alterations are usually necessary in any building not built especially for shop purposes. The fitting shop should be located on the first floor in the most accessible part of the building.

The fitting shop should consist of two parts, or rooms, exclusive of those used for the comfort of the men, the shop office and the fitting shop proper. The shop should consist of one room containing pipe machines and work benches, and even in the larger companies this room may be surprisingly small. A company employing the measurement system and working from fifteen to twenty men may efficiently do so in a shop 18 ft. x 36 ft. In fact room need only be provided for the number of shop men required to cut, thread and assemble the pipe for the measured jobs, irrespective of the number of fitters employed. However, a lounging room must be provided for the men when in shop, but this would best be entirely separate from the shop.

The storeroom should be isolated from all other parts of the building and be accessible to only those responsible for the handling of stocks and materials. A wicket gate should connect with the shop room so that material can be delivered to the cut-out men.

Provision should be made within the storeroom for the storage of a number of meters ready for use. These meters should be delivered by the meter shop in quantities sufficient to last a week. The storekeeper or clerk in this case gives out the meters required in the same

Fig. 244. A Power Drive for Pipe Threader

manner as other material drawn and by this method the work and records of the meter shop are greatly facilitated. Service regulators should be handled in the same way. Meters and regulators returned should be sent to the meter shop every day.

The properly designed gas shop building will have a loading platform extending across the entire width of the building and at a height level with the floor of trucks or wagons. The elevator will be adjacent to this platform and the fitting shop open thereon. In the larger shops it may be found advantageous to receive all incoming materials at one end of the building, either the alley or street end, as conditions are most favorable, and load all outgoing at the other. This method avoids confusion and delay. Where pipe is stored in the basement, a hole should be cut through the shop floor so that it can be readily transferred from the basement to the shop. The hole should be equipped with an automatically closing cover.

Shop Equipment

The equipment of a well-organized shop should consist of machine and hand-operated tools and fixtures

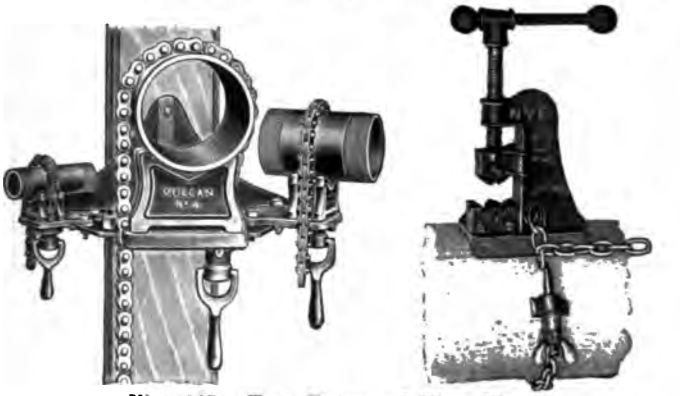


Fig. 245. Two Forms of Pipe Vises

of a most efficient design. These would include pipe-cutting and threading machines, work benches, hand tools and an emery wheel. All shops, except the very smallest, will find it economical to install a power machine for cutting and threading pipe. In addition to cutting out the jobs for the fitters, all nipples used in fitting work may be cut thereon, even though a night man is necessary to do so. The power machine has many advantages over the obsolete and laborious process of cutting and threading by hand, chief of which are: lower cost per cut and thread, increased output of shop, and uniform and better threads, therefore fewer leaks. The type of machine used is not of importance,

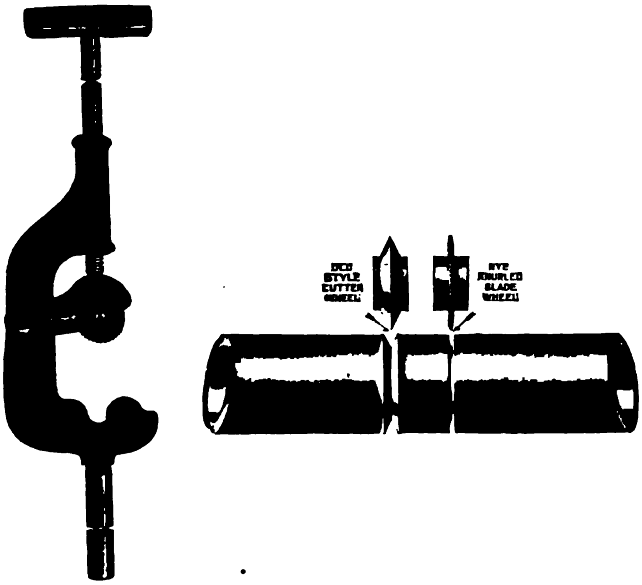


Fig. 246. Two Styles of Pipe Cutter Wheels

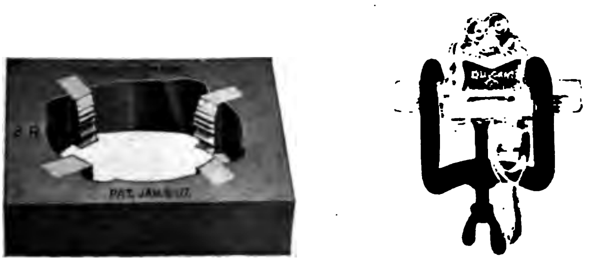


Fig. 247. A Popular Die and Convenient Clamp

as there are a number of reliable makes on the market, either of which are worthy of recommendation. Whether the machine be electric or gas driven is also unimportant, except from the viewpoint of using one's own product, in which case the gas engine should be recommended. The driving arrangement usually necessitates a countershaft, which is desirable, as other tools may be driven by the one prime mover. A small emery wheel may be propelled by this countershaft, which is useful in sharpening the cutting tools used by the fitters, and

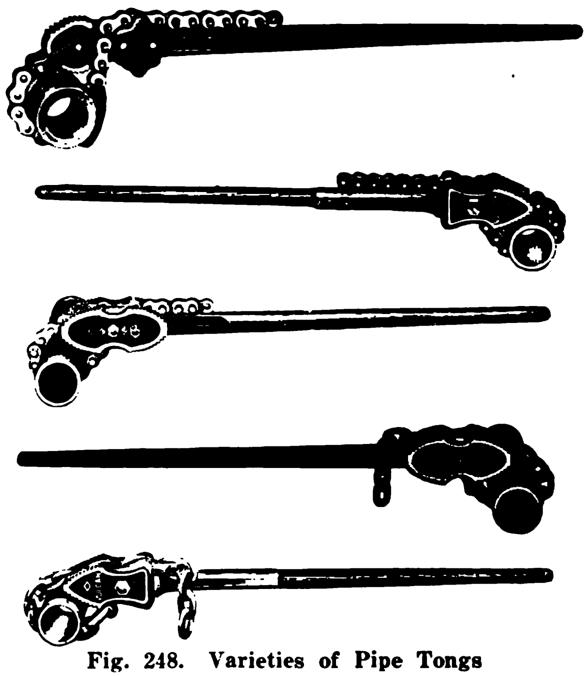


Fig. 248. Varieties of Pipe Tongs

the cutter wheels or knives used in cutting pipe. A very thin emery wheel and a stand of special construction may be obtained, by which the threading dies and pipe wrench jaws may be sharpened. A cut-out man possessing the required degree of mechanical skill will be able, with this equipment, to save the company a substantial sum in tool investment and maintenance.

A neat and substantial work bench may be made with pipe framework and plank top. The framework, which may be constructed of 1¼ in. pipe, should be provided with floor flanges bolted to the floor, making a solid and immovable bench. The top should be of 2-in. hardwood matched flooring, affording a smooth even surface. The benches should be equipped with, preferably, a chain pipe vise.

The hand tools required in the shop would consist of pipe and machine wrenches, oil can, tape line, 6 ft.

Fig. 249. Cutting Thread on Steel Pipe

rule and a machinist's hammer. The hammer will be found superior to a pipe wrench for rapping the pipe to remove scale, as well as saving the wrench for its particular useful purpose. The shop tools should be kept, when not in use, on a board fastened to the wall and provided with hooks, or other means of supporting them. This means will be found superior to keeping them in a tool box or drawer, or lying about the shop, and after the cut-out man becomes accustomed to replacing them on the board when through using, will be found both convenient and neat. A form of tool board that can be recommended is one containing recessed outlines of each particular tool, which insures each tool being put in its own place.

Every pipe threading machine should be equipped with a reamer for removing the burr left by the cutting off tool and its use most rigidly enforced. Most of the up-to-date machines are provided with means of taking

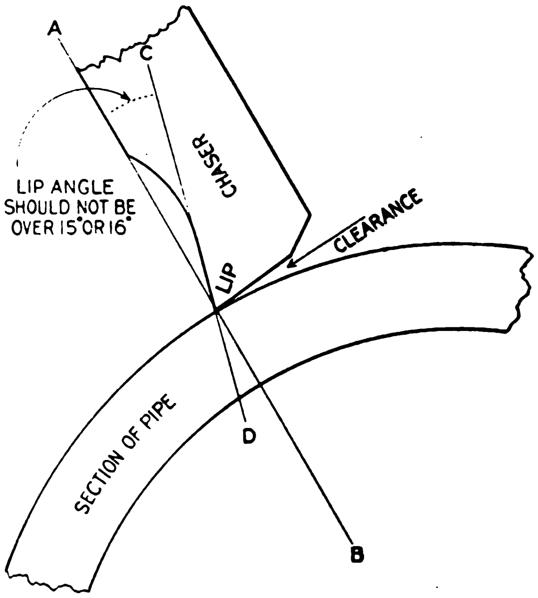


Fig. 250. Cutting Thread on Wrought Iron Pipe

a rounded cut from the outside of the pipe, as well as reaming the inside. This is to be recommended, as it assures threads that are easily started into the fittings. Dies of the Nye style, or patent, with skip and receding teeth are especially recommended. This style of die requires less power to operate and lessens chances of spoiled threads, as well as giving longer service.

The larger shop will find it economical to install a separate machine for cutting and threading pipe from 2 in. to 4 in. in diameter, but machines of larger size are only warranted in the very largest shops, as work requiring their use is not of sufficient amount to warrant the expenditure for such a machine in the ordinary fitting shop.

While not coming under the head of shop equipment, although appropriate here, a rigid rule of the shop

Fig. 251. A Convenient Fitters Pocket Companion

should be that no unthreaded pieces of pipe must exist. Every piece cut should be immediately threaded on both ends, and if not used at once, saved for the next job.

The fitting shop to be efficient must be provided with sufficient natural light and ventilation, and in winter, heat enough for the comfort of the men working therein. Darkness, stagnancy or uncomfortable heat or cold can not be productive of efficient workmanship. Very often we find the fitting shop located in a dark, stuffy, cold or hot ill-smelling basement and wonder why better work is not produced. The environments, even of a work shop, have their effect upon the workmen and the amount and class of work produced. During the season requiring artificial light, the means of lighting should be the best that can be installed and the kind most resembling natural daylight. If we recommend certain lighting features in other workshops our best advertisement is to practice it at home—in our own shop.

Fitters' Tools

The regulator tool kit of the fitter should consist of the following carried in a leather or carpet plumber's bag:

One 14 in. pipe wrench.
One 10 in. pipe wrench.
One clawhammer.
One pair 6 in. gas pliers.
One feeler bit with tee handle.
One brace.
One expansion bit.
One keyhole saw.
One 6 in. screwdriver.
One wood chisel.
One cold chisel.
One 50 ft. tape.
One 6 ft. rule.
One dope can.
One soap brush.
One electric lamp and extra battery.

Larger wrenches, or special tools required on a job, should be drawn when necessary, their need having been made known by the measuring man. The fitter should not be loaded down with any unnecessary tools or material when going from job to job. Everything required, except his regular kit, should be delivered with the appliance and piping.

Within the fitting shop should be a cabinet containing compartments or drawers where the fitters may deposit their tools at night and when not using them. A different lock should be provided for each compartment with two keys, one of which is in the possession of the fitter and the other kept on a board in the shop office.

Conveniences

Where any number of men are employed, as in the gas fitting shop, a place must be provided where they may congregate when not actually engaged in active work. It is much better to provide a separate room than to use the work shop for this purpose, as the lounging period of part of the men may be at a time when others are at work in the shop, and the result is an interference with the men who are working. A man cannot concentrate his mind upon his work and put forth his best efforts when surrounded by, or in the presence of, idle men. The work shop is no place for the men to lounge or eat their lunches, even though no men are working at the time. It is bound to result in disorder, by a disarrangement of tools or materials, and by the litter usually left by a group of ordinary men who carry their lunches, and in such matters discipline cannot be carried to the point of despotism, at least not in America. It is much better to provide a place that the men may use freely and feel comfortable in, and if necessary, provide a janitor to clean up after them.

A place of this nature may be designated by the name "workmen's room," to distinguish it from the fitting shop. It should be a room where the fitter may rest, eat his lunch or arrange and book his orders. It should be adjacent to the wash and toilet room and contain a long table and benches. It may also contain individual sanitary lockers, where the men may keep their clothes. The room should be well lighted and ventilated, kept comfortable in winter and summer, and most important of all, sanitary and clean. The old rule that anything is good enough for a workingman is both obsolete and unjust. The workman is the sinew of any organization and as such is worthy of just consideration. A little paint, judiciously applied, adds to appearances as well as the sanitation of a workmen's room. The walls and ceiling should be painted white (white water paint is cheap and lasting) except for a space four feet from the floor all around the room, which should be painted black. The floor corners should be rounded with cement mortar and painted white, which prevents the accumulation of dirt or debris in the otherwise dark corners, by making them conspicuous and easy to clean. The floors should be painted or covered with linoleum

Fig. 252. A Well Arranged File Room

and the benches and table made of hardwood, stained or painted some dark color. The room should be furnished with plenty of cuspidors and provided with sanitary drinking fountains, or bubblers. The water should be cooled in summer by passing it through ice packed coils, and the bubblers equipped with spring-operated valves to prevent waste.

The wash or toilet room, in addition to containing enclosed closets, should contain ample facilities for washing purposes. The ordinary slate laundry tub furnishes an efficient washing vessel for the fitter, who often gets unusually dirty. These tubs may be connected in batteries, and should contain taps for both hot and cold water. A mechanic soap should be furnished, and judgment used by the purchasing department in its selection. A cheap soap is often found the most expensive as well as inefficient. Some kinds of soap-powder are very efficient in removing the oily

Fig. 253. Typical Appliance Stock Room

grime from the fitter's hands and will not injure them if properly used. "Gold Dust" washing powder can be recommended for this purpose.

These conveniences must not be confused with the reading or club rooms previously recommended, as the latter are intended for the use of the men when off duty, while the workmen's room is intended for his use while on duty, but not actively employed.

The fitting shop office will not differ materially from the office of any factory, warehouse, store or workshop, it being simply a place where orders are given, handled and filed. The orders filed, however, are only duplicates of the original executed copy sent the office, but must be filed systematically as a shop record for a time in order to be of any value in the case of a misplaced or lost original.

Shop Office and Equipment

The office should be located and constructed so as to afford an unobstructed view of the fitting shop and other important activities, and be connected to them in such a way as to afford easy access. A location facing the street with all glass partitions is to be desired. A space should be provided, separated by a railing from the office proper, where the men can receive their orders and consult with the office. Here should be provided a number of pigeon holes or compartments, two for each man, one for his new orders and the other for his completed work and time cards. The foremen's desk should be located in close proximity to this space, but not in the most conspicuous location, which should be occupied by the desk of the clerk handling the orders.

The office should contain, in addition to the desks required, cabinet for the filing of the duplicate orders when in use as shop copies held against the returns of the originals, cabinets for filing meter tags held against meters sent out, and cabinets for the filing of the duplicate orders after the work is completed. The files in which the shop copies and tags are kept should be labeled with the fitter's name, and are of a temporary nature. The duplicate order file is, however, permanent during the period that the order is desired to be preserved, which need not exceed six months.

The office of the storeroom, where the clerical work is done and records kept, may efficiently be combined with the fitting shop office, but the meter repair shop office had best be located in that shop, which of necessity must be separated from the fitting shop in all but the smaller properties.

The matter of transportation equipment is a problem worthy of the most serious consideration, as it represents a considerable investment in most companies as well as an important item of operating cost.

The horse drawn wagon is so rapidly becoming obsolete in this age of efficiency and progress that it is hardly necessary to consider it as a facility for transportation in the modern fitting shop.

Transportation Equipment

Thomas A. Edison, the great inventor, says that the horse is the poorest and costliest motor ever used, and

Fig. 254. A Serviceable and Useful Car

that its thermal efficiency is only 2 per cent. The average cost of feeding a horse one month is $20; this sum will buy 100 gallons of gasoline, which will run a light automobile 2,000 miles. The best that could be gotten out of the horse for that amount of money would be 500 miles, considering that he rested on Sundays, which would be essential. The horse-miles, therefore, cost the company four cents while the automobile-miles cost one cent. The purchase price of the automobile will be no more than that of a good horse and wagon, while the barn or garage expense and maintenance may also be considered equal. A horse on city pavements worked constantly is good for about five years. The automobile with the right kind of driving and attention should be far from worn out in that length of time. The horse may get sick and die at any time, after which he is worth only the few dollars his carcass will net. The automobile engine may die, but it can be brought back to life again by the application of the right kind of remedy. Tires for the light automobile cost but very little more than the horse's shoes. When the motor of the automobile is stopped, expense ceases until it is started again, but the horse is eating or assimilating food all the time, and growing older.

The motor propelled vehicle is without a doubt the logical means of transportation in the fitting shop. As the distribution system of a gas company covers a great many square miles of territory, which is the working field of the shop, distance becomes a source of expense that may spell inefficiency under any system unless the proper transportation facilities are adopted. Distance cannot be reduced but the time occupied in traversing it can. The extent to which the time is reduced is the limit of fitting shop efficiency.

The relative advantages of gasoline and electric automobiles cannot be discussed in this article, as the subject is one entirely foreign to its purpose, but a comparison of merits may easily be obtained and the one showing to the greatest advantage should be the kind selected. However, a heavy car should be avoided.

The meter trucks need not carry a great amount of weight and should therefore be designed for speed and resilience. Special attention should be given the springs to avoid jars and jolts which are injurious to the meters. A rack for carrying meters may be made by fastening a wide board to the top of the box on either side of the truck. The board should be divided into compartments the exact size of the meters, by 2x1 strips securely fastened edgeways to it. A canvas strap 3 in. x 4 in. wide should be fastened to each compartment, equipped with a buckle and leather end, so that the meter can be held rigidly in place. The board and strips should be covered with felt or rubber glued thereon, as an additional protection for the meter. Carrying meters unprotected in the open box of a wagon or truck is equivalent to reducing the net earnings of the company and should be a capital offence.

Motorcycles should be the principal means of travel for all complaint men and measuring men. The work of the former requires the greatest expedition while the latter must cover a great deal of ground during their daily work. The fitter's job may be arranged geo-

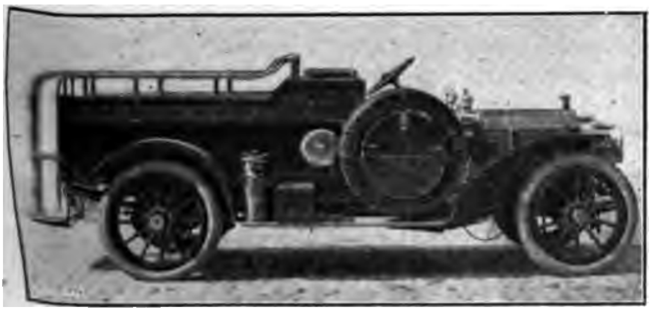


Fig. 255. Car for an Emergency Crew

graphically so that the minimum amount of time is spent on the road, and he may therefore use a bicycle or street car to sufficient advantage. The proportion of his time spent on the road should not warrant the expenditure necessary to provide him with a motorcycle or automobile.

The larger properties will require emergency crews to answer fire calls and attend to all emergency work of a hazardous or important nature. The trucks used by such crews should be designed for speed and contain as part of their equipment all tools and appurtenances necessary to dig up and cut off service, make temporary repairs to mains or services, shut off gas,

for the motorcycle compl
assisted. This class of
stopped services or house
of a force pump, cutting
equipment of these trucks s
the ordinary tools, 100 ft.
Wrigley sewer cleaner, equ
bits, and a force pump, or
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CHAPTER X

CONNECTING APPLIANCES

It has been the endeavor to make the fact plain in preceding chapters that the fundamental principle of any gas company is not the sale of gas, but the selling of service. The prospective customer does not really want our gas, he wants heat energy which can be applied in the most efficient manner and that which will prove the most serviceable to him. For this service he is usually willing to pay, even though the cost per B. t. u. is greater than in some other fuels. Gas is the most elastic, as well as the most convenient of fuels and its usefulness or applicability is so great as to be practically infinite. When the gas companies of the country finally awaken to this fact, the dream of supplying all the heat energy used in any locality from a central station—which will be the gas works—will be a dream no longer, but an ideal reality. We cannot hope to realize this condition while we think of gas sales in cubic feet; we must think in B.t.u.'s of useful energy expended by our customers in turning out work and of the number of cubic feet as one of the factors used in arriving at a basis of compensation for service rendered.

The sale of gas service has proceeded through its evolution up to the time when it is becoming recognized as worthy and needful of the most scientific study and attention. The novice must give way to the expert fuel engineer who is capable of proving the supremacy of gas as a fuel, and the one who can go after and get the big business away from competitors—and with the help of the fitting shop, hold it after it is signed up.

The duty of the commercial department is primarily to get the business, that of the fitting shop to install the appliance in a manner that the claims of the commercial department will be realized.

It is absoluteiy essential that the fitter know the maximum demand of every appliance to be installed, and in the case of special or industrial appliances, this information should be supplied from an unrefuted source. Knowing the demand in cubic feet per hour maximum consumption, the length of the pipe and the desired utilization pressure must be considered and the pipe and meter sizes so planned that maximum efficiency will be obtained in the use of the appliance by the customer. The fact should not be lost sight of that the additional cost of larger pipes is negligible when their increased carrying powers are considered. In running fuel lines to appliances it is best to run full size from the meter to the appliance, even though the book of rules says that the pipe may be reduced after so many feet of a certain size has been installed. The benefit to be derived from larger pipes canot be overestimated.

Rule-of-thumb methods and guesswork should be a thing to be eliminated in the installation of any gas appliance, and the fitter who cannot compute the flow of gas in pipes, and who does not know the capacity of meters at various initial and differential pressures is lacking in an important requirement of the modern fitter, and should be speedily educated.

A gas consuming appliance is an engine for producing energy, and should be considered as such in the same sense as a steam or gas engine or an electric motor would be, and like care be exercised in its installation, adjustment and care. The installation of an appliance may be first class and still its efficiency be curtailed through improper adjustment. Before any appliance is turned over to the customer it should have every burner adjusted to the average pressure at the appliance, so that the greatest efficiency of combustion and heat utilization is obtained. Proper adjustment will have been obtained when the flame appears as a short green cone of a sputtering character. Proficiency in adjusting burners can only be obtained by practice, and the instruction of the fitter by a competent instructor, which may be his foreman, is to be recommended.

The commercial or selling department and the fitting, or installing department, of any gas company are so closely associated that the success or greatest efficiency of either depends upon the degree of co-operation obtained from the other. All the best efforts of either are vain without this co-operation.

Gas Ranges

The instalation of a gas range is a comparatively simple problem, yet certain rules must be observed to make the working of this appliance a perfect success,

Fig. 256. A Standard Type of Gas Range

and cause it to be a year-around necessity instead of a hot weather convenience.

In the first place the judgment of the fitter should be used in selecting the proper place in the kitchen for the range. Too often the customer is left to select this location with no offer of assistance from the fitter, who from his experience should be able to point out certain advantages and disadvantages, with the result that appearance alone is considered. The fitter, if properly trained, should in most cases be able to assist the customer, without appearing officious, and if his advice is

of having plenty of light o
when cooking on the top. Sh
get around the range with
Very often, however, these ad
neglected, with the result that

Fig. 257. Visible Baking

some out-of-the-way hole or co
thing to collect dirt or grease,
ing a help to the housewife and
life, becomes a thing of abhorre
sions as an emergency requires

The attention of the fitter, before the location has been selected, should be given to the assembling of the range. He should see that every part is in its proper place, that no defects are apparent and that everything is securely fastened. It seems needless to say that this work should be carried on with the least amount of inconvenience to the customer, who is usually a lady excitedly watching the operation. All wrapping material and crating should be removed immediately to the basement or trash can and an effort made to remove as far as practicable evidences of dirt and disorder. This will seldom fail of appreciation, or to make an impression on

Fig. 258. Two Sections of a Hotel Range

the customer. As the range is set upon its legs protectors should be placed under them to prevent marring the floor. A leather cup washer about 3 in. in diameter, such as is used in the ordinary pitcher pump, makes a good device for this purpose and allows the range to be easily slid about the floor. When the range is set in place and connected permanently attention should be given to its levelness. This is an important fact that is often overlooked and results in dissatisfaction through the running over of foodstuffs, especially soft pies, and the creating of lop-sided cakes and loaves. A pie pan partly filled with water makes a level sufficiently ac-

Fig. 259. Gas Kitchen Equipped with Hot Water and Laundry Iron

curate for the work of leveling the range. Any inequalities should be adjusted by the use of cardboard or leather placed under the feet and carefully trimmed.

A thing not to be forgotten is the burning off of the oil, grease and paint to be found on all new ranges. This is an offensive operation which should never be left for the customer to do. It is good policy to light up the entire range and leave it all burn while adjusting

Fig 260. Continuous Top Hotel Range

the burners. During the ten or fifteen minutes consumed in this operation the paint and oil will have been burned off to such an extent that it will not prove a serious inconvenience to the customer afterward. While burning off, the fitter should ventilate the kitchen so that the smoke and odor is not carried into other parts of the house.

Another important duty of the fitter, the neglect of which often proves detrimental if not disastrous, is to properly instruct the lady of the house or the person who is to use the range, how to operate it. While it is advisable for gas companies to employ practical demonstrators to follow up the installations, the first lesson should be given by the fitter. He may not be able to instruct the customer in the art of cooking but he can give instructions in the way the burners should be lighted, how they should be removed for cleaning and precautionary measures to be taken to prevent trouble. He should be particular in his instruction regarding the prevention of flash-backs in the mixer which invariably occur when the novice attempts to light a properly adjusted burner by placing the flame of the match against the cold burner before turning on the valve. The lighted match should be held in one hand, ready but away from the burner, and the valve turned on full, then the flame brought down quickly into contact with the flowing gas which will be ignited, when the flame is several inches above the burner, with no flash-back. The lighting of gas in the mixer, with its accompanying noise and odor seldom fails to frighten the operator and, while no damage can result, is productive of timidity on the part of the customer and inefficiency on the part of the burner. The oven should receive a goodly share of the precautionary instruction. The customer should be instructed to always open both doors when lighting the oven and to be positive that the gas is burning before they are closed. Attention has been given this fact in late years by appliance manufacturers so that on most modern ranges an oven explosion is a practical impossibility, but an impression of carefulness, without creating fear, is a thing to be desired.

Piping for Appliances

No fuel line of less than ¾-in. pipe should ever be run to supply any gas cooking appliance. It is false economy, which is detrimental to both the customer and the company, to weigh the saving made by the use of ½-in. and pipe against the greater efficiency to be obtained ng a large size. The appliance may be only a hot nd its demand, or maximum hourly consumption, the capacity of a small sized pipe, but the future be considered when the hot plate will be replaced

261. Lighting Outlets and Flexible Tube Connection

range having a larger demand, and therefore re- ıg a larger pipe. The small pipe must therefore rn out and a larger one installed, causing a need- xpense for labor, either upon the company or the

Pressure drop Per 1,000 Feet in Various Sizes of Pipe—Inches of Water

Diam., in.......	½	¾	1	1¼	1½	2	2½	⅜
Cu. ft. per hr.								
5	.069	.013	.003	....	....	....	....	.278
6	.100	.018	.005	.001	....	....	....	.400
8	.178	.033	.008	.002	....	....	....	.711
10	.278	.051	.013	.003	.001	....	....	1.110
15	.626	.115	.029	.007	.003	....	....	2.500
20	1.110	.204	.051	.012	.005	.001	....	4.450
30	2.500	.460	.115	.026	.010	.003	.001	10.000
40	4.500	.818	.204	.046	.019	.006	.002	3″
50	6.950	1.278	.320	.072	.028	.009	.003	.001
60	10.000	1.840	.460	.103	.042	.012	.004	.001
80	17.800	3.260	.818	.175	.074	.022	.007	.002
100	4″	5.100	1.278	.287	.116	.035	.012	.004
150	.002	11.500	2.870	.646	.260	.078	.026	.008
200	.004	4½″	5.100	1.150	.460	.138	.046	.014
300	.008	.004	11.495	2.580	1.400	.311	.104	.032
400	.014	.007	5″	4.590	1.850	.550	.185	.057
500	.022	.012	.007	7.180	2.880	.865	.287	.089
600	.032	.017	.010	6″	4.160	1.240	.415	.130
800	.056	.030	.017	.007	7.400	2.220	.735	.230
1,000	.088	.046	.027	.010	11.590	3.460	1.150	.360
1,500	.197	.104	.061	.023	7″	7.780	2.590	.800

2,000	.350	.186	.108	.041	.019	13.830	4.610	1.400
3,000	.785	.418	.242	.093	.042	8″	10.350	3.200
4,000	1.400	.741	.430	.165	.074	.037	9″	5.700
5,000	2.180	1.160	.672	.257	.116	.058	.031	8.900
6,000	3.150	1.670	.968	.370	.167	.084	.045	12.820
8,000	5,610	2.960	1.720	.658	.296	.148	.082	10″
10,000	12″	4.630	2.680	1.028	.462	.233	.126	.073
15,000	.064	10.420	6.050	2.318	1,041	.521	.284	.165
20,000	.115	16″	10.750	4.120	1.850	.928	.502	.292
30,000	.258	.060	20″	9.250	4.160	2.080	1.130	.655
40,000	.458	.106	.034	24″	7.400	3.710	2.010	1.170
50,000	.716	.166	.054	.021	11.580	5.800	3.140	1.825
60,000	1.030	.240	.078	.030	30″	8.350	5.050	2.625
80,000	1.830	.426	.138	.054	.017	36″	8.050	4.675
100,000	2.680	.664	.216	.084	.027	.011	12.600	7.300
150,000	6.440	1.500	.484	.190	.061	.024	42″	16.495
200,000	11.450	2.660	.861	.337	.109	.043	.020	48″
300,000	25.800	5.980	1.946	.760	.245	.097	.045	.023
400,000	45.800	10.620	3.441	1.350	.435	.172	.080	.041
500,000	71.600	16.620	5.380	2.110	.680	.269	.124	.065
600,000	103.000	24.000	7.748	3.040	.976	.386	.178	.093
800,000	183.000	42.600	13.800	5.400	1.740	.690	.316	.165
1,000,000	286.000	66.400	21.600	8.415	2.715	1.073	.495	.258

Note that the columns for diameters above 2½″ are in the body of the table.

customer, which could have been eliminated had ¾-in. pipe been run at the outset. A good rule for any gas company to follow, and one which is productive of "better service," is the following: "No piping or opening smaller than ¾ in. shall be allowed for any cooking appliance, or for any other purpose, except for mantels, grates and small heating appliances where the space to be heated does not exceed 1,728 cu. ft., or for bunsen burners used by dentists, doctors or chemists, where not to exceed 30 ft. of ½-in. pipe may be run for one opening only, two such openings being considered as one ¾-in. opening requiring a ¾-in. supply pipe."

Straight Pipe—Assuming the length of the run to be 60 ft. of straight pipe the following volumes will be delivered for various diameters:

Capacity per 60 ft. length of various sizes pipe:

Inches diam.	Cu. ft. per hour
⅜	18
½	36
¾	100
1	200
1¼	350
1½	550
2	1,200
2½	2,000
3	3,200
3½	4,700
4	6,500

Capacity of various lengths of ¾-in. pipe:

Feet length	Cu. ft. per hour
10	236
20	170
30	140
40	120
50	110
60	100
70	92
80	86
90	82
100	78

When computing the size of pipe required it is safe **to assume** a differential or drop in pressure between the **initial** and terminal ends of the pipe of 3/10 in. water **column.** The modern gas company using up-to-date **methods** will carry a service pressure of between 3 to 4 **in.,** either by the use of efficient pressure regulation or **governors**, which will make the utilization pressure between 2½ in. and 3½ in. after meter and line losses are **deducted.**

Friction—The fitter should pay particular attention to eliminating bends and fittings to as great an extent as possible. Every fitting exerts a certain amount of friction which takes pressure to overcome.

Where fittings or bends occur in a line of pipe, their equivalent values in feet of straight pipe should be added to the actual length of the pipe. The following values in feet of straight pipe for various diameters are approximate for ells or tees constituting 90 deg. bands:

Diam. of pipe in inches	⅜	½	¾	1	1¼	1½	2	2½	3	3½	4	6
Equiv. length in feet	0.3	0.8	1.2	2	2.8	3	5	7	9	11	13	24

For 45 deg. ells the above lengths may be divided by 2.

The radius of the ell has an effect upon the friction exerted, as shown by the following table from Kent's handbook:

Radius of 90° bend in diameters of pipe	5	3	2	1½	1¼	1	¾	½
Equiv. lengths of straight pipe in diameters	7.85	8.24	9.03	10.36	12.72	17.5	35.09	121.2

Light and Fuel Piping—Concealed piping to supply fuel apparatus should be laid independently of gas piping supplying lights and concealed fuel piping should be carried to where meters are to be set and there connected to light raisers by R. and L. couplings, long screws or unions.

Concealed fuel piping with openings left for lights, or with any other openings except for such fuel apparatus as will be installed should not be allowed. The reason for these rules is apparent through the great difficulty often encountered by gas companies in separating such piping in cases of a division of the consumption on certain premises occupied by more than one consumer, but need not be applied to exposed piping which may be readily separated.

The practice of connecting cooking appliances to ceiling drops or side light openings of ⅜-in. pipe should be eliminated. This is often done, where the customer does not want to bear the expense of a proper installation, under the belief that a certain amount of consumption will be obtained that would otherwise be lost. The service obtained by the customer is so unsatisfactory in all such cases that it belittles the company to be a party to such service by granting the same. The customer who will not allow himself to be supplied in the proper manner is not a desirable consumer and if salesmanship methods fail to convince him that the gas company is selling service he had best be left unconnected.

Water Heaters

The gas water heater is one of the most important of gas appliances and its use for domestic and industrial purposes is rapidly becoming general in all cases where convenience is considered as akin to efficiency.

The work of installing any kind of gas water heater requires a skill beyond that necessary for connecting most any other kind of an appliance, since both gas and water connections must be made. Hot water heating and circulation is a study in itself of no small value, although the fundamental principle that water, being lighter, rises above cold water appears simple indeed. When this actually takes place circulation is said to have been obtained, i. e., the heated water rises to the top and is replaced by cold water at the bottom of the tank, vessel or pipe. The most important thing to be remembered in connecting water heaters is that hot water will not circulate downward unless a connection is made whereby the water as it cools can be removed from the system, either by being drawn off or returned to the bottom of the tank or heater. A trapped hot water pipe will as effectively stop circulation as a trapped gas pipe will the flow of gas.

There are two methods used in heating water with gas, by the use of storage systems and instantaneously. Either type of heater may be automatic, or not, through the use of a thermostatic arrangement or pressure control valve. Either type performs its function by transferring the heat energy of the gas to the water. In the former the operation is slow, while in the latter it is very rapid, and each has its particular advantages.

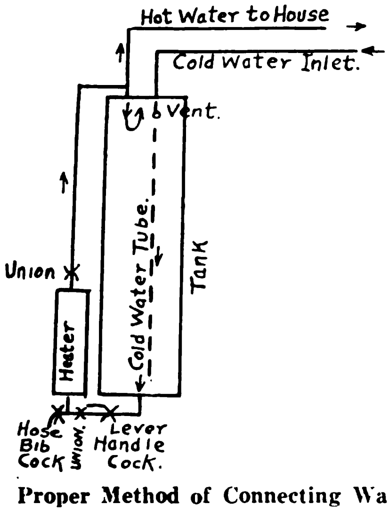


Fig. 262. Proper Method of Connecting Water Heater

The proper method of making the water connections between a storage heater, which is the type in general use, and the tank, follows:

The bottom of the heater should be no higher than the bottom of the tank, if full capacity of the tank is expected. The cold water supply to heater should be taken from the bottom of the tank, with a lever handled stop-cock located between the tank and heater in the cold water line, and a hose-bib cock located between the lever handled cock and the heater. This provides a means of flushing the heater for the removal of rust or sediment, which should be done frequently and periodically to prevent dirty hot water. The hot water pipe from the heater should connect with the tank at the top, but beneath the outlet to house piping and never above it. Connection should not be made to the opening in the side of the tank unless quick service is no object, as all the water above this opening must be displaced with hot water before it will be available at faucets. The heater should be set as close to the tank as possible in order to reduce radiation, or cooling of the water in the pipe leading to the tank, to the minimum. Where possible, the location of heater and tank should be in the kitchen, as close proximity to the place where hot water is needed most is conducive to use.

Fig. 263. Water Heater for Kitchen Boiler

Where the water is automatically controlled, however, the basement is the logical location as better circulation of hot water is obtained where the tank is placed at the lowest point in the system.

Great care must be exercised in hot water fitting that the job is made up tight. The gas company fitter very often makes a poor plumber, water or steam fitter, because he is used to putting together gas pipes, which

Fig. 264. Medium Sized Water Heater

need to hold but a few pounds pressure at most. The water pipes will be under a pressure of from 60 to 90 pounds and must therefore be fitted exceedingly well if no leaks are to result. All fittings and threads should be carefully examined and made up tight without shouldering. Pipe dope should be used sparingly and only upon the male thread, as the action of the hot water, if it does not wash it into the tank to discolor the water, will cause it to harden on the inside of the pipe or fitting, causing a restriction to the flow of water. Nothing but galvanized pipe and fittings should be used on water as the common iron will rust and discolor the water. In no case should a piece of pipe, or fitting, that has ever been used for gas, be installed in a hot water installation as the smell of gas will always be apparent.

Fig. 265. Mechanism of Instantaneous Water Heater

Red rubber packing should be used for gaskets and never leather, which will shrink from the action of heat, causing a leak.

The gas supply pipe to any type of water heater should be not less than ¾-in. As the gas valve on the heater is usually tapped for ½-in. pipe, the reduction should be made as close to the valve as possible.

Automatic heaters, having a very large demand, require a large pipe and meter. It is customary for the manufacturers to attach a tag to all such heaters, stating the size of pipe and meter to be installed, but where this is not done a careful estimate must be made to determine maximum consumption so that the installation may be properly planned. The demand for different

Fig. 266. Casing for Fig. 265 with Doors Open

sizes of automatic heaters range from 100 to 600 cu. ft. of gas per hour and successful operation is not obtained unless the proper amount of gas is furnished and used. Their operation differs from the storage heater insomuch that in the latter its use may be planned to occur when other appliances are idle, thereby conserving conductivity of the pipes and meter, but in the automatic heater its use is necessary at any time hot water is wanted.

A common mistake of many customers is to expect too much of the water heater. The fitter may often help to overcome this difficulty by applying the law of conservation of energy, and impressing it upon the customer. According to this law energy is never wasted, but is simply transformed, and cannot be added to or diminished. One hundred per cent efficiency has never been attained, which means that it is an impossibility to obtain as much energy in the form of useful work from any devise as has been put into it. Nature demands pay and collects it through loss of energy, which may take the form of heat through friction or radiation. A gas water heater consumes a certain known quantity of gas of a certain heating value per cu. ft. By multiplying the amount of gas by its heating value gives the number of B.t.u.'s available for use. It is policy to multiply this by .75 as the average water heater is no more than 75 per cent efficient due to loss by radiation. As it requires one B.t.u. to raise the temperature of one pound of water through one degree, the number of useful B.t.u.'s represents the number of pounds of water that can be heated through one degree, and it is simply a matter of dividing this by the difference in initial and terminal temperatures and converting pounds to gallons to find out just what can be expected of the heater in a given time. The efficiency of the storage heater is always less than that of the instantaneous type, due to radiation from the tank, but their efficiency can be very materially increased by insulating the tank with a non-conducting substance.

A great amount of precaution should be observed in locating water heaters that danger from products of combustion are not experienced. The water heater, unlike other gas consuming appliances, produces a certain amount of carbon monoxide instead of all carbon dioxide, due to the low flame temperature caused by contact with cold water, and may be extremely hazardous if located in a bathroom, bedroom or other small space, in the event that the flue pipe should become dislodged, stopped up or leaky.

Hot Plates, Room Heaters and Small Appliances

The permanent abolishment of the use of rubber tubing or metallic tubing with rubber ends, or, in fact, the abolishment of all forms of rubber connections for gas appliances, is a thing to be very much desired. There is no reason why all hot plates and most of the other small appliances cannot be rigidly connected with pipe and fittings while the movable or temporarily connected appliances, such as room heaters, etc., should be connected with metallic tubing fitted with a ground joint union at either end, that can be easily and quickly connected or disconnected and be perfectly safe while in use. More life and property has been jeopardized by rubber gas connections than perhaps any other one thing pertaining to the gas industry. Tubing pulls apart, becomes leaky, the ends split or become so large that they fall off of the hose nipple or cock, some one stumbles over the tubing or steps on it, which all result in the same thing, escapement of gas with consequent hazard. The gas companies as well as the consumers have been slow to discard the dangerous gas tubing. The former because it was convenient and because the consumer wanted it, and the latter because it was cheap as well as convenient. No tubing connected gas consuming appliance ever came up to the efficiency obtained by connecting it with a pipe, as the tubing is small and a poor conductor of gas. The work of the American Gas Institute in regard to this matter is to be commended and should receive the support and cooperation of all companies.

Gas Engines

A gas engine, like an automatic water heater, has a large instantaneous demand requiring large pipes and meters. The supply for gas engines should be separate from any other appliances and an independent service should be provided. An anti-fluctuator should be installed in all cases between the engine and the meter to prevent a pulsating effect upon other appliances in the neighborhood, particularly if the supply main be small.

Gas Engine Piping

The following table will apply to piping run for gas engines:

Size of Engine	Size of Opening	Greatest length allowed
1 h.p.	1 in.	60 ft.
2 h.p.	1¼ in.	70 ft.
5 h.p.	1½ in.	100 ft.
7 h.p.	1½ in.	100 ft.
12 h.p.	2 in.	140 ft.

Where larger engines are to be installed the consumption should be ascertained, or computed from the horsepower, and pipes and meters planned accordingly. A horsepower is equivalent to 33,000 foot-pounds of expert in their trade if successful operation of the appliance is to be attained.

At the present time there are numerous uses for

Fig. 267. Gas Heated Hot Water and Steam Supply

industrial gas, and industrial fuel appliances have become a common thing in the fitting shop. It will not be the purpose of this volume to enumerate the many different appliances, as that is best covered in a book pertaining to the particular subject.

The important responsibility of the fitting shop lies in the amount of gas delivered to and the terminal pressure at the industrial appliance. The appliance must receive its rated flow of gas or failure of operation is enevitable. The fitter must more than ever before, use his gas flow computer intelligently. Guess work will not do at all. The relations between high pressure in small pipes and low pressure in large ones must be thoroughly understood and used to the advantage of the company. It was previously shown that the volume of gas delivered through a pipe varied as its diameter or initial pressure applied. That is, by applying more pressure more gas will be passed, but if the inlet pressure remained the same and more gas were demanded, a larger pipe must be installed in order to maintain the same outlet pressure at the appliance. Constant efficient pressure at the burner of industrial appliances is essential, but it is not always necessary to install large pipes in order to accomplish this pur-

3½-in., therefore we can stand a loss of 2½-in. in the 100 ft. line. A 1¼-in. pipe will deliver the 700 cu. ft. of gas required through this length with a drop in pressure of 2-in., that is, with ½-in. to spare. The meter drop is 2/10-in., so that the appliance or terminal pressure is 33/10-in. By moving the meter and governor we have therefore increased the appliance pressure 3/10-in.

Fig. 268. Gas Fired Industrial Furnaces

and have supplied the same amount of gas through a 1¼-in. pipe, instead of 2-in., saving thereby a pipe cost of approximately .04 per foot or a total of $4.00. Often existing lines may be utilized and made to supply more gas by adopting the above method.

Where service governors are not used, the volume of gas required must be supplied through the use of pipes large enough to maintain efficient pressure of utilization during periods of minimum main and service pressure.

The adjustment of industrial appliances is a feature of importance that must not be overlooked during installation. The burners must be adjusted to a point as nearly approaching perfect combustion as is possible. Upon this depends in a large measure the successful operation of the appliance and the satisfaction of the operator or customer.

Lamps and Accessories

The lighting part of the gas business is by no means a dead issue. Proof of this fact is evident in any of the large Eastern cities of this country where a surprising amount of street and inside lighting is in use, considering the claims of supercedence by competitors.

The gas light of the present consists essentially of a burner and a mantle. The burner is in principle exactly the same as the burner used on any fuel appliance, being of the atmospheric or bunsen type, in which nd appurtenances by the companies themselves. If the ppliance dealers can make a profit by selling and intalling these things, so can the Gas company. The sale of cheap and inferior burners and mantles by department and notion stores has done much to discourage gas lighting. The gas fuel business to-day would not amount to much if the Gas company depended upon outside stores to supply the appliances. As it is, all

Fig. 269. Angle Reflectors, Used Also for Signs

appliances sold by the company itself are of unrefuted value—the best that science and the manufacturer have produced, and therefore the best that the customers' money can buy. The same should be true of gas lights.

In addition to selling and installing lamps and appurtenances, regular maintenance service should be employed. The principal drawback of the gas lamp, which we cannot but admit, is its requirements in the nature of maintenance. Glassware gets dirty, the mantles get broken or blackened, and the burner gets out of adjustment, or the gauze dirty, in time, resulting in no light or poor light. It seems to be an utter impossibility to impress upon the customer the importance of keeping the lamp in good order himself. It must be done by the company if efficient service and satisfied customers are to result. Weekly inspections are to be recommended at which time all necessary work to put the lamp in good order should be done. This should not be done at a loss to the company, however, but a nominal charge made, sufficient to cover labor and material.

Before installing gas lamps the fitter should take every precaution to be sure the pipes are clear. Illuminating piping is generally of a smaller size than that used for fuel purposes and is therefore more easily stopped with rust or sediment. If a fixture or outlet has been known to have been unused for any length of time, it should be blown through, in case of the fixture with gas pressure and in case of piping with the force pump. This will dislodge and remove any foreign substance that might otherwise stop in the burner orifice, causing poor light. Where piping must be run on the ceiling to supply arc lamps or fixtures it should be of a size conforming to rules hereinafter given and in no case smaller than the outlet from which it is supplied. Where the outlet extends beyond the ceiling, requiring the pipe to be extended back in order to lay against and be fastened to it, thereby causing a trap in the piping, a tee, nipple and cap should be used, forming a receptacle for the accumulation and removal of condensation and sediment. The pipe extension should be taken from the side outlet of the tee and the pipe offset to fit against the ceiling. Fittings should not be used to form the offset unless unavoidable, a skilfully bent pipe making a much neater as well as a more frictionless and satisfactory job. The pipe should be rigidly fastened to the ceiling with pipe straps and screws screwed into joists and never into lathes. The termination of the piping should consist of a bracket or wing ell securely screwed to a joist.

The gas supply to outside arc lamps should be not less than ¾-in. pipe and should be larger in localities where extremely low temperatures are experienced. This applies only to that portion of the piping located outside of the building and exposed to extremes of temperature. The inside piping up to the wall may be run in accordance with rules for installing inside arcs.

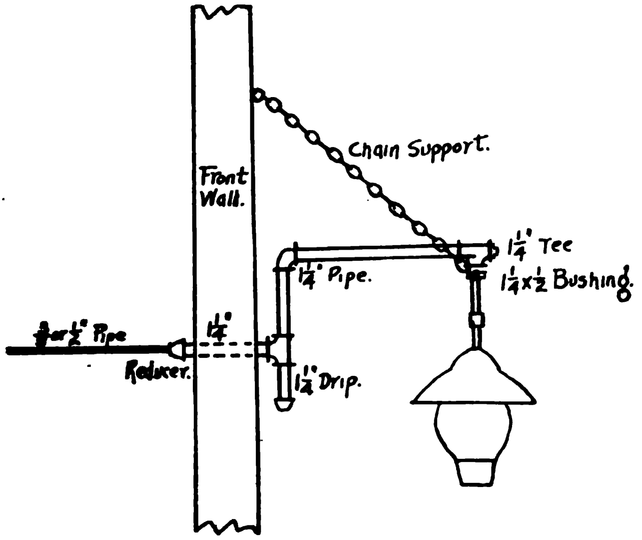


Fig. 270. Outside Arc-Lamp Connections

Directly outside of the wall a drip consisting of a large sized nipple and cap should be installed to receive the condensation that will naturally be formed in the outside piping. From the tee to which the drip is attached the pipe should rise toward the lamp, the object being to drain as large a portion of the piping as is possible to the drip, rather than to the lamp.

A neat and substantial method of supporting the lamp is by means of chain, a size being used corresponding to dog-chain. Two chains should be used, attaching to an iron pipe clamp just above the lamp and extending upward and toward each side of the lamp to a rigid fastening in the wall. This prevents side sway as well as supporting the lamp, is easily and cheaply installed, has a neat appearance and is of permanent character.

As much importance is attached to the adjustment of a gas lamp as to any other gas consuming burner. If the proper mixture of air and gas is not obtained the mantle will not be incandescent nor the lamp efficient. The Bunsen burners should be properly adjusted before the mantles are placed on the lamp, the same rule applying to the appearance of the flame as in fuel appliance burners. The gas should then be shut off, the mantle installed and burned off by lighting at the top, and gas turned on slowly to remove any carbon deposit left on the mantle in the burning off process. The globe and chimney may then be placed in position and the lamp is ready for use. Pilot lights should be adjusted as low as possible without danger of extinguishment from

CHAPTER XI

HOUSE PIPING

The gas meter is the connecting link between the company and the consumer, and each individual consumer is guided largely in his altitude toward the company by the action of his particular meter.

Handling Gas Meters

One of the most important rules in instructions to meter men in handling and setting meters is "Care in Handling."

Gas fitters, as a rule, are not the most careful men in the world and the ordinary meter is often roughly handled. Meters have been seen to be jammed in at the tops or sides, the valve guides bent, raising the valves, or in some cases the flag broken loose, axle disconnected or outer case leaking, so when set meters will not pass gas or do not register correctly. The paint is apt to be scratched off, exposing the tin to the dampness of the cellar, so that it soon rusts, and in time leaks.

The fundamental standard by which meters are measured is service. Service involves the amount and quality of the work, and it involves the non-productive time that the meter is out of service for repairs. The meter that spends the least time in the repair shop is giving greater service in two ways, it is spending more of its time working-earning, and less of its time in the hospital-spending. The service of a meter is affected very materially by the care exercised in its handling.

Gas meters may be likened to the tellers in a bank. They are both paying out. The meter is paying out gas and the teller money, and both keep a record of the amount paid out. The same accuracy and fidelity that are considered essential qualifications of bank tellers must be required of gas meters if the company and the customers are to be given a square deal. The inac-

inaccuracies of gas meters that run fast or slow, or leak, are not as spectacular and perhaps not as easily traced as mistakes in accounts of the bank, but there are more meters in the employ of a gas company than there are tellers in a bank, and the cumulative errors of even slightly inaccurate meters cost the company valuable good will if the meters run fast and valuable gas if they run slow. Either way the company loses, and the lower the errors of the meter can be reduced the smaller these losses become.

The first thing to bear in mind in relation to a gas meter, by anyone handling the same in any manner whatsoever, is the fact that it is a practically perfect and delicately adjusted measuring instrument which is deserving of the same treatment that would be accorded the engraved gold watch carried in the pocket, and which with that same degree of treatment will go on doing its work accurately, without any attention for four or five years. It must be remembered that the principal difference between a gas meter and a timepiece is the fact that the one measures gas and the other time. Neither will do so accurately if abused. The gas meter may be made of baser metal than the watch or clock and be far less ornamental in appearance, but the same degree of scientific knowledge is involved in its mechanism to make it a perfect measuring device. Within the homely tin or cast iron case which represents to most people simply a box containing little more than the gas itself, is a number of perfectly timed and proportioned parts that work together in perfect harmony, each doing its part to make of the whole a reliable and accurate instrument. Anything which tends to disrupt the harmony of any of the parts, such as an injury or displacements, makes of the whole either a thing of no value, by preventing all action, or makes an inaccurate and therefore unreliable and unsatisfactory device that is of no value to either the company or customer. It should be borne in mind that a gas meter does not have to be battered into a shapeless mass before its usefulness as a measuring device ceases.

slight amount of carelessness in handling, or in tion, will effect the accuracy of its registration, ıg in all cases in unsatisfactory service.

Fig. 271. Unusual Installation of Dry Meter

ɜ in handling meters is a thing that cannot be too ·ly impressed upon the fitter. A great deal of expense to the company and annoyance to the customer can be prevented by a strict enforcement of rules governing the handling of meters. One of the drawbacks to impressing the ordinary fitter with the importance of such rules is the fact that he too often is entirely devoid of all knowledge of the inside mechanism of the meter. It is to him, as to most customers, simply a tin box with an inlet for the gas to enter and an outlet for it to emerge, and if it contains anything at all it is nothing but a pair of bellows attached in some manner to the index gear and not capable of injury. The fitters should be thoroughly acquainted with the construction of a meter, either by serving a sufficiently long apprenticeship in the repair shop or through a systematic course of instruction under a practical instructor, wherein all the causes and effects having a bearing upon inaccuracy of registration may be brought to his attention and indelibly impressed upon the mind. We cannot blame him for doing wrong until he has been shown the right way and has learned to his own satisfaction why the wrong way is wrong and the right way is right.

A gas meter should never be set up or carried in any other manner except top side up. To lay it upon its side or back, or turn it upside down, results in oil or condensate getting into the ports or channels or upon the valves, tending to obstruct the former and gum and stick the latter. The valves may also be unseated by placing the meter in an unnatural position. To facilitate keeping the meter always upright, the expense of some form of a handle for carrying the meters is warranted. A good feature of the handle is the prevention of hitting the meter on the corner when setting it down, which invariably occurs where it is handled in the usual manner by one screw. The bottom corner of a meter, where the back or front plate is joined to the case, is always a weak point, a slight jar sometimes causing juice, if not gas, leaks, either of which are detrimental, obnoxious and dangerous. All meters should be capped or plugged at all times when not in service, or in service readiness. This prevents the admission of air to the leather diaphragms, which is detrimental by drying them out, therefore causing them to shrink and the meter to register inaccurately. The first thing done when a meter is removed from the service connections and the last thing before it is attached to them should be the capping or plugging of inlet and outlet screws or removal of same. A meter should never be subjected to jars or jolts, either in transportation or carrying, such action resulting in displacement of valves, guide rods, connections or gears, or the breaking of same. The practice of tossing meters from one man to another to induce haste in handling should never be indulged in, and, in fact, should be a capital offense. The meter handle produces safety from dropping and a properly constructed and equipped meter carrying vehicle reduces jars and jolts to the minimum.

Care in handling large meters is of even a greater degree of importance than is the handling of small ones. Large size meters, in addition to being of considerable weight, are awkward and hard to handle owing to the fact that they are slippery and contain nothing much to hold on to. Their handling should receive unlimited attention and sufficient men or equipment used in so doing that no damage results to the meter. A large meter is for the purpose of measuring large quantities of gas and an error in registration, therefore, represents a larger amount than in a small meter. The handling, transportation and repairing costs on such meters are proportionate to their size.

Meter Locations

Next to the importance of properly handling meters is the care to be exercised in selecting a proper location for them while in service.

They should be placed in a location where they will be exposed to the minimum amount of dangers detrimental to their remaining in service, and retaining their accuracy of registration, and where the maximum degree of efficiency in registration, indexing and maintenance will be obtained. They should be placed where

Fig. 272. Welded Headers for Apartment House Cast Iron Meters

easily accessible and not exposed to extreme heat (as near steam pipes or furnaces), dampness, frost, sudden changes of temperature or liability to damage by having things thrown upon or against them. Gas changes in volume in proportion to the temperature to which it is exposed, so that a meter registering gas at high temperatures does not pass as much gas when corrected to the 60 degrees Fahrenheit standard as the meter which is exposed to lower temperatures. It is therefore important in justice to both company and customer that

Fig. 273. Apartment House Bank of Dry Meters

the meter location be a place of as near uniform and standard temperature as is possible. Extreme heat causes a permanent injury by drying out the diaphragms, thereby causing them to shrink and the meter to register fast. Extreme cold causes the freezing of condensate contained in the gas or meter, either in the form of frost or ice, and usually stopping the flow of gas, although permanent injury to the meter is not necessarily done, if the proper methods are used in thawing. Extremely low temperatures are chiefly detrimental in the cessation of service to the customer. The importance of having the meter in an accessible place effects the indexing more than anything else, although it is of value in case any work is to be done upon the meter, covering complaints, changes or removal. In order to operate, a company must collect from its customers for the amount of gas used by them. This is shown by the meter registration, which should be indexed at the proper time covering the period for which the customer is billed. Delay in indexing caused by

Fig. 274. Well-Arranged Installation of Tin Meters

the meter being in an inaccessible place causes delay in billing the customer and a similar delay in receiving payment. In addition there is the cost of the numerous trips made by the meter reader in securing the index. In no case should a meter be installed in a locked room unless the company is provided with a key thereto. Meters should not be set where the meter reader must crawl over a lot of goods to reach it or where he cannot accurately read the dial, where he will be exposed to danger by stepping into exposed pits or by climbing upon unsafe devices, or becoming entangled in moving machinery.

Meters should not be set in coal cellars or wood bins under any circumstances, nor under the deck of show windows, or in small closets if any other location is available. If such a location is unavailable, means must be provided for thoroughly ventilating the space within such a closet or under deck to eliminate any danger from explosion of escaping gas or the asphyxiation of fitters working therein.

Meter locations should not be accepted where the apparatus to be supplied therefrom is below the level of the meter (as, for instance, a meter on a second floor supplying gas to the first floor), thereby producing a trap in the gas piping. The meter location should be the low point in any installation, except in the case of fuel installations where the meter is located on the wall above the appliance and the piping is drained to a suitable drip at the appliance.

In all buildings where a meter room is not provided the meters should be set in the respective premises supplied by them.

Setting Meters

To be able to set a meter properly is one of the qualifications of the first-class fitter, which involves no small amount of care and skill. . A number of things must be taken into consideration that mark the difference between skillful and unskillful work. Too often the work of meter setting means simply connecting the inlet to the service and the outlet to the house pipe, with no regard for anything else. We have seen meters set sideways, angling and even with their face to the wall, and the job was considered as complete, but of course such jobs did not pass under the observation of a modern inspector.

Several important considerations of meter setting are: (1) That the meter is set in such a manner that the dial may be quickly and easily read by the indexer;

(2) that no strains exist that may cause leaks or damage to the meter; (3) that the meter be properly supported, and (4) that the job may be as pleasing in appearance and as satisfactory from the customer's standpoint as possible and at the same time be in accordance with the company regulations.

The sole purpose of the meter is to measure the amount of gas used by the customer, the index of the registration of which must be taken at certain intervals in order that revenue may be obtained from the gas used. It is essential that this indexing should be done as expeditiously and accurately as possible, and it can be greatly facilitated if the fitter or meterman will keep foremost in his mind the fact that the meter must be set chiefly for the convenience of the indexer.

The proper place for the meter is naturally near the end of the service, but often an extension is warranted where this location is not as good as one farther removed from that point. Natural light and freedom from obstacles and obstructions is a great aid to the indexer, as is also the ability to read the meter while standing on the floor. It should be remembered that the cost of the job is only paid once, while the cost of indexing is perpetual. An additional expense is therefore warranted in choosing the best meter location possible. Meters should be set with their tops 5 ft. 6 in. from the floor unless in buildings where a number of meters make necessary their arrangements in tiers. In such meter rooms, if the upper tiers are out of reach of the eye, a ladder should be furnished and kept within the room.

Many meters are brought in damaged because the fitter tries to make the meter fit the connections instead of arranging the connections to fit the meter. A great many leaks, particularly at the screws, are caused by the fact that at some time the meter has been set with a strain on the connections. A strong man using a 10-in. wrench can put 1,000 lb. pressure on the meter washer, and it is quite natural that if the connections do not line up exactly, the ordinary meter being made of tin plate and soldered together will not stand such strain.

In modern meter setting, where the rigid or pipe connections are in general use, the danger of strains upon the meter is great unless the utmost precautions are taken to prevent them. It has become almost universal practice to use threaded swivels screwed directly into fittings. This is no doubt the cheapest and most efficient form of connection. The use of the offset swivel can be recommended as it allows horizontal distances to be easily made up, and the cost is but slightly in excess of the straight swivel. Two swing-joints made of street ells screwed into ells or tees should be used on every meter set—at the inlet and outlet sides. If this is done and offset swivels used, while at the same time the meter is not made to support any but its own weight, strains will be reduced to the minimum.

A properly set meter will be parallel with the wall and not at an angle therewith. It will also be set level in both directions. It should not touch the wall, as corrosion of the tin is liable to occur if the metal comes in contact with a damp wall. A space of 1 in. should exist between the meter and wall. Greater distances are not recommended. After a meter has been set and turned on the test hand should be closely observed for at least ten minutes to ascertain if any leaks or openings exist.

Supporting Meters

Where rigid connections are in use no other support except the cap and screw is necessary on meters up to 30 lt. in size. They may hang from their connections provided the service and housepiping is securely fastened. All meters of 45 lt. size and larger should rest upon some substantial support, as a bracket securely fastened to the wall or upon the floor. Care should be exercised that the meter does not come in contact with metal, masonry or concrete. If such material forms the support a protecting layer of wood should be placed next the meter. A meter of any size having lead connections should rest upon some solid support. For the smaller sized meters a spike made of 1½ x 5/16 flat iron sharpened at one end and driven in the wall, with a board between the spike and meter, makes a good and cheap support.

Setting Service Governors

Where service governors are used they should be set directly preceding the meter and after the meter cock. Where a group of meters are located in one closet or room one governor of ample size may be used to control

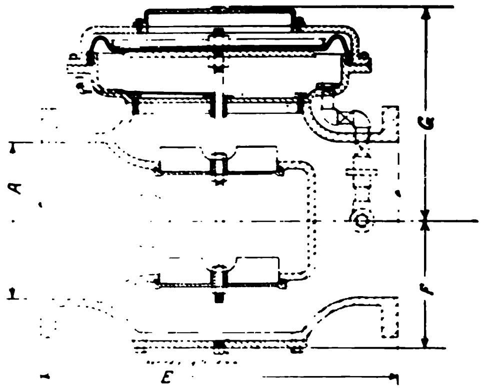


Fig. 275. Section of Service Governor

all, in which case it would precede the individual meter cocks. Unless circumstances make it absolutely impossible the governor and meter should be located in the same room. The reason that the governor should never be located preceding a long service extension and why its logical place is close to the meter is apparent through the fact that the utilization pressure equals that thrown by the governor less line loss, in the service extension, less meter loss, less housepipe loss. The location near the meter cuts out the former loss.

Where service pressures exceed five pounds the vent from the regulator should be piped out of doors and protected from stoppage by running to a suitable height above the ground and attaching a return ell containing a plug with a small hole tapped therein on the end.

In setting governors the fitter should make sure that the shipping pin that is used in holding down the diaphragm is removed and that the governor is working properly. By inserting a lead pencil in the vent hole, after the plug is removed, and pushing down on the diaphragm this can be ascertained, as the diaphragm

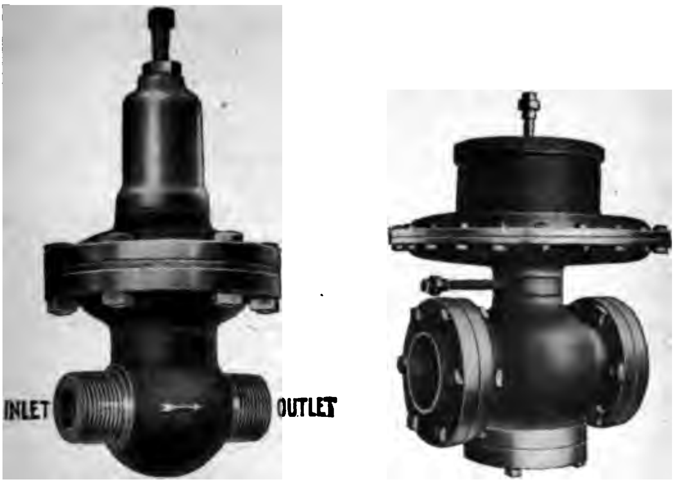


Fig. 276. Types of Service Governor

will return to its original position when released if in proper working order.

In choosing locations for governors consideration should be made for repairs that might be necessitated while the governor is in service. It should therefore be installed in a place where it will be readily accessible and at the same time in such a manner that it may be readily removed if necessary.

Service Extensions and Building Services

Service extensions or building services should be of the same size as the underground service and in no case less than 1¼-in. pipe. While it is granted that the logical place for a gas meter is as close to the end of the underground service as possible and that the underground service should enter the building as near the proper meter location as possible, yet unavoidable conditions often make it necessary to extend the service to the proper meter location. All work done upon service pipes preceding the service meters should be done by gas company fitters, except in the case of building services where the meter rooms are removed a considerable distance from the end of the underground service, in which case outside fitters may do the work subject to the company's rules and inspections, but in no case should connections be allowed made either to the underground service or the meter except by the company's fitters.

No tees or openings should be allowed in any service extension or building service except those necessary for meter connections, cleaning purposes or drains, and all such tees or openings should be left in a conspicuous place where they will be subject to the observance of indexers and inspectors.

Service extensions laid under cement, tile or parquet floors should be run within a conduit making them accessible in case of leaks or stoppages.

On all services or extensions supplying more than one meter or where the meter is located more than 10 ft. from the end of the underground service or is located in a different room, a service cock or valve should be provided just inside the building wall and in an accessible place, where the gas may be turned off of the entire building in case of fire. Single meter installations, where the location is within 10 ft. of the point of entrance of service pipe and within the same room, may be controlled with the meter cock, without the additional installation of a service cock.

Service extensions and building services should be free from traps or sags and unless absolutely impossible should drain toward the underground service. Should unavoidable conditions make this impossible, a large drip receptacle should be provided into which condensation may flow and be removed therefrom. In no case should the condensation be allowed to drain into the meter.

When working upon service extensions where connections must be made and no valve or cock is available to shut off the gas, the fitter should be provided with an expansible rubber plug, which should be inserted in the end of the service where it enters building or in the pipe through a tee preceding the point where connection is to be made. This plug is of the same type that should be in general use by the service fitter of the street department and can be made of a one-hole rubber bottle stopper of the proper size, equipped with a ¼-in. threaded bolt, filler and wing nut.

Plugs should never be removed from a service that is in use, or connections broken thereon, until it has been ascertained that all appliances are shut off. The opening of a service will exhaust all gas contained within it through this opening causing the pressure to drop and any appliance that may be in use will be extinguished with consequent danger of explosion when gas is allowed to flow again.

The following table may be used in planning service extensions and building services:

Sizes for Service Pipe

Diam. of pipe	Greatest length	No. of ¾ in. openings
1¼ in.	100 ft.	4
1½ in.	150 ft.	6
2 in.	200 ft.	12

Meter Headers

The meter header is but a continuation of the service extension or building service and the same rules as to size and regulations are applicable. As previously shown, the conductivity of a pipe fed from both ends or the middle, exhausting along its length is almost three times as great as that of a pipe fed from one end only.

from such openings. Where meters
the openings for the upper tier shou
30 in. above the openings for the lov
in services and headers should be lo
30 in. nor more than 8 ft. above the
services or headers should point u
and never down. This should be d
flow of condensation into the meter.

There is no more satisfactory sig
ness than a group of well set me
properly constructed header. This
however, where a piece of the header
a meter is set. The header should b
entirety before any meters are set,
comes an easy matter to install every
position and all exactly alike.

House Piping

The piping of old houses for light
done by the gas company and muc
from this source if commercial can
urated in that direction. It is well,
agreement to be made with master
tions whereby no houses wi
elapsed since their completion
between the company and the p

after which the salesman has nothing to do but find out how many openings are needed and he can state the price of the job. The company may lose on some individual jobs, but the average should show a profit.

House-piping campaigns afford an outlet for surplus salesmanship energy during a time when the range and water heater business is slack and should therefore be carried on during the fall and winter. The houses to be found that are not using public service lighting will be surprising to the salesman when he once centers all his energy toward finding them. An inducement in the way of trading gas lamps for oil lamps aids in securing contracts.

In piping old houses it is possible in nearly all cases to conceal every bit of pipe installed, and this should be the aim of the fitter. Piping run on walls and ceilings in a living-room is always objectionable. To the ordinary gas company fitter the concealment of all piping is often a seeming impossibility, which to the trained house-piping fitter becomes second nature. It is possible for any fitter with ordinary ability to become an expert house-piping fitter if properly instructed and trained. Ingenuity is a desirable trait which often solves seemingly impossible problems in this business. System is another great aid.

In piping houses a helper to the fitter is necessary. Upon entering the premises to be piped the first thing to be done is to generally size up conditions, at the same time making mental calculations and obtaining general locations. This can usually be accomplished while the owner or occupant of the premises is showing the fitter where he wants the outlets or fixtures located. If the house is of one story a means of getting into the attic above the rooms should be found. While some kind of an opening is provided as a rule in all such houses yet it is necessary in some cases to remove weather-boarding or bricks in the outside wall in order to gain admission. If the house is of two or more stories the location of rooms above the lower floor should be considered relative to those below.

After a general outline of the house has been obtained and all openings located the riser should next be located. An inside partition should be chosen which will afford the best connection to the main gas pipe supplying the outlets, and one in which the riser can be inserted either from above or below in as long pieces of pipe as possible. A partition in the center of the house or one over the basement is usually available. An inside partition is usually free from obstructions, the studdings running vertically with a 2 x 4 plate top and bottom. The plates may be bored with an auger or a square hole mortised in with a sharp wood chisel. After the holes are located and cut through the helper should hold a light to the lower hole while the fitter looks through from above. In some remote cases a brace may exist between studdings which must be knocked loose or bored through. The latter is possible by means of extensions attached to a bit.

After a clear way has been provided for the riser the openings should be located. The ceiling openings for fixtures should be in the exact center of rooms. A quick way to obtain the center is to measure across the room double the tape-line and mark the end on the floor with chalk. Repeat the operation across the room the opposite way and the point where the chalk lines intersect will be the center of the room. With a plumb the point should then be located on the ceiling and by means of a feeler bit a hole drilled through so that the point of the bit can be located by the helper in the room or attic above and the spot marked with chalk. Side lights must be located with the same object in view as in locating the riser, getting the pipe in the wall. In order to do so the upper partition and lower one must be over each other, or a clear opening be obtained from the basement or from above. It is sometimes necessary to diverge from the wishes of the customer in order that this may be done and the running of exposed pipe prevented. The discreet fitter usually experiences little trouble from this source.

After all openings are located and a clear passagety for the piping absolutely assured the job may be sured up. Any flooring removed or rugs and furniture misplaced should be replaced in a safe manner to suit the installation of the piping.

Piping jobs should be planned to remove as little flooring as possible. In taking up flooring the fitter should exercise extreme care so as not to break or split the boards. A thin chisel should be inserted on the groove side of the board to be removed and steady pressure applied. The lower part of the groove will break away from the board and by following along with the chisel the board may be taken up in such condition that it can be replaced with scarcely an appearance of having been removed. Except in hardwood flooring it is not necessary to saw the groove. Where flooring boards must be sawed in two it should be done alongside of joists. By using a thin compass saw this can be done without a large starting hole. In replacing such boards a cleat should be securely nailed to the joist to support the end of the board. In notching joists to receive piping a slot no larger than is necessary to bury the pipe should be made.

Pipes running parallel with joists should be supported every 10 ft. by means of cross pieces nailed between the joists. The drops supplying lights cannot in all cases be composed of bent pipe so that this rule in piping new houses must be waived in the case of old ones; however, the drops should be securely fastened and every precaution taken to prevent their screwing out of the fitting. They should project at least 1 in. below the plaster so that a wrench may be attached when removing caps or fixtures. The drops should be fastened to the joists or to notched cross pieces nailed between joists with two pipe straps.

In hanging fixtures the lowest part of the fixture should be 6 ft. 2 in. from the floor in all living-rooms and bedrooms and 6 ft. 6 in. in halls and dining-rooms. Side lights should be placed 5 ft. 6 in. from the floor. Where rooms are less than 8 ft. 6 in. in height a smoke canopy should be installed over every ceiling light.

They should also be installed over side lights where the distance between the top of the lamp or flame and ceiling is less than 2 ft. 2 in.

Old house-piping jobs done by the company should be subjected to the same inspection and test as if done by outside fitters. Such tests being made by the installing fitter before he hangs the fixtures.

A fitter and helper by measuring up their jobs and having same cut out and delivered from shop should average a five outlet house per eight-hour day, com-

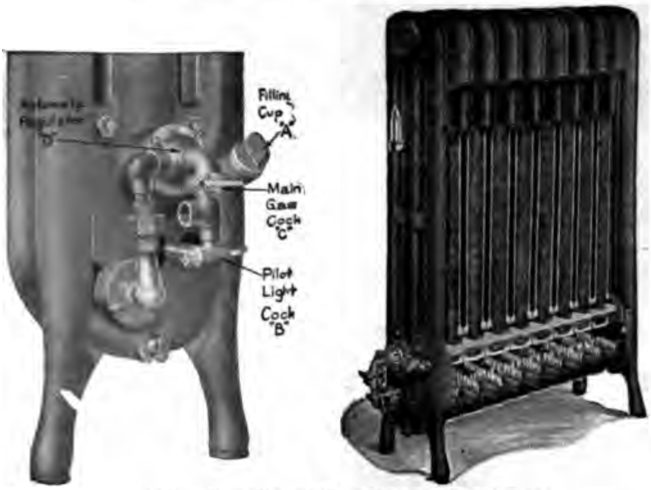


Fig. 277. Details of Gas-Steam Radiators

pleting the entire job, including testing and installing fixtures and lamps.

All boards, brickwork or plastering removed in installing piping, or any disarrangement of furniture goods or fixtures belonging to the customer, should be replaced in as near their original condition as it is possible to do so, and where this cannot be done by the fitter himself he should notify his foreman so that arrangements can be made to have the work attended to.

The following table of pipe sizes and number of openings allowed should be used in all house-piping work:

Sizes for House Piping

Diam. of pipe, in.	Greatest length, ft.	No. of ⅜" openings
⅜	15	1
½	30	3
¾	60	10
1	75	15
1¼	100	30
1½	150	60
2	200	100
2½	250	200
3	300	300

If the above lengths are exceeded use next larger size.

No ¼-in. pipe should be used. Risers should be not less than ¾ in.

House Heating

This phase of the gas business is comparatively new in the artificial field, but bids fair to develop into an important feature of the domestic fuel possibilities.

Heating houses with the gas-steam radiators is not

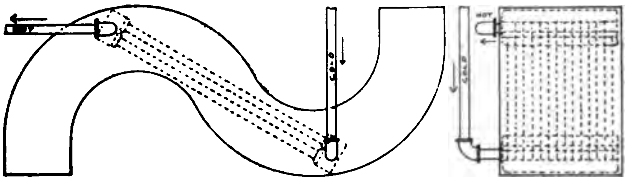


Fig. 278. Hot Water Coils in Chimney Flue

a new idea, and is one that is being quite extensively used at the present time, but not nearly so extensively as it will be later under reduced standards of illuminating and heating values of artificial gas. When equipped with thermostatic arrangements this method of heating is both convenient and efficient.

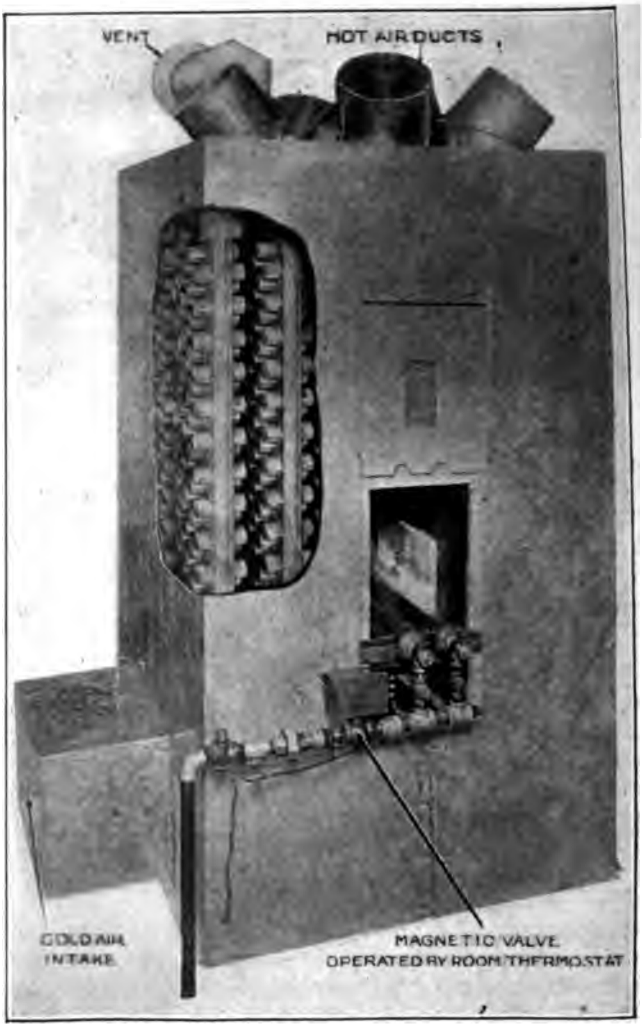


Fig. 279. A Pacific Coast Gas-Fired Furnace

The auxiliary furnace heater is used during cool weather before continuous use of the furnace becomes necessary. It consists of a number of ordinary flat flame burners arranged in the hot air pipes near the registers and is more convenient and efficient than the ordinary room heaters.

Burning gas in furnaces for general heating purposes, in place of solid fuels, is still an economical impossibility in most companies, and it is a question of how far we want to go toward depriving ourself of a market for the coke produced in making cheaper gas. Coke oven gas will go a long way toward settling this question.

Purging

Any pipe, meter or appliance installed must be thoroughly purged of the air contained by turning on the gas and allowing it to expell the air through the open burners of all appliances or lights. This must also be done where meters are turned on that have been shut off for a considerable period of time.

In the work of purging, or letting out air, every appliance and light must be visited by the fitter and individually turned on and left open until by frequent testing the gas lights and burns in the proper manner. Every branch pipe supplying a part of a system will contain its proportion of air that must be expelled. The exception to this rule may be in the case of changing meters where no air has been allowed to get into the piping system, when that contained within the meter itself is all that is necessary to be expelled.

Testing for Tightness

After a job has been installed or repaired and the appliance or lights purged and adjusted, a thorough test should be made of every fitting, pipe, connection and meter to make sure that no leaks exist.

The preliminary test, where a meter has been installed or changed, or where piping or connections have been installed or repaired beyond the meter consists of watching the test hand of the meter for at least ten minutes, after first making sure that every burner attached to the meter is shut off. This test and the accompanying one of visiting every burner while purging are precautions to prevent the escape of gas through leaks that might escape the final test of all piping and connections, but is more particularly important in preventing the escape of gas from open burners, openings in the piping or leaks in concealed piping, and should not be omitted in any instance, no matter how minor the work may have been.

The use of matches, candles or any form of open flame in testing for leaks in gas work of any kind should be prohibited. The enforcement of this as a rule by all gas companies will require the co-operation of the fitters or very strict disciplinary measures on the part of the companies. It means the breaking away from a habit as old as the gas business itself, but the benefit to be derived by the reduction in fire and explosion hazard is well worth the effort.

The dangers attendant with the use of open flames are: (1) Ignition of combustible matter by the flame itself; (2) ignition of gas, the flame of which ignites other combustible matter, and (3) ignition of explosive mixtures of gas and air in confined spaces.

There is always more or less of combustible matter scattered about the customer's premises, particularly in the basement, where the fitter generally does the most of his work. An overturned candle or a carelessly handled or dropped match may cause a conflagration.

The ignition of a serious leak or one that cannot be immediately extinguished may cause property damage and other loss. The most dangerous form of ignited gas leaks, however, are in most cases the very small ones which escape the sight of the fitter. These may be left lighted to cause a fire after the fitter has left. Particularly is this true of leaks left burning around meters which in time melt the solder on the meter, causing a large stream of gas to be ignited, resulting in serious consequences.

The saying that a real gas man can detect the odor of a cubic inch of gas in the entire atmosphere, no matter how much of a conglomeration of other odors may be present, is not far from being true. A gas man never becomes used to the smell of gas, but rather he becomes so trained in time that his olfactory organs become very sensitive to that odor. A man without unimpaired nasal organs mistakes his calling in entering the gas business as a fitter and, in fact, is a dangerous person while working at that vocation.

In searching for leaks the nose should be used very extensively and where possible every fitting, foot of pipe and meter should be smelt of first, after which soap suds should be applied to all joints and around the meter. The soap and water should be mixed up in a cup or other vessel and applied with a small brush. A shaving brush is very good for this purpose. Common laundry soap or other soap which does not lather too freely is best. A stiff lather is apt to act as a seal, preventing the escape of gas on small leaks. The entire surface of the joint, either in pipe, fitting or meter, should be covered with the soapy water which will show a leak of any magnitude as a bubble. The soap and water test can be made in any place that a flame test could, and just as easily, the only essential thing being light, which should be supplied by means of an electric or safety lamp.

The Use of Lights

Where necessary for the fitter to use artificial lights of the company's furnishing they should be either electric dry cell lamps or approved oil lamps similar to the Davies safety lamp. In no case should candles or other forms of open flames be used.

Appliance Tests

The following consumptions were shown by actual test on various appliance burners in the laboratory of the Denver Gas and Electric Light Co. in March, 1913. The utilization pressure at appliances was 3.8 in.:

[redacted]

Gas Consumption

No.	Make	Cu. ft. per hr.
400	Clark Jewel water heater burner	58
5R	Humphrey water heater burner	47
2	Lion water heater burner	60
222	C. J. laundry stove, 2 burners	51
820	Reliable room heater	41
48D	Reliable hot plate, Grant burner	30
48%	Reliable hot plate, single burner	17.5
221	Stanford heater	59
5	Backus heater	28
1	Reznor heater	27
66	C. J. Range, single burner	18.5
166	C. J. Range, Grant burner	22
166	C. J. Range, 2-16-in. oven burners	48
252L	Acorn range, Grant burner	27
252L	Acorn range, 3 single burners	54.5
252L	Acorn range, $4\frac{1}{8}$-in. oven burners	85
252L	Acorn range, Simmer burner	4

Complaint Work

Complaint work is the most important responsibility of the fitting shop and should be given preference over any other class of work. No gas company can hope to entirely eliminate complaints, but it should be the aim of all companies to so carry on their operations that the number of complaints will be reduced to the minimum and those occurring be attended to in such an efficient manner that the least amount of inconvenience and annoyance will be caused the customer. Upon these two principles depend the quality of service rendered. A complaint is like a decayed apple in a basket of good ones. If the apple is allowed to remain a number of good ones will be spoiled. One complaint in a neighborhood, if allowed to become chronic by inattention or failure to remedy by removal of the cause, will, through neighborhood gossip, effect customers who really have no cause for complaint at all. It is therefore of the utmost importance that every effort of a gas company be directed toward the prevention of complaints and their speedy permanent remedy when encountered.

Complaints may usually be classified under seven general heads, namely: Leaks, no gas, poor pressures, appliance adjustment, high bills, reread meters and miscellaneous.

Leaks

There are many good methods of handling leak orders, but only one best method which will fit all cases. All leaks are dangerous, some being more so than others, but it is often impossible to determine from the customer's report whether the leak is of a serious nature, only an annoying odor or simply imaginary. Leak orders should therefore be given precedence over all others. Complaint men should be positively instructed to give immediate attention to leak orders and never to leave the premises wherein the leak was reported until the leak, if one exists, has been stopped or by most exhaustive test it has been proven to be non-existent.

In cases where it is found impossible with the means at hand for the complaint man to permanently repair the leak it should be left in a safe condition until permanent repairs can be made, either by the use of hard laundry soap smeared over the leak or in extreme cases by shutting off the meter or service cock. Every means should be employed of expediently making permanent repairs, or causing same to be made where the piping or apparatus effected is not within the responsibility of the company. Hair lines should not be drawn in the latter cases and a liberal policy should be used in designating responsibilities of the customer and company. It is always best where the repairing of leaks in the customer's piping or apparatus does not involve too large an item of expense to include such repairs in the service rendered. A liberal policy of this sort is conducive of the good will of the customer and is seldom taken advantage of.

Complaint men should be forbidden to use open flames in searching for leaks. Some fitters and complaint men

.... the odor is detected. fixtures in the rooms and all e examination either by smellin piping or by rubbing the finger the fingers, or by listening for escaping gas. The test hand watched on all leak complaints used, for at least ten minutes. tion fails to show any movemen safe to assume that there is apparatus supplied by the mete

A delicate test of any job of section thereof, may be made by d and setting a test bottle in its p ing the section of piping to be te test bottle between it and the system.

The test bottle may consist of the lid of which an inlet and ou The inlet may consist of a ⅜ through the lid and into the bott should be soldered directly to project through it. Suitable con from the inlet and outlet pipes to or piping, using gas tubing if des with water to a point submergin pipe, the depth of submergence ...

bubbles which pass in a given length of time the amount of leakage may be accurately determined. By the use of the test bottle customers may be convinced of the absence of leaks on imaginary or high bill complaints, which is sometimes very hard to do with any other method. In demonstrating to the customer that no leak exists one should be formed in his presence by loosening the outlet connection to the bottle. His attention

Fig. 280. Pocket Pressure Testing Outfit

should then be called to the bubbles of gas passing through the water and to their cessation when the leak that has been formed is stopped. This rarely ever fails to stop even chronic imaginary complaints. (Fig. 226.)

In searching for gas leaks carefully examine all gas cocks, greasing the plugs with tallow or prepared cock grease and tightening them, if necessary. The stuffing boxes of all gas valves in use should also be examined and the packing renewed with well greased or graphited candle wicking if found necessary. The meter and connections should be critically examined. The hands should be carefully passed over the meter case, especially the bottom and back and smelled of. Often small rust holes causing "juice leaks" will cause complaints for long periods before discovery.

If no leakage can be found in the piping or apparatus within the building, the walls on the street side and the walls separating the premises from adjoining premises, especially around any pipes or sewers, should be carefully examined. If gas is found entering from the outside of the building communication must at once be made with the foreman or proper authority who will send men with equipment to handle ground leaks. In the meantime, if the leak is serious, the service should be shut-off at curb cock if one exists and it is possible or the ground opened up outside of the building to allow the gas to escape into the open air. In such cases the complaint man must not leave the premises until the emergency crew arrive prepared to handle the trouble.

In every leak complaint a full report must be made by the complaint man giving location of the leak, if one existed, whether on inlet or outlet side of meter and an estimate of the amount of leakage. The statement of the meter should also be shown. If a leak is found it is good policy to show the customer both before and after repairs are made, and if after exhaustive test the complaint man is satisfied that none exists, the utmost endeavor should be made to convince the customer of the fact. This often prevents repetition of complaints from the same place.

"No Gas" and "Poor Pressure" Complaints

It is customary to designate complaints involving the supply of gas to appliances or lights as "No Gas" or "Poor Pressure," while some companies attempt to show a distinction between the two. The term "No Gas," as commonly applied, is erroneous as very seldom such a state of affairs exists when the complaint is made. The usual causes that influence such complaints do not stop the supply of gas all at once, but rather cause a gradual reduction of the supply until complete stoppage may occur. Rarely does the customer await a complete cessation of the gas supply before a complaint is turned in. One of the advantages claimed for gas lighting over electricity is the fact that when the

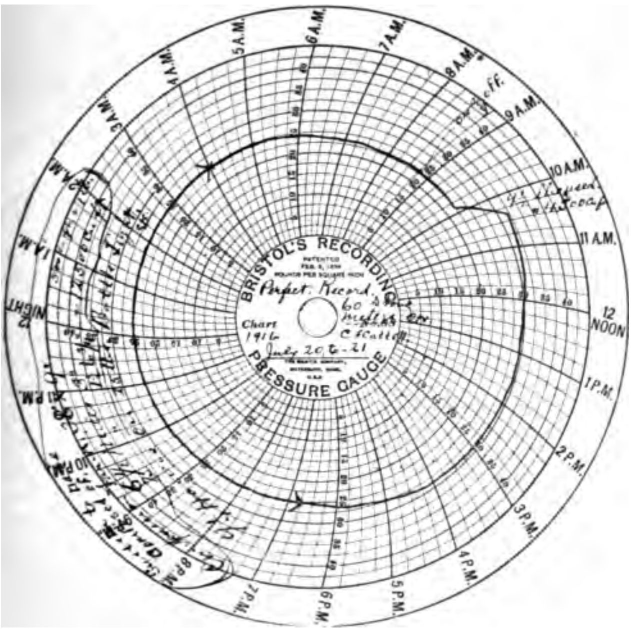


Fig. 281. Pressure Chart Test for Tightness

latter fails the customer is in complete darkness, while with the former some light at least is always available. A better name for any complaint involving the gas supply would be "Poor Supply."

Complaints of no gas or poor pressure should receive precedence over all orders except leaks. In taking the customer's order for such complaints an effort should be made to ascertain what appliances are unsatisfactory and as much information concerning the trouble as it is possible to obtain. This information aids the complaint man in expediently locating and remedying the trouble.

The cause leading to poor supply complaints may be: (1) Stopped services, either from naphthalene, frost, condensation or rust; (2) stuck or binding meters; (3) condensation, frost or naphthalene in meters or connections; (4) frozen or stopped risers; (5) stopped housepiping or fuel lines; (6) stopped fixtures or appliances; (7) governor trouble; (8) main trouble; (9) small pipes; (10) small meter, and (11) appliances in need of adjustment or repairs.

Each case must be considered by itself. The first thing to do is to determine the cause of the trouble; the second to remedy it in such a manner that it will not recur. Main trouble should never be assumed as a cause until all other efforts to locate and remedy have failed. The first thing the complaint man should do on arriving at the premises is to ask the customer to give removed. If there is water in the service it will be noted by a gurgling sound and intermittent flow ot s.

Solid stoppage in the service may usually be attributed to naphthalene or frost, although sometimes rust encountered in an old service. The season of the year ould decide between naphthalene and frost as it is

Fig. 282. Force Pump for Clearing House Piping

rare to encounter the two causes during the same period of the year. If extremely cold weather has been experienced or if the frost is deep in the ground a stopped service pipe can be safely assumed to be filled with frost. At other times naphthalene will be most liable to cause the stoppage. Failure to relieve the trouble with the proper remedies for frost and naphthalene would indicate a stoppage due to rust or sediment.

A little wood or denatured alcohol poured into a service after which a blow is given with the mouth will usually free a service from frost. The same method substituting gasoline for the alcohol is the remedy for naphthalene. Condensation in a trapped service may be removed by using the force pump, but in all such cases a written report should be turned in to the foreman as sooner or later the trouble will recur and the only permanent remedy is to dig up the service and relay it.

Where services are stopped with rust or sediment they can sometimes be cleared by use of a force pump, although this method is very liable to force the obstruction into a compact mass in a fitting, causing a complete stoppage. Any use of a force pump should be made very carefully as their promiscuous and careless use results in more trouble than is overcome. The first discharge into a pipe must be a very light one, followed by charges of gradually increased pressures until the

f one of these cleaners will practically eliminate eed of service renewals due to stoppage
›uble in a main will be indicated when several ces connected to the main in the same locality show ıame trouble. In such cases a pressure survey

Fig. 283. Types of House Pipe Force Pumps

ld be made along the main during time of peak umption until the location of trouble has been itely located, after which it may be remedied by ying the remedy that is apparent.

properly results in injury to the
found to be all right, by the pro
trouble must exist either in the
or appliance. The principal cau
piping is rust or sediment which
careful use of the force pump.
discharge pressures, succeeded b
be used. The meter outlets shou
the pump attached to the closes
for the first discharge. After t
openings farther removed shoul
far openings must never be blow
is assumed to be frost in the rise
outside wall, a little alcohol inse
connection, after a trap has bee
will effectually clear the pipe.
poured into the trap a burner s
provide an outlet and a blow giv
the mouth. In any case of fros
the customer should be notifie
changed to prevent a recurrence.
may or may not be taken care
although it is good policy, as
leaks, to go a little more than h
troubles that rightfully belong to

A portable "U" gage is of the
locating causes of poor supply an

A gas pipe containing a stoppage assumed to be
ɩphthaline or frost should never be cleared by blowing
ith the mouth or force pump. A solvent should always
: used. Blowing only tends to make a hole through
ıe obstruction or blows it into another position. In
ther case a repetition of the trouble is almost certain
ı occur in a short time. A solvent removes the ob-
ruction entirely by dissolving it, either carrying it into
ıe main or by evaporation with the gas to the point
here it is consumed. The use of a blow torch is often
nployed in thawing frozen or frost obstructed pipes

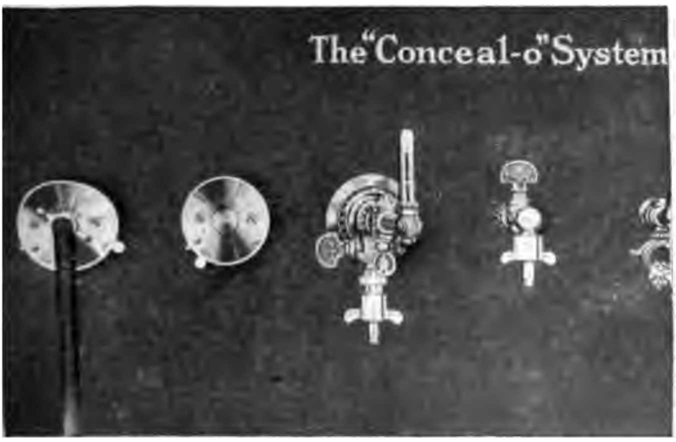


Fig. 284. Secure Flexible Tube Attachment

and meters. It is a hazardous practice that should be prohibited by all companies. A frozen pipe or meter that cannot be cleared by the use of alcohol should be wrapped with rags and hot water poured on them. A very little hot water will usually accomplish the purpose. The Hauck portable steaming outfit is a new thing but recently put on the market, which can be recommended for thawing frozen pipes and meters. The accompanying cuts show this equipment in operation and being carried by one man.

[redacted]

It is important that a detailed report be made of every poor supply order executed that the company may profit by the information in preventing recurrences of the trouble. The usual signing up of an order, such as "Fixed O. K., J. Smith," shows just as much of a deficiency as if the trouble had not been remedied.

Appliance Adjustment

Often complaints of poor supply will be found to be appliances out of adjustment, or vice versa. A properly adjusted appliance will, if conditions of pressure and quality of gas remain unchanged, and the burners given warranted attention, seldom get out of adjustment. A great many complaints of lack of adjustment will be found to be caused by dirty burners or carelessness on the part of the customer himself. Things are allowed to boil over or grease is allowed to accumulate on the burners, until part of the holes are stopped up, causing a long flame on those that are open. In other cases the air mixers are allowed to stop up with grease and dust, so that a luminous flame is produced, causing soot to accumulate on cooking vessels. In others the orifice gets stopped up with the accumulation, so that the gas pops back into the air mixer when lighted. Sometimes, of course, an appliance will lack adjustment because it has been purchased from a hardware store, or elsewhere, where the seller has no interest beyond selling the article. In all cases the burners should be cleaned if necessary and properly adjusted. Then the customer should be given polite instructions in keeping the appliance in that condition by frequent cleaning of the burners.

Re-read Meters

This source of complaint is one that can hardly be entirely eliminated, as some portion of any gas company customers must in duty to their dispositions complain of their bill. It must be granted that in some cases these complaints are warranted, but from experience it has been found that they are a small proportion of the whole.

Preventative measures are: accurate indexing and teaching the customers to read their own meters. All companies should strive for accuracy as well as speed in reading meters. Speed counts for naught if the work must be duplicated. Some form of bonus for both accuracy and speed should be given, with forfeits for demerits. In one company a bonus of $5 per month is given the indexer if no mistakes are made and a

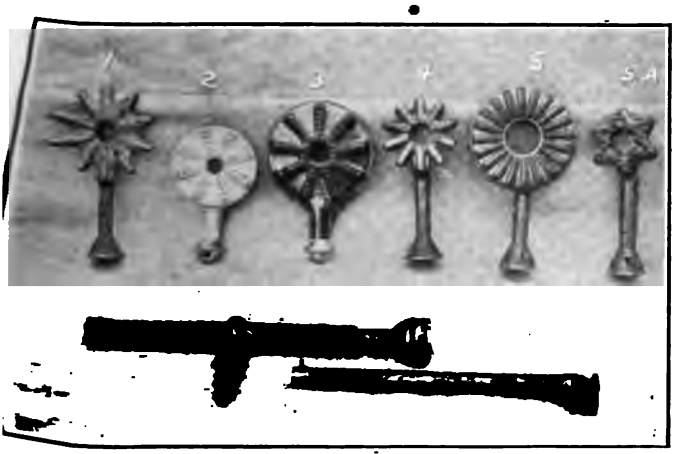


Fig. 285. Pressure Must Be Suited to All Burners

certain standard of speed obtained. The reader is compelled to re-read meters at his own expense if the reading is proven incorrect. Changes of indexers should be avoided as much as possible, without depriving the man of his chance for promotion.

The distribution among the customers of cards instructing them to read their meters, or the attachment of such a card to every meter, is to be recommended. Stickers containing this information attached to the gas bills, or newspaper advertisements all encourage the habit. Customers should be taught to check up their gas consumption just as they do their groceries and other commodities. When this is done to the extent that it should be very few complaints to re-read meters will be received unless they are justified.

High Bills

Perhaps the most difficult of all gas complaints to handle and remedy satisfactorily, both from the company's and the customer's standpoint, are complaints of high bills. While these complaints and those preceding under the heading of "Re-reads," bear a very close relation and originate from the same cause, the former may exist and necessitate attention after the original indexing has been verified by a re-read order, thus putting them in a separate class from the latter order.

The handling of high-bill complaints requires the use of the utmost tact and diplomacy in order that the customer be fully satisfied and the company lose neither honor nor dignity. If, however, after thorough investigation, the company is found to be at fault, the same should be explained to the customer and t ınd to be abnormally large, it becomes a question of ıvincing the customer of this fact. If, however, there reason to believe that the bill is larger than could : expected, an investigation should be made of the ıstomer's premises to ascertain if there were any easons for abnormal consumption. Often in these in-estigations facts are brought to light of conditions rarranting unusual consumption, such as new or inex-erienced maids or cooks, social functions, illness in ıe family, guests, new appliances connected, or ap-liances not adapted to economical use. If no such rea-ons are found, the meter should be removed and sted and the test bottle applied to the house piping make sure that no leaks exist.

In cases where the conditions warrant the consump-n and the company is still unable to convince the stomer of the fact, a complaint meter should be set r a week to show the amount and time of consumption.

In all dealings with the customer during investiga-n of high bills, he should be treated in a manner nductive of obtaining or retaining his good will, thout the acknowledgment of error on the part of the mpany until all the facts have become known.

scellaneous Complaints

There will always be a number of complaints handled a gas company that cannot be included in any of the preceding classes. Some may be of a trivial char-ter, while other occupy various degrees of im-rtance. In any instance they are complaints, having bearing upon the class of service rendered, and should e given prompt attention and satisfactorily executed. satisfied customer is a booster, whether the satisfac-ion came from having the house piping blown out or rom the prompt and efficient manner in which a key ras loosened up on a range. The effort to please is hat makes friends for a company, and in the handling f complaints, even of a trival nature, an opportunity given to exemplify the class of service which the ompany should claim as its standard.

CHAPTER XII

CONSUMERS METERS

The consumer's meter is the connecting link between the gas company and its customers, and upon its accuracy of measurement depends to a large extent the friendly feeling that is necessary on the part of the customer in order that the company may be prosperous.

Consumers' Meters

It will always remain a difficult problem to convince the customer of the accuracy of a gas meter, which measures something that cannot be seen. In view of this ever-present doubt it behooves every gas company to give unlimited attention to the condition of its meters and to the methods employed in handling, testing, repairing and setting.

tance from the top of the meter. This horizontal partition separates the top of the meter from the two spaces beneath it. Within this top space, or gallery, is usually another small enclosed space containing the sliding valves. The two spaces beneath the gallery contain leather diaphragms, one in the front and the other in the back of the meter, which are connected to the valve ports or channels. The valve mechanism is so arranged that one diaphragm is inflating or filling while the other is deflating or emptying, the motion of

Fig. 286. Installation of Large Size Meters

the diaphragms being imparted to a tangent and shaft, which in turn operates a chain of gears attached to the registering dial.

The working of a gas meter may well be described by comparing it to a simple steam engine, in which there is a considerable analogy if the comparison be made with the horizontal cylinders of a slide-valve engine, in which the motion of the pistons is precisely the same as that of the discs attached to the diaphragms of a dry gas meter.

In the steam engine the pressure of the stea applied alternately to either end of the piston, the opposite end is opened to the exhaust, the open of pressure and exhaust ports being controlled means of the automatic action of a slide valve. the meter the disc, taking the place of the engine pis moves backward and forward through the action of gas pressure applied alternately on the inside

Fig. 287. The Ordinary or Tin Meter

outside of the diaphragm and exhausting into the channel of the meter, the action of the diaphragm controlled, as in the engine, by a slide valve. Th termittent pressure on the exhaust of the steam en which is made noticeable by the "puffing" of steam ing from the exhaust pipe, is overcome in the gas by having two diaphragms, one of which is filling the other is emptying, thus maintaining a steady pressure and flow of gas at the exhaust or outlet side of the meter. This also prevents the meter stopping on a dead center. The motive power furnished by the gas pressure drives the mechanism of the meter and is transmitted to the chain of gear wheels operating the registering dial. Each expansion and contraction of

Fig. 288. Front and Top Removed From Tin Meter

the diaphragm allows a certain definite volume of gas to pass from the inlet to the outlet side of the meter, in accordance with the adjustment of a tangent regulating the extent to which the diaphragms are opened and closed, so that the function performed by the meter is to transmit the movements of the diaphragms as they empty and fill to a dial calibrated in units of volume. Adjustments are made by moving the tangent forward or backward on the tangent arm, thus increasing or decreasing the travel of the discs, and, by so doing, the volume of gas passed from the inlet to the outlet side of the meter for each cycle of operation. As each cycle of operation corresponds to a certain part or number of units of volume on the registering dial, regardless of the amount of gas passed by the

e term "light," used in designating meter sizes, is a lc of the early days, when capacity ratings were sed upon the standard English burner consuming

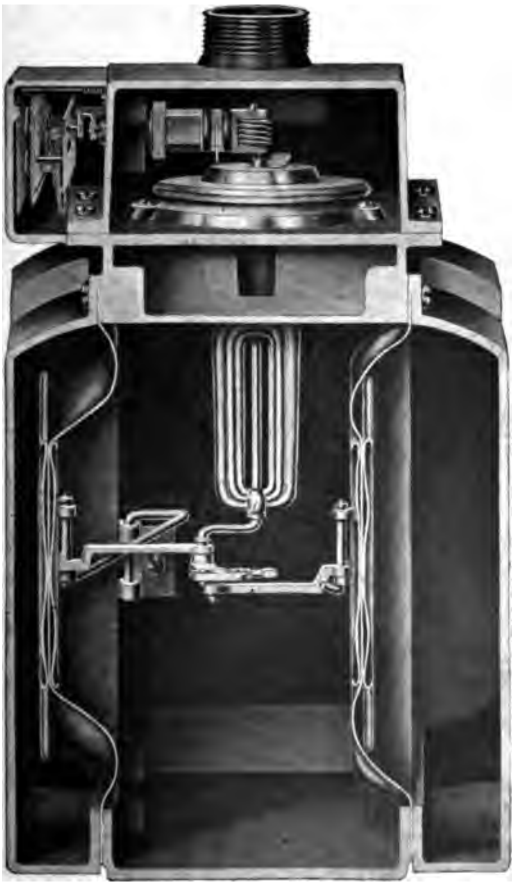


Fig. 290. Cross Section of the Sprague Cast Iron Meter

c cu. ft. of gas per hour. A certain sized meter then is supposed to supply a given number of these burners, so that the capacity of the meter in cubic feet was the number of burners or lights that it was sup-

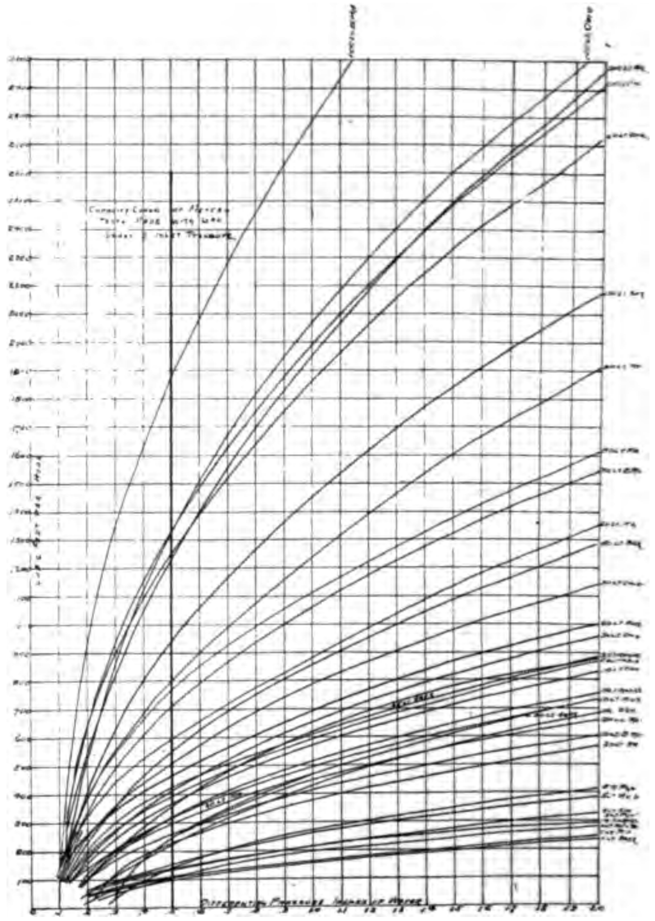


Fig. 291. Capacity Tests of Meters (see Table)

posed to supply multiplied by six. The unit of size or capacity was therefore called "light," which was equal to six cu. ft. of gas per hour. We have but to multiply the common "light" sizes of our present meters by six to prove the inaccuracy of this unit for rating the capacities of present-day meters. The ordinary "3-Lt." meter, by this rating, should pass only 30 cu. ft. of gas per hour, while it actually will pass about 100 cu. ft. under a 2-inch initial pressure and ½-inch loss.

Table of Meter Capacities

(At 2-inch initial pressure, ½-inch differential)

No. Light	Maker	Capacity in cu. ft. per Hour	Capacity in cu. ft. per "Light"
3	Maryland	90	30.
5	American	100	20.
3 "B"	Maryland	114	38.
5	Maryland	114	22.8
10	American	120	12.
5	Standard	135	27.
5	Pittsburg	135	27.
10	Maryland	138	13.8
No. 1 "A"	Sprague	140	...
5 "A"	Pittsburg	140	28.
5 "B"	Maryland	158	31.6
No. 2	Sprague	228	...
20	American	230	11.5
30	American	250	8.33
20	Maryland	270	13.3
10 "B"	Maryland	275	27.5
30	Maryland	294	9.8
No. 1	Ironclad	320	...
No. 3	Sprague	360	...
10	Ohio	370	37.
..	Equitable	400	...
20	Ohio	415	20.75
45	American	430	9.55
60	American	470	7.8
45	Maryland	480	10.7
30	Ohio	520	17.3
60	Maryland	528	8.8
80	American	560	7.
80	Maryland	606	7.58
30 "B"	Maryland	660	22.
100	Maryland	750	7.5
150	American	945	6.3
150	Maryland	1225	8.16
60	Ohio	1260	21.
100	Ohio	1330	13.3
60	Maryland	1350	22.5
200	Maryland	1450	7.25
100 "B"	Maryland	1850	18.5
250	Maryland	2275	9.1
300	Maryland	2500	8.33

A study of the accompanying tables and chart of meter capacities shows that there is no definite ratio between "light" and capacity, proving that the use of the term "light" as a unit of capacity is both erroneous and confusing.

In the foregoing table the largest part of the capacities used were obtained by actual test in the proving room of the Denver Gas & Electric Light Co. The capacity curves at different differentials were plotted upon the accompanying chart, a study of which will show that the ratio of capacity and differential is not the same in all meters, nor is there any reason for the use of the term "light" as a unit of size.

By consulting the table and chart it is seen that the present 10-Lt. "B" meter has a working capacity practically equal to the 30-Lt. old style meter; the 30-Lt. "B" has a capacity slightly more than the 80-Lt. old style; the 60-Lt. "B" has a capacity greater than the 150-Lt. old style, while the 100-Lt. "B" exceeds the 200-Lt. old style meter. Every make of meter has a different capacity per given size, which the meter man must familiarize himself with, especially in those companies which do not stick to one make of meter or in a suitable place, while a parallel installation of smaller meters could be more readily located in a safe and accessible place.

The Sprague Meter Co. covers the range of sizes from the 3-Lt. to the 100-Lt. old style meters in three sizes, namely, No. 1-A, No. 3 and No. 5. Their No. 1-A replaces the 3-Lt., 5-Lt. and 10-Lt.; the No. 3 replaces the 20-Lt., 30-Lt. and 45-Lt., and the No. 5 replacing the 60-Lt., 80-Lt. and 100-Lt.

Fig. 292. Natural Gas Cast Iron Meter

The efforts of the men in the gas industry should be directed more forcibly toward a co-operation with meter manufacturers, leading to the standardization of a defined unit for meter sizes. It might be possible to adopt a standard similar to that used in water meters, by rating the size of the meter according to the diameter of the pipe required to carry the gas for a given length and pressure drop. If such a standard were adopted, with the length of pipe taken at 60 feet and the differential pressure at 3-10 inch, the following capacities per meter size would be obtained:

Proposed Rating for Meter Sizes

Size of Meter	Capacity per Hr. in cu. ft.
¾ inch	95
1 inch	200
1¼ inch	350
1½ inch	550
2 inch	1100
2½ inch	2000
3 inch	3000
4 inch	6200

This would give a suitable range of sizes and would facilitate the setting of the proper sized meter on piping jobs.

Relation Between Capacity and Demand

The capacity of a meter installed must always equal the maximum instantaneous demand of the appliances connected at a suitable differential to maintain the most efficient terminal or utilization pressure at the appliances. Adherence to this rule often requires the installation of a very large meter where the average hourly demand could be carried by a much smaller one. However, this is a matter over which the operating department of a gas company has no control, and they must depend upon the efficiency of the commercial department in keeping the appliances connected in use. This relation between capacity and demand affects piping installations in the same manner that it does meters.

In choosing meters to supply certain maximum demands, a differential pressure of ½ inch between the inlet and outlet should be decided upon. It is with this differential that a meter will operate most efficiently. Higher differentials will cause the meter to operate at a high rate of speed, which is not conducive to a long period of service for the meter operating under such conditions.

Some of the high capacity meters, such as the Maryland "B", are capable of working efficiently at as much as a 50 per cent overload for a reasonable length of time and thereby provide for the so-called peak load,

Fig. 293. Direct Reading Cost Meter

but in continuous service such an overload is not advisable. Overload meters have been brought into the shop with valve guides worn completely in two after a comparatively short period of service. The modern high capacity meters are as a matter of fact constructed to stand the strain of overloads much better than the old style meters, but this advantage is not great enough to allow them to be subjected to abuse in the way of overloading.

High Capacity Meters

The question has often been asked, "What is a high capacity meter and how does it differ from the old style meter?" Mr. Dickey of the Maryland Meter Co. answers this question in reference to his "B" meter as follows:

The "B" meter is the regular consumer's meter, remodeled for increased efficiency to meet the general demand as existing prior to the year 1904.

At the Ohio Gas Association meeting in 1903 a representative meter manufacturer had an interview with a prominent official of a Western gas company and as a direct result thereof it was decided to remodel certain sizes of meters with the least possible delay.

After carefully going over the details of the subject with other prominent engineers a definite policy was laid down for better efficiency in meters not only in respect to the question of capacity, but also in the matter of general construction features, to eliminate as far as possible wear on moving parts, lost motion, etc. To cover the situation properly it was decided that, while increase in capacity was the most sought for feature, yet due regard should be given to other very important considerations as follows:

1. Speed ratio of meter. (Number of tangent revolutions per foot.)
2. Actual speed of meter. (Total number of tangent revolutions to secure given capacity under given loss of pressure.)
3. Actual and uniform enlargement of valves and channels necessary to produce given capacity increase.
4. Actual strengthening (without unnecessary waste) required to prevent undue wear and lost motion in meter; also to determine at what points additional strength was needed.

5. Improvement, if possible, in mechanical design of meter.

6. Changes to be made, if possible, without increase in cost of meter.

All of these considerations are very close in their relation to the improved conditions desired, as they all tend to produce much sought for results as follows:

1. Less repairs.
2. Longer life or service.
3. More accurate registration.
4. No increase in selling price.

As a comparison the following table gives capacities on the "B" meter over those of the old style:

Capacities of Old and "B" Style Meters

(2-inch initial pressure, ½-inch loss)

	Capacity per Hour	No. Rev. Tangent per Cu. Ft.	No. Rev. per Hour at Rated Cap.
5-Lt. Avg. Old Style	95	6	570
5-Lt. "B"	156	6	936
10-Lt. Avg. Old Style	141	3 3-5	507
10-Lt. "B"	260	3 3-5	936
30-Lt. Avg. Old Style	287	1 3-5	459
30-Lt. "B"	600	1 3-5	960

It is seen by the above table that the speed ratio (number of tangent revolutions per foot) is maintained at the same rate as with the old style meters, while no abnormal increase in the running speed of the meter (tangent revolutions per hour at rated capacity) is required to produce its rated capacity.

In the design of high capacity meters their actual size is increased, but very little over the old style of the same "light," while their capacity is increased in some cases more than 100 per cent. The extra capacity is obtained chiefly through the enlargement of valves, channels and openings whereby the differential pressure through the meter is reduced for given volumes of gas.

Iron Case Meters

The use of consumers' meters in cast or malleable iron cases was suggested by the increasing cost of tin plate and solder, the greater strength and ability to withstand rough usage or fire, the greater ability of the iron to withstand the action of moisture and chemicals and the decreased amount of work required to take apart, repair and assemble. The advantages of this case cannot be refuted and it will no doubt be but a matter of time until the iron or pressed steel case will be universally adopted for consumers' meters. One thing must be overcome, however, and that is inside corrosion, which should be a comparatively simple matter.

The iron meter may be made of a shape more nearly conforming to the inside mechanism of the meter, thereby reducing its actual size. After patterns are made the castings cost but a small part of the cost of tin plate. Bolts, screws and nuts are cheaper than solder and can be used by a less skilled workman. Iron will withstand accidental jars or jolts better than tin. It will also reduce the hazard of burning gas in case of fire. An iron meter may be set in damp basement or out-of-doors in Southern latitudes or in places such as tanneries, slaughter-houses, stables, etc., where corroding chemicals would soon destroy a tin meter. Any ordinary mechanic may take this kind of a meter apart and put it together again with a screwdriver, while it takes a skilled mechanic to do the same with a tin meter. While it takes a man who understands the inside mechanism of a meter to do the repairing, it can be done in a shorter time at less cost, as the use of a soldering iron is not necessary, and therefore the principal requirement of a first-class meter repairer (the use of the soldering iron) is eliminated.

No special advantages of the inside mechanism of iron meters may be claimed, as any such improvements might as readily be adapted to tin meters. The inside mechanism of the present iron meter does not differ materially in principle from other meters and any difference that does exist may be classed as a detail rather than otherwise.

The Sprague cast iron meter was one of the first and is at present the most extensively used of the iron meters. It was first put upon the market in 1900 and today is known practically everywhere that gas is used. The Sprague meter is a high capacity meter and is made in but three sizes. The accompanying illustration shows a comparison between these sizes and the corresponding sizes of tin meters. The company making this meter has shown its progressiveness by dropping the "light" from its meter sizes, designating them simply by number.

Prepayment Meters

The use of prepayment meters has been more or less of a fad that is going out of date. Ten or fifteen years ago this type of meter was looked upon as a means of solution for the problem of supplying gas to consumers whose credit was of a questionable nature. It was thought that by this means of paying in advance a certain amount of gas would be sold and paid for that otherwise would not be sold, would be sold and lost through non-payment, or would be sold and the profit used up in collection expense. Their use was especially recommended for transients, those owing bills and others of questionable reputation.

In actual use the prepayment meter is found to possess disadvantages offsetting their theoretical value as perfect collectors. A prepayment meter cannot be set in places where an ordinary meter could. The location must be one where robbery and tampering is reduced to the minimum and it must also be accessible to the customer for inserting the coins and to the company for their removal. In order to secure such a location a considerable expense is often encountered which must be borne by the company. These meters cannot be set in closets, basements or rooms where any but the customer himself has access, which prohibits their use in flats and public buildings having more than one occupant unless the piping can be so arranged that the meter is set in the premises occupied by the customer. In a great many cities ordinances prohibit their use in hotels or rooming houses due to danger of the meter shutting off while lights are burning in rooms occupied by sleeping persons. In the latest prepayment meters, however, this danger is reduced to the minimum by the meter not immediately shutting off tight, giving warning by the small amount of gas passed that another coin must be inserted. The gas burning from a prepayment meter invariably goes out when it shouldn't, in the midst of a meal, when baking is being done, late at night or when a business house is the busiest. At such time a coin of the proper denomination is often not available. Often counterfeit coins or slugs are used which the company cannot get replaced. The cost of collecting from prepayment meters is considerable. This work cannot be done by the ordinary meter reader. Perhaps as much money is lost through robbery of cash boxes as would be lost in unpaid bills with ordinary meters. There is no way to avoid this as a deposit put up by the customer to secure the cash in the box each month would also secure the payment of his bill with a regular meter and would destroy the theoretical purpose of the prepayment. If the prepayment is removed after being robbed it amounts to the same thing as removing a regular meter for an unpaid bill.

From the experience of a great many companies who are abandoning the use of prepayment meters it would seem that this type of meter is not of a desirable nature and that the ultimate abandonment of its use is inevitable. Prospective customers who cannot secure their bills by depositor guarantee are not of the class of customers desired by any company and are not safe persons to be the custodians of the company's money contained in the cash box of a prepayment meter.

The prepayment meter is a consumer's meter of the ordinary type, having an arrangement attached which prevents the passage of gas through the meter until by the insertion of a coin, which allows the movement of certain mechanism, a definite amount of gas is allowed to pass. The prepayment mechanism is attached to the shaft of the meter operating the registering gear in such a manner that when a certain number of revolutions of the shaft are made, corresponding to the amount of gas prepayed, the meter shuts off. Any amount of gas may be prepayed by the insertion of as many coins of the proper denomination as is desired. Prepayment devices may be attached to any ordinary

Fig. 294. Prepay Tin Case Meter

meter and contain in addition to the operating mechanism a cash box or receptacle for holding the coins. A suitable arrangement of gearing must be made to obtain the proper ratio of the revolutions of the index shaft per cubic foot of gas passed and the prepayment device.

CHAPTER XIII

METER REPAIRS AND TESTS

The matter of locating the meter repair shop has been briefly discussed in a previous chapter in conjunction with the fitting shop. There are, however, several essential features that should receive especial consideration in order that the shop may be most efficiently operated and not become an offense to neighboring tenants or the public.

The work of repairing old gas meters cannot be carried on without the production of offensive odors so that the mitigation instead of the elimination of these odors should be the aim of the gas company. If for no other

The best ventilation is obtained where the meter shop is situated on the top floor of the building it occupies, where the air currents are not obstructed by other buildings in close proximity. A sufficient number of roof ventilators, in addition to plenty of windows, should be provided to thoroughly ventilate all parts of the shop. The situation of the shop on the top floor of the building reduces to the minimum its offensiveness to other occupants and those of surrounding buildings. A location, however, is not desirable in a building surrounded by taller ones.

Fig. 296. A Convenient Portable Test Meter

Another important requirement in the gas meter shop is light. The men should receive all of the natural daylight that is obtainable during working hours in order that good work may be done. Practically the same conditions effect lighting as in ventilating the shop, which makes the top floor of the building most desirable. By the use of combination skylight ventilators an even distribution of light is obtainable.

The location of the meter repair shop in close proximity to the fitting shop is desirable and within the same building preferable. These two departments of a gas company are so closely related that efficient and economical operation cannot be carried on if the two shops are widely separated. Facilities should be provided for

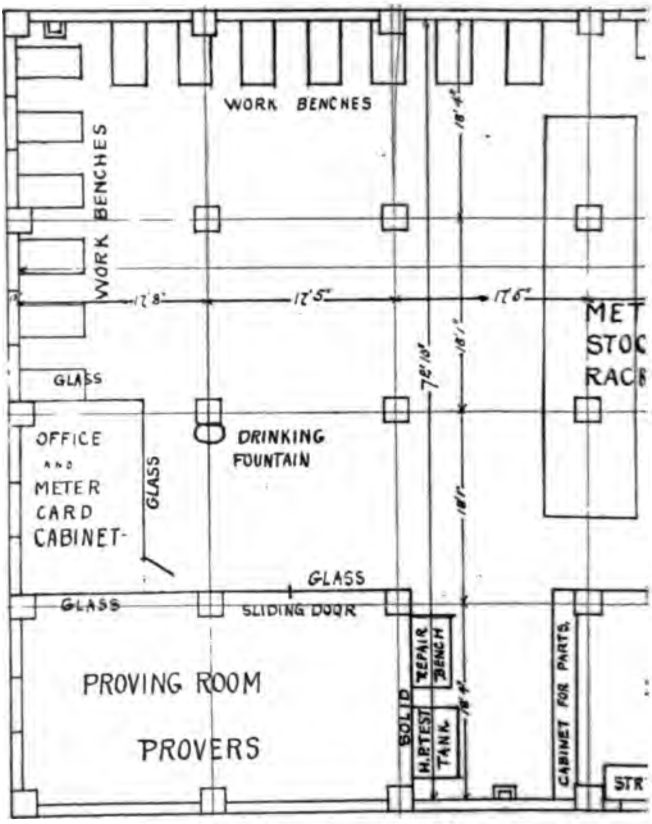
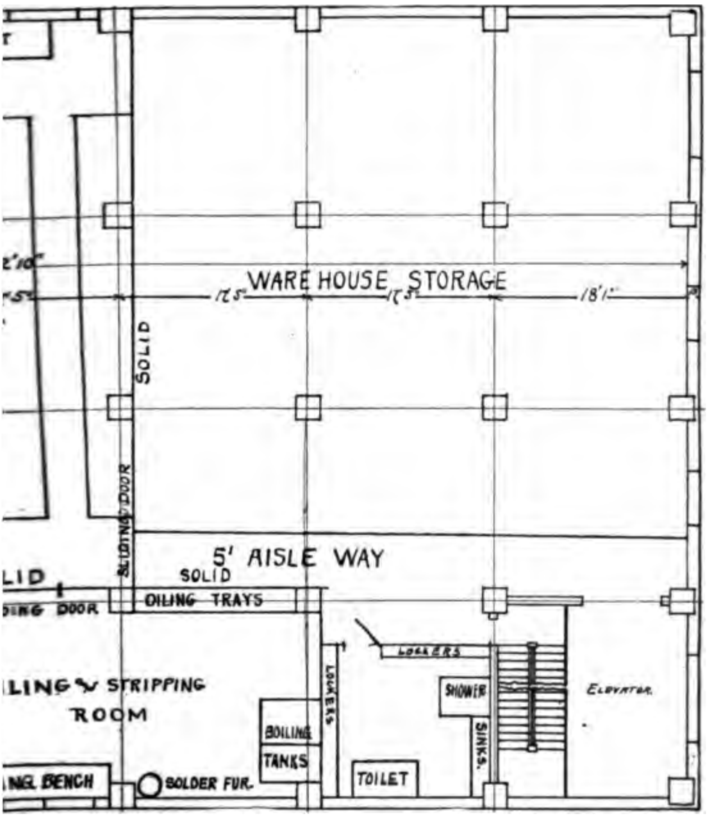


Fig. 297. Plan of a Meter Repair Shop

transporting meters to and from the repair shop and fitting shop with the least amount of delay and handling. An elevator, by which the meters may be transported in truck loads, is a very desirable part of the equipment of any shop.

A well regulated gas meter shop should be divided into at least three separate rooms: a proving and test-



Showing Effective Arrangement

ing room, a stripping and boiling room, and the work shop proper. The proving and testing room should be kept at an even temperature at all times or accurate results cannot be obtained. This is practically impossible where all classes of work are done in one general room. This room should be kept in a clean and orderly condition and may be used as an office by the foreman, in which case the partitions separating it from the rest of the shop should consist of glass, giving him an unobstructed view of the shop. The stripping and boiling room should be used for all classes of offensive work, such as stripping, boiling, making solder, tinning, oiling diaphragms, etc. The removal of this class of work from the workshop proper mitigates to a great extent the odorous atmosphere that the men would otherwise be compelled to work in and also greatly aids in keeping a neat orderly shop by confining the dirtiest work to one location. The partitions separating this room from others should be solid except for the necessary doors. No windows should exist except those opening to the outside of building. The room should be especially well ventilated by means of roof ventilators and canopies provided over boiling vats and solder furnaces. The drains from vats and stripping benches should not be connected to sewers, but should lead to a collecting receptacle from which the drainage may be removed and transported to a dumping place. A desirable way to handle this drainage is to provide a suitable tank, properly vented to the outside of the building, from which the collection of liquid may be removed by drip wagons and handled in the same manner as condensation from main drips. Screens should be provided on all drainage inlets to the tank to prevent the passage of solid matter. If handled in this manner the condensate in the form of hydrocarbons drained from meters may be separated from the water by gravity and become a source of revenue for the company instead of waste.

The workshop proper should contain the necessary benches for the use of repair men, facilities for case leak testing, painting, and the storage of O. K. meters and those to be repaired. The general layout of the shop should be so arranged that the meters travel with he minimum amount of handling and transporting from he repair stock through the various operations to the). K. stock. We have seen shops where the meters traveled across the width or length of the room a half dozen

Fig. 298. Meter Provers and Meter Under Test

imes before finally landing in the O. K. stock ready to o out. This may easily be avoided with the proper rrangement of operations so that the meters travel hrough the least possible space.

An arrangement of individual benches where the men face each other's back instead of being side to side can be recommended. These benches may be arranged along the sides or ends of the room or through the center as is most convenient or preferable. Instead of these benches being set end to end parallel with the wall they are placed at a right angle thereto and separated from each other by 3 ft. of space.

All meters in shop, whether O. K. or to be repaired, should be kept in racks rather than piled on each other as is the general custom. The racks are comparatively inexpensive, being made of iron pipe framework and planking, and add much to the appearance of the shop as well as allowing more meters to be stored in the same amount of floor space. They are also easier to take stock of at inventory time and the possibility of injury by falling or other cause is practically eliminated.

Shop Equipment

The equipment of a well organized meter shop should consist of provers, testing banks, work benches, oiling racks, boiling vats, a high pressure testing tank, solder melting furnace, tinning furnace, a paint bench and all necessary tools and paraphernalia used in the repairing of meters and regulators.

In any company large enough to support an organized meter shop at least two provers should be installed and they should preferably be of the 10 cu. ft. size. They should be installed at opposite ends of a proving table so that the operator can prove two meters at a time alternatively. They should be provided with foot operated clamps for attaching to the meter and vent. The vent from the meters should be run out of doors and should be provided with a calibrated cock or valve for obtaining the different speeds of operation. A small air blower or compressor similar to the Westinghouse automatic airbrake compressor will prove its worth as a time saver in lifting the prover bells. Where the automatic air compressor is used no compensating tanks are necessary, the air line being connected direct to the provers and controlled by a governor set at the desired pressure. The compressed air can also be used for testing for case leaks, a suitable pressure to use being about one pound. Hot and cold water connections should be attached to the proving tanks for regulating the temperature. A room thermometer and tank thermometers should be essential parts of the proving room equipment and carefully observed. The proving room should be heated by some manner of controllable heat-

Fig. 299. A Typical Meter Testing Outfit

ing devises other than stoves. Hot water, steam or gas heating is desirable. Means of efficiently controlling the room temperature is vitally important.

A testing bank for testing meters for capacity should be a part of every prover room equipment. In order to obtain an accurate capacity test on a meter the apparatus used should be such that the meter will be tested under as near actual working conditions as is possible. Throttling the outlet of the meter to desired initial pressure does not give accurate results. A testing bank should consist of a number of burners sufficient to take care of the full capacity of the meter to be tested, or it may be in excess thereof, attached to a manifold of piping, with necessary piping of ample capacity arranged to connect with the meter outlet. A sensitive pressure gage should be arranged directly at the inlet and outlet side of the meter. Connection should be made from the inlet gage to a gas filled prover or a governed gas line.

A good work bench can be made of 1¼-in. pipe framework with No. 8 iron top turned up 18 in. for a back. Individual benches are recommended, which should be 6 ft. long, 3 ft. wide and 3 ft. high. A drawer for the repairmen's tools should be attached to the bench. The dip pot may consist of a pottery jar containing a flange or ring at the top and is very convenient if inserted in a hole cut in the top of the bench so that the pot rests upon its flange and is out of the way beneath the top of the bench. A small anvil-vise and a hatchet face should be attached to every bench, which should also contain a soldering furnace, flux pot and brush, two soldering coppers, opening knife, various kinds of plyers, chisels, a tinner's hammer, scratch awls, a coarse and fine file and a wooden mallet.

The racks for oiling diaphragms should consist of a trough-shaped galvanized iron box covered by a coarse screen upon which the meters may be laid. One end of the trough should be lower than the other so that the oil draining from the meters may flow to a collecting receptacle at the lower end.

The boiling vats should consist of at least two heavy iron tanks at least 3/16 in. in thickness. Thinner tanks, particularly the one used for lye water, will soon be destroyed by the action of the caustic potash. A boiling unit should consist of one lye water boiling tank and one rinsing tank. The tanks should not be too large as nothing is gained thereby, about 4 ft. square and 3 ft. high are the proper dimensions. Both tanks should be equipped with steam heating coils, if steam is obtainable, and gas burners. They should be provided with drains. Pieces of ½-in. pipe about 2 ft. long, to which meter caps and swivels fastened solidly together are attached, are useful in handling meters in the tanks. Wire brushes, swabs and rubber gloves comprise the balance of the boiling paraphernalia.

The equipment for testing for case leaks under high

Fig. 300. A Typical Meter Prover

pressure should consist of a suitable tank containing water into which the meters containing gas or air at about one pound pressure are immersed. One side of the meter being capped and the other attached to the pressure by the use of a hose connection is immersed in the water which affords the most delicate and quick means of testing imaginable. The slightest leak will

can be made in shops using a
solder by this means and sold
may be made. The solder melt
melting up scrap white meta
which it may be molded into
dealers at an advanced price
material.

A saving can be made in t
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driven rotating wire brush for
paint or, if high pressure air is
to be used for the same purpose
be applied through a spray by
This equipment would be classe
vises for use of the larger shop
warranted in the smaller shops
brushes and paint brushes are al
necessary.

Management

The secret of the successful o
repair shop lies in the foreman w
of the shop and its operations.
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good meter foreman can turn out
the minimum number of expert
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nd of such vital importance to a company that it must e inspected by some one bearing the responsibility of ll work done.

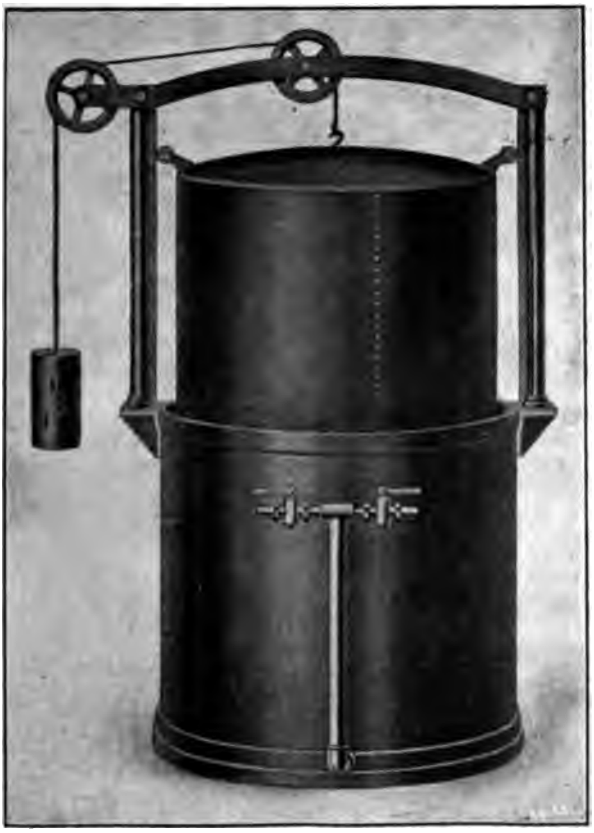


Fig. 301. Small Testing Holder for Gas

In most shops it is customary for the foreman in harge to do all proving and testing, but this should nly be done where that work allows the foreman ample

Fig. 302. Employes' Instruction Equipment in House Piping, Meters and Connections

time to supervise and inspect all other operations. A foreman who is too busy to properly supervise and inspect ceases to serve the purpose for which he should be employed. The amount of money lost to a company through improper work where the foreman has not the opportunity to prevent it by seeing all work done will usually pay the wages of an additional man to do the proving and testing.

The best meter repair foremen are those promoted from the bench and selected for their qualities of efficiency instead of period of service.

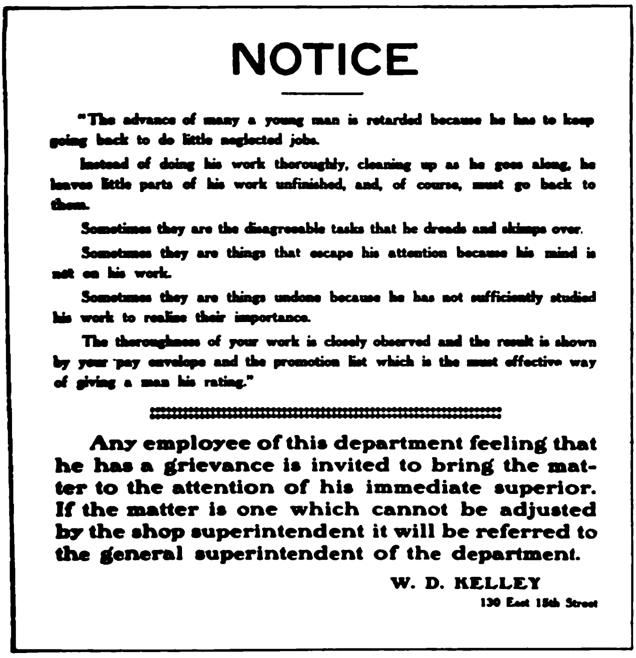
Employes—Meter repairmen cannot be promoted from other departments as the work done by them is of such a character that a skilled workman is a necessity. There are two ways of obtaining this class of labor: from other companies and by an apprenticeship system. The latter system recommends itself as being the best for several reasons: (1) Experienced meter repairers are seldom obtainable when needed; (2) those obtainable are usually of the nomadic class and undesirable; (3) the apprentice may be trained to suit the particular shop conditions in which he is employed; (4) the apprentice may be carefully selected for steadiness and other desirable qualities; (5) the organization of the meter shop may be made to conform with the fluctuations in amount of work done by using apprentices on repair work temporarily during periods of intermittent rush; (6) it is not necessary to use experienced repair men on any but most important work, where an expert foreman is in charge; (7) the largest part of the work of meter repairing can be done by apprentices of varying stages of competency; (8) a carefully selected apprentice looking forward to promotion will put forth his best efforts unprotestingly, therefore becoming a most efficient workman.

Young men of an age where they have lost the frivolties of youth and still are not old enough to become set in their ways should be chosen as apprentices. They should be men who take an interest in the work and are apt scholars. The latter can only be ascertained by trial. Sobriety, steadiness, a certain amount of education and embryo mechanical ability are necessary qualifications. The apprentice should be started on the paint bench or boiling vats and gradually trained to the more important work. He may do tinning and solder-making, after which, by learning the use of the soldering iron, he may untop, strip and top up. All the work that he does should be carefully inspected by the foreman and as he goes along he should be thoroughly instructed and trained in such a manner that he will be made to understand all about a gas meter and why certain operations are necessary. All of his work should lead up to the point where he is able to put in diaphragms at which time he may be considered as a repairman lacking simply the skill of experience.

Amount of Work Done by Meter Repairmen—The meters should come into the hands of the repair men stripped and tinned ready for reassembling. Each separate part should bear a corresponding mark or number to that of the case. The meters should be divided into classes of those requiring new diaphragms, those where the diaphragms have been oiled and those requiring the grinding of valves or special repairs. In the two former classes a general overhauling should be given the meter. The arrangement of work should be such that the repairmen are given a certain amount of work to do in a given time preferably of one class. The best results are not obtained where the men alternate continuously from one class of work to another.

A good repairman should be able to complete five new diaphragm meters or twelve meters where the diaphragms have been oiled in an eight-hour day. This would include grinding valves, assembling, etc., leaving the meter ready for the prover. Where topping and untopping are done by repairmen 100 tops put on or taken off should be considered a day's work. Where this work is done by apprentices quality of work should be considered at the sacrifice of quantity. One hundred meters tested or 40 proved may be considered as a good day's work where double provers and rapid connections are used.

Compensation—The compensation of repairmen should always be upon a straight wage or salary basis. Piecework is as detrimental to efficiency of service here



NOTICE

"The advance of many a young man is retarded because he has to keep going back to do little neglected jobs.

Instead of doing his work thoroughly, cleaning up as he goes along, he leaves little parts of his work unfinished, and, of course, must go back to them.

Sometimes they are the disagreeable tasks that he dreads and skimps over.

Sometimes they are things that escape his attention because his mind is not on his work.

Sometimes they are things undone because he has not sufficiently studied his work to realize their importance.

The thoroughness of your work is closely observed and the result is shown by your pay envelope and the promotion list which is the most effective way of giving a man his rating."

Any employee of this department feeling that he has a grievance is invited to bring the matter to the attention of his immediate superior. If the matter is one which cannot be adjusted by the shop superintendent it will be referred to the general superintendent of the department.

W. D. KELLEY
130 East 15th Street

Fig. 303. From the Bulletin of a Fitter's Stock Room

as in the fitting shop. Under a competent foreman a certain amount of work per day or, in other words, a time system per piece, will be demanded and the men will be paid according as they approach the standard set. The man who can only complete four diaphragm meters is not worth as much as the man who does five in a day, considering that the class of work done by each is equal as it should be.

The apprentices doing the minor work in a shop should receive compensation based upon the period of service and competency. As they advance to a higher grade of work their wage should be increased. Their advancement should not be rushed so rapidly that they only hit the "high spots," but their training should be thorough and they should be made to profit from experience and be made to feel that the goal ahead is worthy of achievement.

Promotion and Benefits—The men of the meter repair shop should be eligible to promotion to higher positions with the company and be entitled to all privileges and benefits in the same manner as employes of other departments. Their working surroundings should be made as comfortable as possible, which would take into consideration ventilation, sanitation and light. Washing and bathing facilities, cold drinking water, individual lockers and a place wherein they may congregate and eat their noonday lunch apart from the workshop, are recommendable features.

Method of Handling Work

Meters brought into the shop may be classified: Returns, Routine Change, Request Test and Complaint Change. Return meters would include the ordinary removal of meters for any cause not necessitating a change. Routine changes are those meters changed periodically for test. Request test changes are those changed for test upon request of the customer succeeding a high bill complaint. Complaint changes may include all meters changed for causes other than the foregoing, such as leaks, don't register, stuck fires, increased or decreased consumption, injuries, etc.

Returns—All meters returned for any cause should first go to the proving room for twenty-four hours to attain the room temperature before test. The result of the test should be recorded on the shop card attached

Fig. 304. First Aid Cabinet for Employes

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In meters where the conditions
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may become obliterated should be avoided. Some companies paint the inside of the dial lid a different color for the different years, which would require as many colors as there are years in the period of service plus one. This method is illustrated as follows:

Allowable period of service five years.

1912	1913	1914	1915	1916	1917	1918	etc.
Red	White	Blue	Green	Yellow	Gray	Red	etc.

While the "Red" meters set in 1912 would be returned for test in 1917, the color red could not be again used in 1917, owing to the fact that other meters would be set that year before all of the routine "Reds" were returned, which might cause confusion. The colors could be rotated the following year—1918.

Perhaps a better method than the color scheme is the soldering of brass tags containing the last two numerals of the year on the front of the meter. Another way is to float a disc of solder in some conspicuous place and stamp the numerals of the year thereon.

Meters testing within the allowable percentage of error and not requiring general inspection or to be held for cause, should receive a high pressure test of not less than 10 in. water column to determine if case leaks exist, after which they should be repainted and put in stock for resetting.

Meters testing without the allowable percentage of error and, as shown by identification mark, not in need of general repairs should have the top removed and the cause ascertained. Tests for tightness of diaphragms and valves should be made, and packing of flag and tangent shafts examined in cases where the meter runs slow. Fast meters are usually caused by shrunken diaphragms, which necessitate the removal of back and front casings for repairs.

Meters which don't register or are stuck require a thorough investigation to determine the cause, the cause determining the disposition to be made. If evidence shows that a meter has been tampered with to prevent its registering or to cause it to register slow, a full report should be made to the proper official and the meter held as evidence.

All meters removed for causes requiring the probable use of the meter as evidence should be held in the shop for at least sixty days following its removal and test, in the exact condition in which it was returned, unless released by order of the proper official.

Routine Changes or Changes for Age—All companies should have a certain fixed period of time of continuous service for its meters, after which they should be brought in for inspection and test. The length of this service period should be the maximum time, proven by average test, that the meters maintain accuracy of registration under actual conditions of continuous service.

No fixed period can be given that will apply to all companies or even to all of the meters of one company as the length of time that a meter may safely be left in operation depends upon: (1) The kind of gas used; (2) the location of the meter; (3) the size of the meter, and (4) the number of times the meter has been reset without general examination or repairs. The length of the period is often arbitrarily fixed by the public service commissions, which is usually five years. While it is very probable that this period is much too small it can only be proven in those companies where the period is not decided by an authority over which they have no control, by an actual record of all meters returned showing: Length of time in service, test of meter, cause of removal and condition of meter.

All meters returned for routine or age test should receive general inspection and repairs as outlined before under the heading of returns.

Request Changes—Meters changed at the request of the consumer may or may not be in need of adjustment or repairs, but should be handled in a manner affording greatest expediency of the report of test and condition of meter reaching the office and consequently the customer.

The cause of request changes are usually complaints of high registering, which if found to be substantiated by the test should be adjusted to the satisfaction of the customer. If the meter is found to be O. K. or slow, the customer should be convinced of the fact. Some manner of identifying request change meters should be employed in order that these meters will receive preference over all others in the testing room. A good method where the original order does not accompany the meter to the repair shop is to have the shop card, which is attached to the meter by the fitter, of a different color from those on meters returned for other causes or to stamp the cards on such meters in a conspicuous manner so that they can be readily sorted from the rest. The tests and report on these meters should be sent to the office by special delivery to avoid any possibility of delay or annoyance to the customer. It is good policy to hold request change meters in the shop, in the exact condition received, for a reasonable length of time or until released by the office. Meters tested by authority of or under the jurisdiction of public utility commissions need not be held.

Complaint Changes—Meters under this heading would include all those changed for reasons not previously referred to such, as leaks, high or low consumption, too large or too small, fires, damaged meters, stuck or don't register, condensation, broken dials or dial glasses, oil leaks, noisy meters, etc.

It is probable that a great many of the complaints preceding the changing of such meters will be turned in by the customer, which does not necessitate their being included as request changes, inasmuch as the customer is usually not interested in the condition of the meter beyond the standpoint of annoyance through interrupted service or possible danger from escaping gas. In some cases leaking meters may be classified as request changes where the customer is of the belief that a leak exists on the outlet side of the meter.

Leaking Meters—Meters changed for leaks should be plainly marked with chalk by the fitter at or around the point at which the leakage is known to occur. In addition to this locating of the leak, as an additional precaution, the original order, and shop card attached to meter should be marked: "Inlet screw leaking," "outlet screw leaking," "leak in right back bottom corner," "leak at dial," etc.

After such meters are tested for accuracy, if the leak is in such a position that it would register on the dial the outlet should be capped and with a pressure on the meter as nearly as possible equaling that at which the meter had been operating under while in service, a test for amount of leakage should be made. The result of this test should be included in report sent to office.

A great number of meters will be changed for leakage where the leak is too small to be located by the fitter or in some cases where no leak exists. All such meters should be subjected to the high pressure test in the meter repair shop which will prove conclusively the existence or non-existence of a leak. The use of the test bottle, previously described, by the fitter on the job will prevent the needless changing of meters for leaks where none exist.

Oil or "juice" leaks are often the bane of the meter repair shop. New meters or repaired meters that have withstood every test in the shop for leakage quite often develop oil leaks after being in service a short while. The odor of this oil, condensation or "juice," as it is commonly called, is as offensive as a gas leak, but lacks the hazard attached to the latter. It invariably causes the complaint of a leak from the customer and must be brought in. The development of oil leaks need cause no reflections to be cast upon the efficiency of the repair shop as we have known shops to specialize upon the prevention of this annoyance with indifferent success. While "juice" leaks quite frequently develop in new meters, particularly at the bottom corners, they are more often found in old meters where the tin has disappeared from the iron leaving an infinitesimal pit that may be covered by paint sufficiently well to withstand the shop tests, but which develops a leak in service after the oil or condensation has broken down the resisting qualities of the paint. A method of reducing such leaks to the minimum is to install an arrangement in the shop whereby a large number of meters may be connected up at one time and subjected to gas pressure for a period approximating a couple of weeks. This would necessitate connecting up at one time as many meters as would be used in the period corresponding to that of the duration of test so that an equal number could be replaced each day as the meters were taken off to be sent out, following a system of rotation. Care in handling, particularly the striking of corners on hard substances, and rigid internal and external inspection of the casings of old meters will aid greatly in reducing "juice" leaks.

All meters removed for leaks, provided they test O. K. and do not come under routine or age inspection and repairs, may be repaired, painted and put in O. K. stock.

Miscellaneous Complaint Changes—The disposition of all meters changed for cause must be determined by the nature of the cause and repairs made accordingly. We have included in this classification meters containing condensation which may seem impractical but is far from such. The practice of allowing the fitter to attempt to remove condensation from a meter by turning it upside down and manipulating it in such a manner that a portion—and a portion only—of the condensation is allowed to escape through the tubes, does more harm to the meter than the expense of changing or properly removing the condensation costs. The condensation running through the channels and over the valves and seats, causing them to become coated with the thick hydrocarbon, evidently effects the accuracy of registration of the meter, while the valves may be unseated or other mechanism displaced by the unnatural position in which the meter is placed.

Condensation may be readily removed in the shop by punching holes near the bottom of the meter on each side of the division wall—which may be easily closed again with a drop of solder and no damage to the meter occasioned.

TESTING AND PROVING METERS

The following instructions for testing and proving meters are reprinted by courtesy of Mr. Dickey of the Maryland Meter Company from his booklet, "The Correct Measurement of Gas:"

Instruction for Testing Meters—To arrive at accurate results in testing gas meters necessitates very close attention to a great many details. Merely to connect a meter to the prover, pass a small quantity of air or gas through it without regard to the following rules, is simply an approximation, not a test.

To test a meter accurately the prover must be mathematically correct, must be perfectly level, duly counterpoised and adjusted so as to give uniform pressure from top to bottom during the movement of the bell in the tank. The water in the prover, the air or gas in the bell, and also the meter to be tested, must all be uniform in temperature with the air of the room in which the tests are to be made, and all of these temperatures must be kept uniform during the entire test. To assist in securing these conditions the prover should be connected with hot and cold water, or, in the absence of this convenience, a live-steam line should be connected to the prover for the purpose of maintaining absolute temperatures for the water in the prover tank.

The meter or meters to be tested should be brought to the proving-room at least five hours (if possible ten hours or longer) before making tests, thereby giving the meters themselves an opportunity to become adjusted to room temperatures, and after insuring that all conditions described above are properly taken care of, testing can then be commenced.

[redacted]

After filling the holder with air or gas, connect the meter, making sure that all connections are tight, and then run through meter small quantity of air or gas (not less than one cubic foot), and on this run stop the meter so that the pinion finger will rest exactly on one of the divisions of the 2-ft. index circle, generally termed the "proving head" of the meter. Refill tank, if necessary, and by means of adjustment valve set the pointer on tank to 0 (or to any other convenient point on scale); then open prover cock and start testing, making either 2-ft. or 4-ft. run should you be testing a 5 Lt. meter. If making a 4 ft. run, see that the prover is shut off when the index finger or proving finger has made two complete revolutions and reaches exactly the original starting point on the index dial. If the quantity registered by the meter exactly corresponds with that taken from the prover, the meter is correct, but if more or less the percentage of error is easily determined.

Meters are usually tested with initial pressure of from 1½ to 2 in. at inlet pipe (be sure that inlet pipe has ample capacity to take care of size of meter being tested), and tests are usually made under two different speeds—one with full open outlet of meter, the other with a check opening, restricting the different meters to the following capacities on this check opening:

2 Lt.	12 ft. per hour.
3 Lt.	18 ft. per hour.
5 Lt.	30 ft. per hour.
10 Lt.	60 ft. per hour.

(Larger sizes in proportion.)

It will be noted from the above that each meter should be tested under two different rates of speed, the purpose being to secure uniformity of proof for whatever speed the meter may meet while in service.

In proving meters there are two necessary adjustments required. It is necessary at times to melt the solder holding the tangent to the top of the crank, altering slightly the position of the tangent for the purpose of securing uniformity of action between the diaphragm stroke and the valve movement. This adjustment is made whenever the proof tests under the two different rates of speed do not agree, and is made only for the purpose of bringing these separate tests together. After having the speed tests corrected to agree one with the other it is usually necessary to change the position of the tangent bat by moving it either in or out, as may be required to make meter register either faster or slower.

Ordinarily in figuring the percentage of error on the meter the reading of the prover is taken, and the error is reached without calculation for absolute figures. This is not entirely correct for the following reason: Suppose we are testing a 5 Lt. meter with a 2 ft. proving head, running only 2 ft. of gas through the meter in making tests. If the scale shows that 2.05 cu. ft. have been used in this test, that is, the prover registering 2.05 cu. ft. the meter registering 2 cu. ft. the meter would ordinarily be called 2½ per cent slow. As a matter of fact, the correct figure would be .05 divided by 2.05=2.44 per cent slow. In this same test had the prover shown only 1.95 cu. ft. with the meter registering 2 cu. ft. the meter would ordinarily be called 2½ per cent fast, but correctly it would be .05 divided by 1.95, or 2.66 per cent fast.

General tables giving absolute figures for correction of percentage of error in the testing or meters are shown on the following pages:

We might only add, speaking generally, that the laws under which gas is sold vary slightly in different sections of the United States, but the average limit within which gas meters are said to register correctly is usually 2 per cent fast and 2 per cent slow, sometimes the law allowing only 1 per cent fast and in other cases allowing as much as 3 per cent slow.

After the test is made, take the set of columns headed by the number of feet the meter has passed during the test, then run down the column until you find the figure

Percentage of Error Table

PASSED ACCORDING TO METER—2 FEET

Feet Passed According to Prover	Per Cent. of Error	Feet Passed According to Prover	Per Cent. of Error
1.75	+14.3	2.03	— 1.5
1.76	+13.6	2.04	— 2.0
1.77	+13.0	2.05	— 2.4
1.78	+12.4	2.06	— 2.9
1.79	+11.7	2.07	— 3.4
1.80	+11.1	2.08	— 3.9
1.81	+10.5	2.09	— 4.3
1.82	+ 9.9	2.10	— 4.8
1.83	+ 9.3	2.11	— 5.2
1.84	+ 8.7	2.12	— 5.7
1.85	+ 8.1	2.13	— 6.1
1.86	+ 7.5	2.14	— 6.5
1.87	+ 7.0	2.15	— 7.0
1.88	+ 6.4	2.16	— 7.4
1.89	+ 5.8	2.17	— 7.8
1.90	+ 5.3	2.18	— 8.3
1.91	+ 4.7	2.19	— 8.7
1.92	+ 4.2	2.20	— 9.1
1.93	+ 3.6	2.21	— 9.5
1.94	+ 3.1	2.22	— 9.9
1.95	+ 2.6	2.23	—10.3
1.96	+ 2.0	2.24	—10.7
1.97	+ 1.5	2.25	—11.1
1.98	+ 1.0	2.26	—11.5
1.99	+ 0.5	2.27	—11.9
2.00	0.0	2.28	—12.3
2.01	— 0.5	2.29	—12.7
2.02	— 1.0	2.30	—13.0

PERCENTAGE OF ERROR TABLE

Passed According to Meter—4 Feet

Feet Passed According to Prover	Per Cent. of Error	Feet Passed According to Prover	Per Cent. of Error	Feet Passed According to Prover	Per Cent of Error
3.50	+14.3	3.84	+ 4.2	4.18	— 4.3
3.51	+14.0	3.85	+ 3.9	4.19	— 4.5
3.52	+13.6	3.86	+ 3.6	4.20	— 4.8
3.53	+13.3	3.87	+ 3.4	4.21	— 5.0
3.54	+13.0	3.88	+ 3.1	4.22	— 5.2
3.55	+12.7	3.89	+ 2.8	4.23	— 5.4
3.56	+12.4	3.90	+ 2.6	4.24	— 5.7
3.57	+12.0	3.91	+ 2.3	4.25	— 5.9
3.58	+11.7	3.92	+ 2.0	4.26	— 6.1
3.59	+11.4	3.93	+ 1.8	4.27	— 6.3
3.60	+11.1	3.94	+ 1.5	4.28	— 6.5
3.61	+10.8	3.95	+ 1.3	4.29	— 6.8
3.62	+10.5	3.96	+ 1.0	4.30	— 7.0
3.63	+10.2	3.97	+ 0.8	4.31	— 7.2
3.64	+ 9.9	3.98	+ 0.5	4.32	— 7.4
3.65	+ 9.6	3.99	+ 0.3	4.33	— 7.6
3.66	+ 9.3	4.00	0.0	4.34	— 7.8
3.67	+ 9.0	4.01	— 0.2	4.35	— 8.0
3.68	+ 8.7	4.02	— 0.5	4.36	— 8.3
3.69	+ 8.4	4.03	— 0.7	4.37	— 8.5
3.70	+ 8.1	4.04	— 1.0	4.38	— 8.7
3.71	+ 7.8	4.05	— 1.2	4.39	— 8.9
3.72	+ 7.5	4.06	— 1.5	4.40	— 9.1
3.73	+ 7.2	4.07	— 1.7	4.41	— 9.3
3.74	+ 7.0	4.08	— 2.0	4.42	— 9.5
3.75	+ 6.7	4.09	— 2.2	4.43	— 9.7
3.76	+ 6.4	4.10	— 2.4	4.44	— 9.9
3.77	+ 6.1	4.11	— 2.7	4.45	—10.1
3.78	+ 5.8	4.12	— 2.9	4.46	—10.3
3.79	+ 5.5	4.13	— 3.1	4.47	—10.5
3.80	+ 5.3	4.14	— 3.4	4.48	—10.7
3.81	+ 5.0	4.15	— 3.6	4.49	—10.9
3.82	+ 4.7	4.16	— 3.9		
3.83	+ 4.4	4.17	— 4.1		

PERCENTAGE OF ERROR TABLE

Passed According to Meter—5 Feet.

Feet Passed According to Prover	Per Cent. of Error	Feet Passed According to Prover	Per Cent. of Error	Feet Passed According to Prover	Per Cent. of Error
4.50	+11.1	4.88	+ 2.5	5.26	— 5.0
4.51	+10.9	4.89	+ 2.3	5.27	— 5.1
4.52	+10.6	4.90	+ 2.0	5.28	— 5.3
4.53	+10.4	4.91	+ 1.8	5.29	— 5.5
4.54	+10.1	4.92	+ 1.6	5.30	— 5.7
4.55	+ 9.9	4.93	+ 1.4	5.31	— 5.8
4.56	+ 9.7	4.94	+ 1.2	5.32	— 6.0
4.57	+ 9.4	4.95	+ 1.0	5.33	— 6.2
4.58	+ 9.2	4.96	+ 0.8	5.34	— 6.4
4.59	+ 8.9	4.97	+ 0.6	5.35	— 6.5
4.60	+ 8.7	4.98	+ 0.4	5.36	— 6.7
4.61	+ 8.5	4.99	+ 0.2	5.37	— 6.9
4.62	+ 8.2	5.00	0.0	5.38	— 7.0
4.63	+ 8.0	5.01	— 0.2	5.39	— 7.2
4.64	+ 7.8	5.02	— 0.4	5.40	— 7.4
4.65	+ 7.5	5.03	— 0.6	5.41	— 7.6
4.66	+ 7.3	5.04	— 0.8	5.42	— 7.8
4.67	+ 7.1	5.05	— 1.0	5.43	— 7.9
4.68	+ 6.8	5.06	— 1.2	5.44	— 8.1
4.69	+ 6.6	5.07	— 1.4	5.45	— 8.3
4.70	+ 6.4	5.08	— 1.6	5.46	— 8.4
4.71	+ 6.2	5.09	— 1.8	5.47	— 8.6
4.72	+ 5.9	5.10	— 2.0	5.48	— 8.8
4.73	+ 5.7	5.11	— 2.2	5.49	— 8.9
4.74	+ 5.5	5.12	— 2.3	5.50	— 9.1
4.75	+ 5.3	5.13	— 2.5	5.51	— 9.3
4.76	+ 5.0	5.14	— 2.7	5.52	— 9.4
4.77	+ 4.8	5.15	— 2.9	5.53	— 9.6
4.78	+ 4.6	5.16	— 3.1	5.54	— 9.8
4.79	+ 4.4	5.17	— 3.3	5.55	— 9.9
4.80	+ 4.2	5.18	— 3.5	5.56	—10.1
4.81	+ 4.0	5.19	— 3.7	5.57	—10.2
4.82	+ 3.7	5.20	— 3.9	5.58	—10.4
4.83	+ 3.5	5.21	— 4.0	5.59	—10.6
4.84	+ 3.3	5.22	— 4.2	5.60	—10.7
4.85	+ 3.1	5.23	— 4.4	5.61	—10.9
4.86	+ 2.9	5.24	— 4.6	5.62	—11.0
4.87	+ 2.7	5.25	— 4.8	5.63	—11.2

PERCENTAGE OF ERROR TABLE

PASSED ACCORDING TO METER—10 FEET

Feet Passed According to Prover	Per Cent. of Error	Feet Passed According to Prover	Per Cent. of Error	Feet Passed According to Prover	Per Cent of Error
9.00	+11.1	9.38	+ 6.6	9.76	+ 2.5
9.01	+11.0	9.39	+ 6.5	9.77	+ 2.4
9.02	+10.9	9.40	+ 6.4	9.78	+ 2.3
9.03	+10.7	9.41	+ 6.3	9.79	+ 2.2
9.04	+10.6	9.42	+ 6.2	9.80	+ 2.0
9.05	+10.5	9.43	+ 6.0	9.81	+ 1.9
9.06	+10.4	9.44	+ 5.9	9.82	+ 1.8
9.07	+10.3	9.45	+ 5.8	9.83	+ 1.7
9.08	+10.1	9.46	+ 5.7	9.84	+ 1.6
9.09	+10.0	9.47	+ 5.6	9.85	+ 1.5
9.10	+ 9.9	9.48	+ 5.5	9.86	+ 1.4
9.11	+ 9.8	9.49	+ 5.4	9.87	+ 1.3
9.12	+ 9.7	9.50	+ 5.3	9.88	+ 1.2
9.13	+ 9.5	9.51	+ 5.2	9.89	+ 1.1
9.14	+ 9.4	9.52	+ 5.0	9.90	+ 1.0
9.15	+ 9.3	9.53	+ 4.9	9.91	+ 0.9
9.16	+ 9.2	9.54	+ 4.8	9.92	+ 0.8
9.17	+ 9.1	9.55	+ 4.7	9.93	+ 0.7
9.18	+ 8.9	9.56	+ 4.6	9.94	+ 0.6
9.19	+ 8.8	9.57	+ 4.5	9.95	+ 0.5
9.20	+ 8.7	9.58	+ 4.4	9.96	+ 0.4
9.21	+ 8.6	9.59	+ 4.3	9.97	+ 0.3
9.22	+ 8.5	9.60	+ 4.2	9.98	+ 0.2
9.23	+ 8.3	9.61	+ 4.1	9.99	+ 0.1
9.24	+ 8.2	9.62	+ 4.0	10.00	0.0
9.25	+ 8.1	9.63	+ 3.8	10.01	— 0.1
9.26	+ 8.0	9.64	+ 3.7	10.02	— 0.2
9.27	+ 7.9	9.65	+ 3.6	10.03	— 0.3
9.28	+ 7.8	9.66	+ 3.5	10.04	— 0.4
9.29	+ 7.6	9.67	+ 3.4	10.05	— 0.5
9.30	+ 7.5	9.68	+ 3.3	10.06	— 0.6
9.31	+ 7.4	9.69	+ 3.2	10.07	— 0.7
9.32	+ 7.3	9.70	+ 3.1	10.08	— 0.8
9.33	+ 7.2	9.71	+ 3.0	10.09	— 0.9
9.34	+ 7.1	9.72	+ 2.9	10.10	— 1.0
9.35	+ 7.0	9.73	+ 2.8	10.11	— 1.1
9.36	+ 6.8	9.74	+ 2.7	10.12	— 1.2
9.37	+ 6.7	9.75	+ 2.6	10.13	— 1.3

PERCENTAGE OF ERROR TABLE

Passed According to Meter—10 Feet

Feet Passed According to Prover	Per Cent. of Error	Feet Passed According to Prover	Per Cent. of Error	Feet Passed According to Prover	Per Cent. of Error
10.14	— 1.4	10.52	— 4.9	10.90	— 8.3
10.15	— 1.5	10.53	— 5.0	10.91	— 8.3
10.16	— 1.6	10.54	— 5.1	10.92	— 8.4
10.17	— 1.7	10.55	— 5.2	10.93	— 8.5
10.18	— 1.8	10.56	— 5.3	10.94	— 8.6
10.19	— 1.9	10.57	— 5.4	10.95	— 8.7
10.20	2.0	10.58	5.5	10.96	— 8.8
10.2	2.1	10.59	5.6	10.97	8.8
10.22	2.2	10.60	— 5.7	10.98	— 8.9
10.23	— 2.3	10.61	— 5.8	10.99	— 9.0
10.24	— 2.3	10.62	— 5.8	11.00	— 9.1
10.25	— 2.4	10.63	— 5.9	11.01	— 9.2
10.26	2.5	10.64	6.0	11.02	— 9.3
10.27	— 2.6	10.65	— 6.	11.03	— 9.3
10.28	— 2.7	10.66	— 6.2	11.04	— 9.4
10.29	— 2.8	10.67	— 6.3	11.05	— 9.5
10.30	— 2.9	10.68	— 6.4	11.06	9.6
10.31	— 3.0	10.69	— 6.5	11.07	— 9.7
10.32	— 3.1	10.70	— 6.5	11.08	— 9.8
10.33	— 3.2	10.71	— 6.6	11.09	- 9.8
10.34	— 3.3	10.72	— 6.7	11.10	— 9.9
10.35	— 3.4	10.73	— 6.8	11.11	—10.0
10.36	— 3.5	10.74	— 6.9	11.12	—10.1
10.37	— 3.6	10.75	— 7.0	11.13	—10.2
10.38	— 3.7	10.76	— 7.1	11.14	—10.2
10.39	— 3.8	10.77	— 7.2	11.15	—10.3
10.40	— 3.9	10.78	— 7.2	1 16	—10.4
10.41	— 3.9	10.79	— 7.3	11.17	—10.5
10.42	— 4.0	10.80	— 7.4	11.18	—10.6
10.43	— 4.1	10.81	— 7.5	11.19	—10.6
10.44	— 4.2	10.82	— 7.6	11.20	—10.7
10.45	— 4.3	10.83	— 7.7	11.21	—10.8
10.46	— 4.4	10.84	— 7.8	11.22	—10.9
10.47	— 4.5	10.85	— 7.8	11.23	—11.0
10.48	— 4.6	10.86	— 7.9	11.24	—11.0
10.49	— 4.7	10.87	— 8.0	11.25	—11.1
10.50	— 4.8	10.88	— 8.1		
10.51	— 4.9	10.89	— 8.2		

corresponding to the amount passed according to the prover during the test. Immediately opposite this figure, under column headed "per cent of error," will be found the result of the test. If plus (X), the meter is fast; if minus (—), the meter is slow. Thus, if the meter registers 4 feet and the prover 4.09 feet, the meter is 2.2 per cent slow.

Instructions for Using Percentage of Error Tables

When readings are obtained that are not on this table, subtract one from the other, and divide the difference by the amount passed according to the prover. If the meter reads more than the prover, the meter is fast; if less than the prover, the meter is slow. For example: If the meter registers 20 feet and the prover 22 feet, the difference is two feet. This divided by 22 feet, the amount passed according to the prover, gives .0909, or 9.1 per cent slow. (Dickey-Maryland Meter Co.)

It is a question of significance to Gas Companies whether the percentage of error shall be considered or the percentage of correction. As the gas is sold by meter registration, and corrections are based upon these registrations, it would appear that the latter would be the correct method to use in adjusting bills for inaccurate meters. In the method outlined in the preceding, necessitating the use of the accompanying tables, the correction formula is:

$$\text{Correction} = \frac{\text{Meter reading—Prover reading,}}{\text{Prover reading}}$$

while in the more simple method, which is commendable for general use, the formula is:

$$\text{Correction} = \frac{\text{Meter reading—Prover reading,}}{\text{Meter reading.}}$$

The Bureau of Standards suggests that the latter method be adopted as it allows the percentage of correction to be read directly from the prover scale, and the difference between the two methods is usually so slight as to be neglible. A great many State Commissions have also adopted the percentage of correction method instead of the percentage of error.

As an example of the correctness of using this method imagine a meter which has registered 10,000 cu. ft. of gas and upon test is found to register 2 cu. ft. while the prover shows that but 1.86 cu. ft. have been passed. For each cubic foot of gas registered by the meter, therefore, but .93 cu. ft. of gas has actually been passed and for the total meter registration of 10,000 cu. ft., 9,300 cu. ft. was actually passed. The customer is entitled to a rebate for 700 cu. ft. which is 7 per cent of the gas registered by the meter, but is 7.5 per cent of the gas actually passed by the meter. If the customer were rebated for 7.5 per cent of 10,000 cu. ft. (meter registration) it would be an incorrect adjustment and unfavorable to the Gas Company, while if he were allowed 7.5 per cent of the actual amount of gas passed it would amount to the same thing as 7 per cent of the meter registration but would involve a much more complicated method of arriving at the amount of rebate due the customer.

The above example proves that either method of arriving at the amount of gas due the customer or company through the inaccuracy of meters is absolutely correct and that the amount of gas due to error is the same in either instance, but where two methods produce like results, the simpler should be generally adopted. It means nothing to the Gas Company whether the meter was 7 per cent past by meter or 7.5 per cent fast by prover, so long as they knew which reading was used as a divisor. Adjustment of bills must always be made from some certain meter registration and it will necessarily require a great deal of explaining to convince a customer that his meter is 7.5 per cent fast, yet his rebate can only amount to 7 per cent of this registration. For this reason, if for no other, the simpler method should be employed.

With some companies it is desirable to have a record of proof tests on all meters removed from service; other companies, however, do not desire to keep this record. Should the record not be desired, about the quickest procedure would be to take meters on receipt of same at shop, immediately remove tops and place meters on burner or pilot test—with some companies even this pilot test is omitted, and meters upon being brought in are immediately opened—that is, the tops, back plates, backs and fronts are removed. After removing these parts the diaphragms are carefully inspected as to condition and tested as to leakage; if the diaphragms should pass this inspection, the meters are set on the oiling table, and the diaphragms are reoiled from the outside without being removed from the case, being allowed to remain at least twenty-four hours, then receiving a second oiling, after which they are again allowed to stand at least over night. Should diaphragms now show tight on pressure test or from 3 to 6 in. pressure the case should be carefully cleaned out preparatory to putting on the backs and fronts, closing in this portion of the meter. When this is completed it is necessary to clean out top of meter above meter table, carefully cleaning the valves and all fittings, after which the covers are placed in position, and the valves tried for tight. If the valves show leakage they should be reground (both valve seats and covers), after which the meter is ready to have the back plate put on and in turn ready for pressure test, pilot test and proof test. This would cover the so-called operation of "General Repairs."

Repairing Meters

It might be well to note here the practice which is gradually becoming more general in the repairing of meters in respect to work done on general repairs. It is the custom with quite a number of gas company repair shops on opening a meter to remove only the top and back plate from the meter and on testing diaphragms, should they find the diaphragms to be tight, they proceed at once to close in the meter and make final tests. As against this practice some of the companies are now adopting the shop rule requiring the backs and fronts to be taken off all meters even though diaphragms should show tight, doing this extra work as it affords an opportunity for examination and reoiling of the diaphragms before finishing out the meter as a General Repair. The cost in removing the backs and fronts is so small an item that it would appear as though this practice were a very good one, and it certainly deserves consideration at the hands of any shop foreman.

With new diaphragm meters, where diaphragms are in bad condition, it is, of course, necessary to strip or remove the old diaphragms, after which it is generally customary to boil out the case in a caustic-soda bath. Before sending the cleaned skeleton cases to the regular repair men the cases should first be tested under about 6 in. pressure to detect leakage in channels, etc., which may have been caused in the stripping or tinning process, after which, on bringing the meter to the regular shop, the repair work would commence by replacing old parts with new equipment, using as far as possible, the old guide wires, discs, etc., and after testing the ned diaphragms for tight under-pressure of from 3 to 6 in., proceed to finish meter as with a general repair. (Dickey-Maryland Meter Co.)

The oil used for oiling diaphragms is a special neutral oil that may be purchased from the larger oil companies under the name of "Meter Oil." A good meter oil may be made by mixing equal quantities of rape seed oil, neats foot oil and sperm oil.

Painting Meters

The painting of meters is in no way the least important part of the work of meter repairing. The tin plate case of the generally used consumer's meter would last but a short while in service if it were not for the protective covering of paint which resists the corrosive action of moisture.

The paint used should be carefully selected and more carefully applied to the meter. There are any number of good meter paints on the market and an equal number of poor ones. It is always good policy to pay a little more per gallon for a reliable paint than to buy something in the paint line because it is cheap and pay for it later in meter maintenance. Co-operation between purchasing departments and meter shops is necessary in this respect.

In applying the paint, extreme precautions must be taken that the meter is free from oil or dirt and is uniformly covered over its entire surface. If the right kind of paint is used and it is properly applied, one coat is sufficient on even new tin—but no spot even as large as a pin head must be left uncovered to become a prey to the corrosive action of moisture. It should be borne in mind that the coat of paint applied to a meter must last through the period allowed for continuous service, which may be from 5 to 10 years.

The use of an air spray for applying the paint is the meters in service as shown by the proof tests on meters brought in and the general condition of the meters as shown by diaphragms or general repair record.

Following the system as previously outlined of attaching a shop card to every meter returned by the fitter, which remains on the meter until it is again set after which it may be filed for a definite period by company number, affords a simple and efficient method of recording all data desirable. As the meter passes through the shop the record of test and repairs made are entered on the card by the man doing the work. When the meter is ready for the O. K. stock the foreman or clerk may take off such information as is necessary for reports or records, the card itself, when returned from the fitting shop as the meter is set serving as a record of test for as long as it is desirable.

The office is usually only interested in the tests made on meters returned to the shop at the request of customers complaining of high bills. In such cases a report of the test should be furnished them either on a special form or on the original return meter order. A report of test on all return meter orders is superfluous.

A monthly report should show the number of meters on hand at the beginning of period, number received, number sent out; number repaired, number condemned, number testing O. K., within allowable error fast, within allowable error slow, without allowable error fast, without allowable error slow, stuck, don't register and those requiring general repairs. The testing and repairing data may be taken from shop cards daily and compiled at the end of the month, requiring but a small amount of clerical work.

A card record of general repairs is unnecessary where meters are changed for routine or age test at regular intervals and a system of identifying the year repairs were last made, is used. The latter method is superior to any form of record as the meterman knows at a glance, the instant the meter enters the shop, the year repairs were made. Meters should be called in for age test by the consumer's bookkeepers in numbers as desired by the meter shop foreman.

Meter Stock—To and From Fitting Shop

A large part of the plant investment of Gas Companies is represented by its meters. Meters in service are earning dividends, those in idle stock represent money tied up for which no interest is being obtained. Very careful watch should be kept on meter stock that the amount of money tied up thereby is reduced to the minimum. Meter purchases should be made only after a careful estimate of future requirements over a period of 6 months have been gotten up, taking into consideration the gains or losses that can be expected for the various months, and the number of meters that will possibly be condemned for old age. Replenishment to stock should equal gains in meters in service plus those condemned. The purchase of meters haphazard or by guess, or the purchase of those of sizes that may probably never be used, is a lack of economy—in other the monthly stock inventory. Meters returned from service by the fitting shop should be delivered to the meter shop at the close of each day.

Meters Locked or Shut Off

It is not good policy to return to the shop all meters from vacant buildings where the probabilities are that the premises will be occupied by a gas consumer within a reasonable length of time. Such meters should be shut off and locked or sealed by the use of a lock cock or suitable clamp enclosing the meter cock. The use of blind washers should be discouraged as being productive of leaks and an inefficient and unsatisfactory method of assuring the prevention of gas being used without the knowledge of the company.

The theoretical length of time that a meter should remain shut off and out of service would be the time in which the interest on the meter investment plus cost of turning off and on and keeping ledger records equals the cost of removing and resetting, testing and interest charges on these expenditures.

Complaint Meters

A complaint meter is an ordinary consumer's meter, equipped with a revolving drum operated by clock work, upon which a chart is arranged.

Suitable marking apparatus is provided to record upon the chart the amount of gas passing through the meter in units of an amount corresponding to one revolution of the dial shaft.

The chart is divided into eight vertical sections corresponding to days, which are again subdivided into A. M. and P. M. The chart is also divided horizontally into sections corresponding to hours. The drum containing the chart makes one revolution in twelve hours and the clockwork runs eight days with one winding.

Complaint meters are used in cases where the customer disputes the amount of his meter registration and all other means fail to convince him of its authenticity. It is installed in series with the regular consumer's meter and records on the chart the exact amount of gas consumed during every period of the day and night.

As the cost of having a number of complaint meters of the various sizes would be a considerable item,

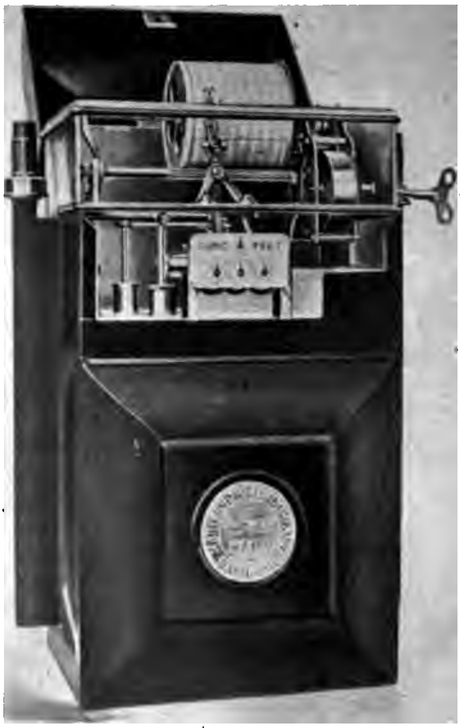


Fig. 305. Recording or Complaint Meter

most companies have but the 5 Lt. size and experience difficulty when a complaint requires the use of a complaint meter on meters of larger size. In such cases the recording mechanism from the 5 Lt. complaint meter may be lifted out and suitably arranged in the gallery of a meter of the size required. As the lug attached to the dial shaft causes the pen arm to make a horizontal mark for each revolution of the shaft it is evident that the marks on the chart would correspond to the equivalent value of one complete revolution of the test hand on the meter dial in cubic feet, i. e., if a revolution of the test dial represented 20 cu. ft. each mark would represent an equivalent amount of gas. One complaint meter in this manner can be made to serve

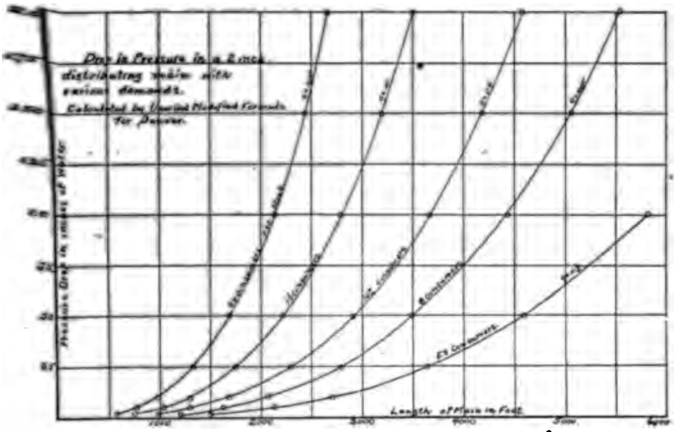


Fig. 306. Influence of Consumption on Pressure

the purpose for every size of consumer's meter from a 5 Lt. up to a 300 Lt.

Service Governors

Where service governors are used their maintenance is a matter similar to that of gas meters and can best be handled by the meter repair shop. It is not necessary, however, to remove the governor from service for cleaning, oiling or replacing parts, the saving in labor thereby being a considerable item.

A system similar to the routine changing of meters for age test should be used and a period of service determined in the same manner by the condition of the governor in regard to the length of time in use. After this period has been established governors should be examined, oiled, cleaned and put in good condition on the customer's premises at the expiration of the time limit for service.

The best way to handle this work is by a house to house method, as governors should not be brought in once they are installed except in cases of a permanent discontinuance of service. They should be considered as a part of the service piping and maintenance men

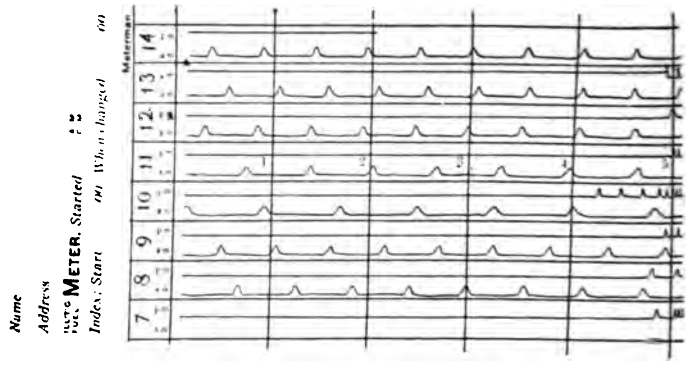


Fig. 307. Record Made

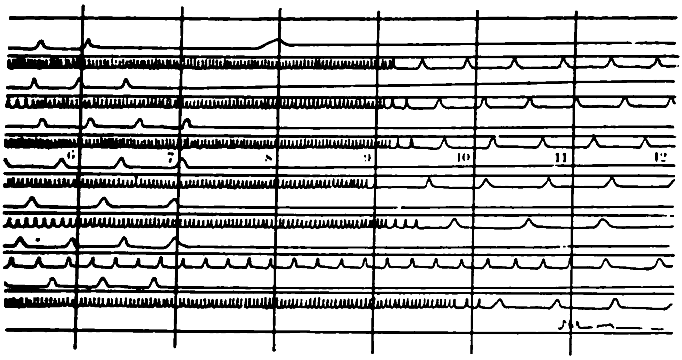
may route their stops from the service record cards. A record of governor installations is unnecessary as it should be understood that in the governor areas every service will be equipped with a governor. When the maintenance man completes the repairs on a governor he should place some form of identifying mark on it showing the year the work was done. A similar mark should also be placed on all new governors installed. A brass tag containing the last two numerals of the year wired to the governor is a good way to mark them.

Maintenance work on governors may be so arranged that it can be done when work is slack in the meter shop, as it is at certain periods of the year, and often affords a means of keeping the shop force intact.

The Handling of Repair Meters in a Small Company

It is often a question with the manager of a small gas plant as to the best method of procedure in handling his consumers' meters for examination and tests, and more especially how far he should go in the repair and adjustment of such meters as are found to be incorrect.

In order to cover this situation in an intelligent manner it is necessary to assume that the smaller gas com-



by Complaint Meter

pany would have among its shop equipment an accurate and well maintained meter prover. To attempt to lay down any definite and fixed rule to govern all smaller gas companies would be out of the question, as local conditions often bring up different problems which will not lend themselves to correction as readily as conditions in other localities, and it would be our object to merely cover this ground in a general manner, based on general experience with this class of work.

The matter of any repairs which a smaller gas company could make while not maintaining a completely equipped repair shop would depend greatly upon one point—as to whether or not the company would have at its works a man capable of handling a soldering iron, as there could practically be no repairs made unless such a man were in the employ of the gas company. On the other hand, if the company has a man capable of doing ordinary tinning work with a soldering iron, a considerable benefit would accrue to the gas company in the handling of all meters brought in for tests in the following manner:

When meters are first brought to the shop they should at once be placed in testing room for the purpose of proof test, and after completing this preliminary proof or record test the meter should be placed on test to insure against inside leakage in the meter as follows: The top of meter should be removed and the meter should be connected to gas supply with a pilot burner placed on the outlet of meter; then light the pilot burner, turn down to an exceedingly small flame, and under this consumption make sure that your meter will make a complete revolution of the tangent within a reasonable period of time. A 5 Lt. meter, with flame turned sufficiently low to burn only blue flame, should make a complete revolution of the tangent in about three hours, and if the meter does not make this revolution within a reasonable period of time you may be assured that you have a by-passage of gas from inside leakage—possibly leakage in the diaphragms, leakage in the valves, or possibly sufficient lost motion from wear to prevent the meter operating correctly. It might be mentioned here that the pilot-burner test with as low a flame as the blue flame above described is quite a severe test, and it would possibly serve the purpose of an ordinary gas company to use a somewhat higher or larger flame in making this so-called "burner or pilot test."

If on making the burner test your meter should not make complete revolution, it is very probable that the condition of the diaphragms is bad, that the valves probably need regrinding, or some other defective condition exists in the interior of the meter, and with the small company, not maintaining a complete repair department, it would be better with a meter of this class to discontinue any further work and set the meter aside to be forwarded to a regularly equipped repair shop.

Reverting to the pilot test, if meter should pass this test correctly it would indicate a fair condition in the interior, and the meter could then be immediately returned to the proving room for correct adjustment, after which it can be topped up and be ready for new service connection. It would be advisable, however, before proving and adjusting meter to remove the flag arms from the tangent post and revolve the tangent very slowly by hand to determine whether the valves of the meter were dirty. If the valves are dirty a perceptible drag can be felt by slowly revolving the tangent, and if a drag should be noticable it would be advisable to clean these valves before attempting to make proof adjustment on the meter. This can be done with very little labor by removing the back plate, thus giving access to the valves themselves, and then remove the covers from the valves, clean both valve seats and covers with rag moistened with benzine, replace the covers and reback-plate the meter. It should be noted that if the valves are cleaned, care must be taken not to cause any burr, or to in anywise disturb the surface of either valve seats or covers, as these valves must be kept perfectly level to insure being gas-tight, and further, in replacing the covers on the valves particular care should be taken to see that the cover arms are properly attached to the valve wrists and held in position either by the wrist nuts or wires used for this purpose. Again, it would be noted that when meter has had back plate removed it should be tested under pressure of at least 9 in. water column after the back plate has been resoldered in position, as a test of this nature will immediately show any leakage in the new solder seams. After meter has been tested under 9-in. pres-

[redacted]

sure for leakage it should be placed as a repaired meter on pilot or burner test, and then reproved for proper adjustment before being retopped and ready for service.

We believe the above would cover all the work which could be undertaken by a smaller company in handling its meters as to go further into this work necessitates the removing of backs and fronts, the examination of diaphragms and other detail work, which could only be handled properly by a regularly equipped meter shop. (Dickey-Maryland Meter Co.)

CHAPTER XIV

STREET DEPARTMENT—MAINS

Where the size of a gas company warrants the maintenance of a street department as a separate and distinct organization from the fitting shop, this department should exercise jurisdiction over all work appertaining to the underground distribution system of mains and services. The work of installing all underground piping, the maintenance of the same and such regular operations as pumping drips, taking street main pressure surveys, handling permanent recording gages, caring for valves and district governors, etc., comprise the general duties of this department.

General Duties of a Street Department

Except in the very small companies it will be found advantageous to maintain a street department as a separate unit under the supervision of a competent outside foreman, as the class of work done is of a nature so different from that encountered in the fitting shop that the efficiency obtained by specialization is impossible otherwise.

The work of installing and maintaining underground piping and the operations appertaining thereto are of vital importance, as the quality of service rendered the customers depend in a great measure upon the quality of this work. The largest part of the plant investment of any gas company is represented by its distributing system which is largely hidden from observance by the earth. This very fact of invisibility makes distribution work one of vast importance, as faulty work cannot be detected after the pipe is covered up until the inevitable complaint leads to its discovery, perhaps after costly effort and dissatisfaction among the customers effected.

Aside from annoyance to customers, there is the ever present deadly hazard of fire, explosion or asphyxiation, which is very liable to follow improperly executed street work, damage suits arising from destroyed trees, grass or shrubbery and the costly, and to be avoided large proportion of lost and unaccounted for gas.

The importance of good work in the underground system of mains and services, which can only be obtained through competent supervision, may be compared to that of piping concealed in buildings, but on a much larger scale. The piping must be subjected to the same rigid inspection and test and be installed under much the same rules pertaining to size and methods. Any common laborer can no more install a gas service or section of main than he can properly pipe a large building for gas. An expert street pipe layer is as much of a specialist and of equal value to the company as the best inside fitter. They must both work toward the common end—perfect service—which can only be attained through co-operation and harmony. The outside man begins the work and carries it to a certain point where the inside fitter takes it up and carries it to completion. The proper location of the service through the building wall minimizes the cost and effort necessary on the inside of the building and conduces to the proper installatión of meter and inside piping.

In addition to the proper installation of underground piping is the importance attached to the work of excavating and replacing matter from trenches in streets, alleys, sidewalks and lawns. This work must be done in such a manner that city rules and ordinances are observed and at the same time it must be done at minimum cost per unit of excavation. The cost of actually installing the pipe is usually but a small part of the total labor cost of street work, so that the outside fitter is for the greater part of his time a foreman over laborers engaged in excavating, refilling and replacing pavement, sidewalk or sod. That this be done properly is of utmost value.

Organization—The organization of a street department should be composed of a general foreman, having supervision over all operations carried on in the department and himself directly under a superintendent, a number of gang foremen, laborers, drivers and operators. The gang foremen may be divided into main and service layers and maintenance men, the latter being necessary in all of the larger plants to handle complaint work requiring excavating and work of such a nature that it cannot be conveniently handled by the regular force of trouble men. They may also attend to the maintenance work required on valves and district governors.

The laborers who will vary in number with the size of the company or the extent of the work being done, comprise at most times the larger part of the organization. The truck or wagon drivers are used to transport materials and to move the tool boxes from one location to another. Operators would consist of men employed in pumping drips, attending to pressures, etc.

The location of the street department headquarters may be at the plant or at some conveniently located holder station where transportation and storage facilities are satisfactory for handling pipe and materials.

Management—In the larger companies the man at the head of the street department should be an engineer or a man who has graduated from the school of practical experience and who is possessed of uncommon ability to handle men and the class of work encountered in this department. In the smaller companies, where a major portion of the work is actually done by the department head, he must be a practical man as well as one of sufficient engineering ability to intelligently solve the many problems encountered in distribution work. The size and local conditions of a company have effect upon the status of the department head, who in some companies may be a superintendent of distribution with supervisory duties over all branches of the distribution department, while in others he may be a general foreman having supervision over the street department only.

In all cases street work should be carried on in such a manner that every job receives a supervisory inspection by some one of responsible authority. As in fitting shop work inspection by the departmental head or one of his assistants of like authority should be imperative.

Much the same qualifications should be demanded in the street department head as in that of the fitting shop except that engineering ability is not so important in the latter as in the former. Street distribution work is of such a character that it involves a great deal of both civil and mechanical engineering. Especially is this true of the work of installing large mains. An uncommonly good practical man, as in any other class of work, may develop into a first class distribution foreman, but one possessed of both technical and practical knowledge is of undisputed value.

The value of distribution engineering has been too slightly appreciated in the past with the result that costly expenditures have in a great many cases become necessary, through the rule-of-thumb methods followed by predecessors, that could to a large extent have been avoided had engineering knowledge have been used at the outset. There are very few cities where some sort of trouble from this source has not been encountered or is not being encountered right along and it is only a step in the right direction, which many cities have already taken, to include engineering ability in the qualifications necessary in the street department foreman or superintendent.

The street department foreman must be a judge of men and a handler of men, he must be able to choose the best men from among a group of applicants for labor and to get a full day's work from every man employed in the department. He should be fully informed as to the unit costs for each particular piece of work done and should demand of his gang foreman commensurate results in accordance with this information or knowledge.

Employes—The street department employes may be divided into two general classes; permanent and transient. The latter class is composed of common labor, numerically proportionate to the amount of work being done, and no especial qualification need be demanded except the ability to deliver a full day's work. The former class comprises the gang foreman, maintenance men, operators, drivers and a certain number of permanent laborers.

The qualifications of these permanent employes should not differ from those of any other department of the company and they should be entitled to the same rights and benefits. There is sufficient range of responsibility between the permanent laborer and the main foreman to afford a number of promotion steps, while the ranks of the transient labor should be called upon to fill vacancies as permanent laborers. It should be possible, where good judgment is used in choosing men and a proper course of training is employed, to promote main foremen to the position of head of the department. This is the logical rule and one which all companies should endeavor to follow. The men should be encouraged to understudy those ahead of them and be given every opportunity to make good.

A main foreman on large work must be a man of no common ability and his qualifications must be but very little beneath those of the head of the department. All gang foremen, either main, service or maintenance, and irregardless of whether they are working foremen or supervisory only, should possess as one of their chief requirements, the ability to handle men. Without this requirement, which may be natural or developed, a man should not be promoted, as the efficiency of the street department is dependent in a great measure upon the work actually done by all common labor under the direction of the various foremen.

Methods of Handling Street Work

Gas Mains—The gas mains of the present day are either composed of cast iron or steel pipe, the latter being the so called wrought iron pipe in general use. Cast iron pipes are joined together with bell and spigot joints, using cast lead, wool lead or cement packing, or with a universal ground joint using white or red lead packing. Steel pipes are either screwed, welded, flanged or joined by the use of a patent coupling, such as the dresser.

The chief advantage of cast iron pipe over wrought iron is in its ability to resist the destroying action of elements which is conductive to long life. The longer life of cast iron pipe is not due entirely to its greater thickness but to the composition of the pipe itself. Against this very important advantage is the cheaper cost of wrought iron pipe of the ordinary sizes and the saving in cost of laying and jointing. In the larger

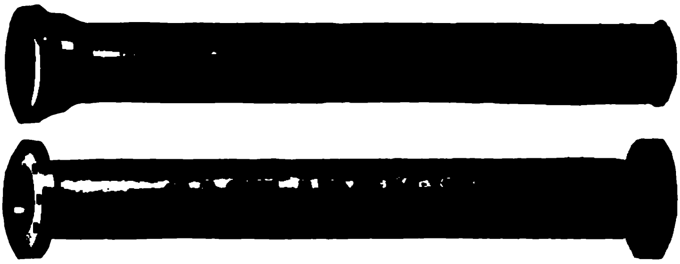


Fig. 308. Bell-and-Spigot and Flanged Mains

sizes these advantages are materially reduced. The general use of auto-geneous welding in the past decade has done much toward causing wrought iron mains to become extensively used. In addition to making a cheap and permanent joint, the use of the blow torch has eliminated the necessity of purchasing and using expensive specials or fittings, which has further tended to cut costs and reduce leakage.

Cast iron mains will still continue to be used and for certain soils and conditions of service are to be recommended, but they will never be used to the extent that they were in the past. With the advent of high pressure gas a necessity has arisen requiring tight joints that are difficult, if not impossible to maintain with cast iron pipe. The smaller pipes required for conveying high pressure gas is another factor in favor of wrought iron. Our recommendation would be that where soil and other conditions are favorable to the life of wrought iron pipe, that it be exclusively used with welded joints.

Joints—Of the four methods of jointing cast iron pipe the use of cement is the most theoretically perfect, although the difficulty in securing uniformity in the joints, due in most cases to imperfect workmanship, has to a large extent withheld its general adoption.

Fig. 309. Laying Cast-Iron Mains

A properly made cement joint should and will remain tight indefinitely. Where they have failed it has been due to one or all of three things. Imperfect workmanship, a poor or improper grade of cement or insufficient protection to the joint while setting.

In the making of cement joints a slow setting Portland cement should be used. The joint should first be "yarned" with one strand of damp "yarn." The joint space should then be filled with a pure cement mortar (no sand should be used) of the consistency of putty. The mortar should be tamped solidly into the joint space after which another strand of damp yarn should be caulked tightly on top of it and the joint space filled up and smoothed over with a pointing trowel, allowing a beveled surface at the face of the joint extending back on the pipe for a distance of 1 in. from the face of the bell. The joint should then be covered with a damp cloth and allowed to set at least 12 hours before being covered with dirt or disturbed in any manner. Precautions should be taken to prevent moving or jarring the pipe before the cement is set. A test should be

Fig. 310. Adaptability of Steel Mains

made of every joint before permanent filling is done. Sufficient cement for one joint only should be mixed at a time.

Cast lead joints are and have been the most extensively used in cast iron mains, but at their best they are inefficient and productive of an accumulated leakage amounting to the excessive proportions of lost and unaccounted for gas found in a great many plants. The cast lead joint is simply made but requires a thoroughness of workmanship to assure a reasonable efficiency. There are three essentials to the maximum efficiency of these joints; proper yarning, pouring the joint in one pour and proper calking of the lead. A properly "yarned" joint should be nearly gas tight in

Fig. 311. Connecting Machined-Joint Cast-Iron Main

itself, and to assure a perfectly "yarned" joint the pipe must be "at home," i. e., the spigot end must be securely seated in the bell and the joint space properly equalized. If the spigot is not seated there is great danger of the "yarn" being driven through into the

Weight of Lead Requ

In Pounds per Jo

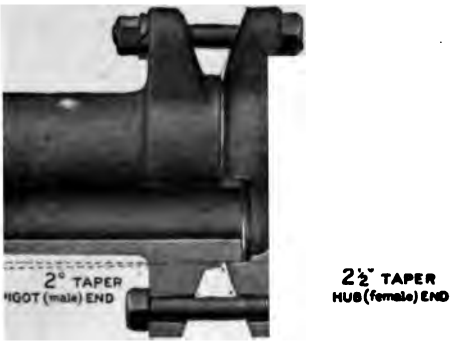
Diameter pipe, inches	W o p
3	[illegible]
4	[illegible]
6	[illegible]
8	[illegible]
10	(
12	(
16	(
18	1
20	1
24	1.
	2.

Lead and Yarn fo

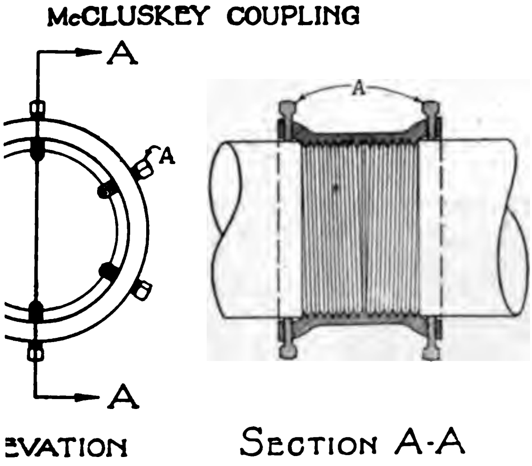
Diameter of pipe, inches	D of in
4	1
6	1
8	2
12	2
16	2
20	21
24	23
30	3

After th

ıde of the clay on top of the joint into which s poured. The lead should be heated until it a pine stock quickly dipped into it and with-



'ig. 312. Machined·Metal-to-Metal Joint



. 313. A Useful Coupling for Quick Work

ıll dirt or dross should be skimmed off before ı poured. The joint should be poured quickly t "freezing" or cooling of the lead before the joint is entirely full. After the joint is run the runner and clay should be removed and the lead thoroughly calked, or compressed, within the joint space. A small calking tool should first be used, calking toward the inside and outside rings of the joint, after which larger

vice test has proven very efficient. It differs from a cast lead joint in that lead is thoroughly calked into the joint space from the yarn out, instead of being compressed only a comparatively short distance from the surface. Yarning should be done in the same manner as for cast lead joints.

Fig. 315. Dresser Coupling for Plain-End Pipe

Universal jointed pipe is not extensively used owing in a great measure to the lightness and weakness of the pipes and to the necessity of perfect alignment that is difficult to attain.

Of the cast iron pipe joints the one using lead wool

Fig. 316. Dresser Couplin-

Standard Weight and Thickness of Cast Iron Pipe

Weight, Tested to 100 ft. Hydraulic Head or 43 lbs. Gage Pressure (Kent's Handbook)

Nominal inside diam., inches	Gas. Thickness, inches	Weight per Foot of length	Weight per 12 ft. length
3	0.39	14.5	175
4	0.42	20.0	240
6	0.44	30.8	370
8	0.46	42.9	515
10	0.50	57.1	685
12	0.54	72.5	870
14	0.57	89.6	1,075
16	0.60	108.3	1,300
18	0.64	129.2	1,550
20	0.67	150.0	1,800
24	0.76	204.2	2,450
30	0.88	291.7	3,500
36	0.99	391.7	4,700
42	1.10	512.5	6,150
48	1.26	666.7	8,000
54	1.35	800.0	9,600
60	1.39	916.7	11,000
72	1.62	1,283.4	15,400
84	1.72	1,633.4	19,600

Weight and Thickness of Cast Iron Pipe

Nominal inside diam., inches	Thickness, inches	Weight per ft. of length	Weight per 12 ft. length
4	0.40	19.33	232
6	0.43	30.25	363
8	0.45	42.08	505
10	0.49	55.91	671
12	0.54	73.83	886
16	0.62	112.58	1351
20	0.68	153.83	1846
24	0.76	206.41	2477
30	0.85	284.00	3408
36	0.95	379.25	4551
42	.1.07	497.66	5972
48	1.26	663.50	7962

Weight of Miscellaneous Cast Iron Specials

Diam. pipe, inches	Elbow	45 deg. bends	22.5 deg. bends	Caps	Sleeve
3	50	40	35	20	35
4	60	50	45	25	45
6	95	70	60	40	60
8	155	155	100	60	75
10	215	160	130	85	100
12	290	210	170	110	125
14	355	260	210	145	150
16	495	355	280	165	175
18	575	405	320	235	200
20	745	515	410	290	240
24	1,040	715	555	435	345
30	1,580	1,060	800	680	475
36	2,230	1,490	1,120	1,015	630

Weight of Miscellaneous Cast Iron Specials in Pounds

Diam. pipe, inches	One bell bends			Caps	Plugs	Sleeves
	90 deg.	45 deg.	22½ deg.			
4...........	68	63	58	25	9	47
6...........	100	97	91	37	16	65
8...........	149	138	130	52	24	100
10...........	198	183	175	65	34	122
12...........	278	253	239	95	50	160
16...........	491	387	366	151	82	269
20...........	707	544	508	220	127	372
24...........	1003	748	694	330	193	500
30...........	1478	1053	966	476	294	676
36...........	2121	1445	1306	668	433	871
42...........	2984	1948	1744	916	620	1133
48...........	4193	2625	2319	1266	901	11421

The cost of threading large sized wrought iron pipes, plus the cost of the jointing device and labor of connecting, eliminates flanged or coupled pipe except in the smaller sizes. In sizes up to 6 in., line pipe with recessed couplings make a fairly economical and efficient joint; although the leakage hazard is not eliminated. Patent couplings have a high efficiency but are expensive. They are however, more economical than threaded couplings or flanges on the larger sizes.

Weight of Standard Cast Iron Fittings

Approximate Weights Compiled by the Massilon Iron Steel Co.

CROSSES AND TEES

Diameter, inches	Crosses	Tees	Diameter, inches	Crosses	Tees
3x 3	85	65	18x18	1,055	860
4x 4	115	90	18x14	865	735
4x 3	105	85	18x10	695	610
6x 6	165	130	18x 6	550	510
6x 3	125	105	18x 3	455	435
8x 8	290	230	20x20	1,335	1,100
8x 6	230	195	20x16	1,100	935
8x 4	205	175	20x12	900	800
8x 3	185	165	20x 8	730	665
10x10	380	300	20x 3	565	545
10x 6	280	240	24x24	1,800	1,565
10x 3	225	205	24x18	1,480	1,280
12x12	495	395	24x14	1,215	1,085
12x 8	405	345	24x10	1,035	945
12x 3	275	255	24x 6	840	800
14x14	665	525	24x 3	725	705
14x10	530	445	30x30	2,850	2,415
14x 6	390	350	30x20	2,020	1,790
14x 3	330	310	30x16	1,755	1,585
16x16	810	735	30x12	1,475	1,370
16x12	715	615	30x 8	1,255	1,190
16x 8	585	520	30x 4	1,030	1,005
16x 3	415	395	36x36	4,160	3,490

WEIGHT OF BRANCHES

Diameter, inches	Degrees 30	45	60	Diameter, inches	Degrees 30	45	60
3x 3	70	70	60	16x16	1,185	910	815
4x 4	115	95	85	18x18	1,415	1,080	935
6x 6	180	145	130	20x20	1,935	1,455	1,400
8x 8	310	250	230	24x24	2,795	2,140	1,840
10x10	450	370	320	30x30	4,445	3,390	2,905
12x12	650	545	445	36x36	6,595	4,565	4,115
14x14	830	650	565				

WEIGHT OF TAPER PLUGS

3"	4"	6"	8"	10"	12"	14"	16"	18"	20"	24"	30"	36"
7	10	20	25	40	60	80	95	135	170	260	430	600

WEIGHT OF REDUCERS

Diameter, inches	Pounds	Diameter, inches	Pounds	Diameter, inches	Pounds
4x 3....	50	14x12....	295	20x14....	430
6x 4....	70	14x 8....	220	20x10....	380
6x 3....	60	14x 4....	165	24x20....	645
8x 6....	100	16x14....	355	24x16....	555
8x 3....	55	16x10....	290	24x12....	485
10x 8....	175	16x 6....	220	30x24....	865
10x 3....	115	18x16....	435	30x18....	825
12x10....	230	18x12....	345	36x30....	1,455
12x 6....	165	18x 8....	280	36x18....	950
12x 3....	140	20x18....	520		

Weight of Cast Iron Crosses and Tees in Pounds

Diam. pipe, inches	4 bell crosses	3 bell tees	Diam. pipe, inches	4 bell crosses	3 bell tees
4x 4......	137	105	20x16......	1115	947
6x 6......	194	151	20x12......	1006	893
6x 4......	169	138	20x10......	824	755
8x 8......	282	221	20x 8......	802	745
8x 6......	251	206	20x 6......	774	730
8x 4......	224	192	24x24......	1686	1405
10x10......	372	295	24x20......	1554	1338
10x 8......	346	282	24x16......	1458	1291
10x 6......	314	266	24x12......	1180	1089
10x 4......	285	251	24x10......	1136	1067
12x12......	519	417	24x 8......	1114	1056
12x10......	478	397	30x30......	2398	2029
12x 8......	450	383	30x24......	2223	1942
12x 6......	416	366	30x20......	2091	1876
12x 4......	385	350	30x16......	1995	1828
16x16......	875	707	30x12......	1670	1579
16x12......	765	652	30x10......	1626	1557
16x10......	634	561	30x 8......	1604	1546
16x 8......	610	549	36x36......	3305	2867
16x 6......	580	534	42x42......	4701	4144
20x20......	1211	995	48x48......	6074	5468

Weight of Cast Iron Branches in Pounds

Diam. of pipe. inches	45 deg. 3 bell	Diam. of pipe inches	45 deg. 3 bell
4x 4	105	20x20	1271
6x 6	171	24x24	1828
8x 8	254	30x30	2984
10x10	347	36x36	4090
12x12	502	42x42	5981
16x16	864	48x48	8677

The most desirable, economical, efficient and permanent methods of jointing is by means of the welding process where the pipe and all its branches and fittings

Fig. 317. Cast-Iron Sleeve Coupling

are joined into one continuous and unbroken section. A short time past this method would have been considered unpracticable due to the rigidity of the solid pipe and the dangers through presence of breaks through expansion and contraction. It has been proven

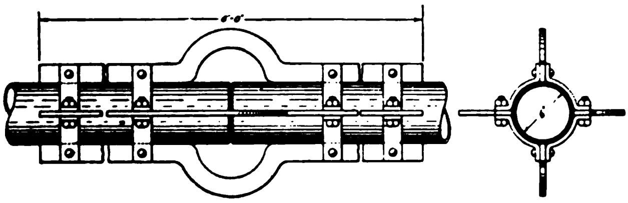


Fig. 318. Aligning Pipe Ends

in late years that the expansion or contraction of pipes in the ground is a myth or is so slight as to be negligible, due to the great degree of heat conductivity of the earth in contact with the pipes and the negligible change in temperature at the depth to which the pipe should be laid to assure its safety from jar of traffic

Fig. 319. Examples of Welded Main Branches

on the surface of the street and immunity from frozen condensation in the gas.

Cost—The following costs are based on work done by competent and experienced welding operators at 30c per hour, using Prest-O-Lite Welding Apparatus with compressed oxygen and Prest-O-Lite purified Acetyline, each at $2 per hundred cu. ft., and Norway Iron weld-

ing wire at $9 per hundred pounds. Highly skilled operators are able to do this work at about a third less than the figures show.

Approximate costs of making butt welded pipe joints:

Cost of making butt welded pipe joints:

Diam. steel pipe	Labor Men	Labor Am't.	Oxygen Cu. ft.	Oxygen Am't.	Acetylene Cu ft.	Acetylene Am't.	Welding wire Oz.	Welding wire Am't.	Total cost
2	3	0.015	1.1	0.022	1.0	0.02	2	0.012	0.069
4	12	0.06	4.6	0.022	4.4	0.088	4	0.022	0.266
6	18	0.09	8.8	0.176	8.0	0.16	8	0.045	0.471
8	25	0.125	18.7	0.374	17.0	0.34	12	0.067	0.906
10	30	0.15	23.1	0.462	21.0	0.42	14	0.078	1.11
12	35	0.175	28.6	0.572	26.0	0.52	16	0.09	1.357
16	50	0.25	39.7	0.794	37.0	0.74	24	0.135	1.919

Constructing Special Fittings

(Cost of preparing and welding 8-in. main)

Diam. connection	6 in.	4 in.	4 in.
Angle connection	90°	90°	60°
Cutting preparatory...	**$0.19**	**$0.12**	**0.165**
Welding	**1.27**	**9.975**	**1.19**
Total	**1.46**	**1.095**	**1.355**

Total cost for three operations, $3.91.

The speed and cost of welding vary slightly with the expertness of the individual operator and depend somewhat upon local conditions

Where large selections of trench ca nbe opened at a time, it is natural that the work will proceed much more quickly than in crowded city streets.

Cost of Laying Gas Mains

In laying gas mains a number of activities or essential parts of the work must be considered separately in order to insure efficiency in the completed work.

Engineering—All main installations require a certain amount of engineering work depending upon the magnitude of the installation to be made. In the small extensions this work may simply take the form of a preliminary measurement and estimate, with considera-

tions for connections to existing mains, future extensions and drainage. In such cases a sketch should be drawn on the main order showing size of main to be

Fig. 320. Lowering Main Into Trench

installed, points where main begins and ends, distance from property line, direction of drainage, location of specials or fittings to be installed and size and depth of existing main. After the order is completed and returned to the office the data from the foreman's sketch and report should be copied on the record maps and the actual cost of the job compared with the estimated. A record of these individual costs should be kept so that average unit costs per foot of each size of main for certain kinds of soil or pavement is definitely know and may be used for estimating purposes.

In the installation of large mains, or considerable amounts of supply main, a great deal of importance is attached to engineering details and such matters should not be left to the judgment of the foreman doing the work, who should be furnished with detail drawings of the entire job and with a corps of engineers to carry out the plans.

When a main installation of considerable magnitude is contemplated an exhaustive study and survey of the district to be supplied should first be made, taking into consideration pressure conditions on existing mains, direction of growth and future possibilities for consumption from the new main After this, which will determine the size of main to be laid and material requirements, a complete survey of the grade of streets within the district should be made after which, if the streets have no pavement or established grade, a consultation should be had with the engineering department of the city with a view of learning the contemplated grade of such streets. All sewers and other pipes either existing or proposed, should also be definitely located A profile and plan drawing should then be made showing present street grades, proposed grades and grade of pipe on the profile, and distances, street intersections, specials, necessary measurements and any data of value on the plan.

In running large jobs it is advisable for the engineers to keep track of costs and various operations separately, such as trenching, laying pipe, joint making, backfilling, etc., and to look after the delivery of materials and keep track of same. It is not advisable for the foreman to be burdened with detail work, as upon him should depend primarily the work to be gotten out of the men. The engineers should keep the work laid out ahead of the gangs so that no delays are encountered in carrying on the work and to keep a record of all locations and measurements so that a true and detailed record of the entire job may be had upon its completion.

Delivery of Materials—Material requirements should be made known so that deliveries can be made in ample time before the materials are needed. An efficient delivery system is one of the salient factors of distribution work.

Large gas main pipe may be delivered before work commences and should be strung out on the same side of the street that the main is to occupy. If the pipe is cast iron the hub ends should be laid in the direction in which work is to progress. At intersections the specials and pipe crossing the street should be stored on either side of the intersection. If the pipe cannot all be delivered at once enough should always be kept ahead of the pipe layers to insure continuous operation. Small wrought iron pipe, lead, tools, and miscellaneous supplies should not be delivered until the gang, or at least a watchman, is on the ground.

Trenching—The first thing to be done before excavating begins is to lay out the trench for a distance ahead of the gang. For this purpose a marking line should be used similar to sash cord or clothes line rope. The proper distance should be measured off from the property line or curb to the inside of the trench at either end of the distance to be marked off. The rope should then be stretched taut between these two points and a distanct line made in the earth with a pick. If the street is paved the marking may be done with a chalk line. The width of the trench is then measured off at either end and the outside line similarly marked off.

The position that the main is to occupy in the street relative to parallel property lines often depends upon the position of other pipes, sewers, conduits, etc.

Where this point is not dependent upon such conditions and becomes one of judgment of the engineer or foreman a distance of 10 ft. from the curb is proper. This distance allows pipe to be stored on the near side of the street, and the dirt from the trench on the outside. Pavement material and top surfacing should be placed on the near side opposite from the dirt.

The advantages of this arrangement over that of piling the dirt on the curb side and the pipe on the opposite side of the street, as is often done are: (1) All

Fig. 321. Usual Method of Lowering Mains

work is carried on in one side of the street, leaving the other side unobstructed at all times to traffic. (2) The dirt piled on outside of trench affords an effective barrier between traffic and the open trench. (3) Pipe is closer to trench and the labor of laying thereby reduced. (4) Gutters are kept free from obstructions in the way of dirt, the pipe not being an obstruction to drainage.

After the trench is marked out it should be divided into sections 12 ft. long and a 2-ft. bulkhead left between each section, if the pipe is to be laid in cast iron in 12-ft. lengths. Leaving these bulkheads, which may be tunneled through at the bottom, saves 15 per cent of the trenching labor and strengthens the walls of the trench In laying street pipe the bulkheads should be dispensed with but the trench should be laid out in 12-ft sections with a man to dig out each section.

Fig. 322. Lowering Main to River-Bed Trench

Enough trench should be kept open ahead that tl pipe layers may be kept busy.

After the trench is excavated to grade the bell hol should be marked off and dug. These holes should l 24 in. long measuring from the back end of the be and should afford a clearance of 6 in. under the pi] and 15 in. on each side of it. Where welded joints a

be made in the trench on rigid pipe joint holes simi-
: to the above are necessary except that at least 9 in. clearance must be had underneath the pipe to allow
ıe use of the torch.

The depth to which gas mains are laid is purely de-

Fig. 323. Lowering Shore End of Under-River Main

ındent upon local and climatic conditions. It must be ıfficient to insure protection to the pipe against frost ıd jar of traffic on the surface of the street and will ıry in this country from 2 ft. to 6 ft. From an economical standpoint it must be the minimum depth at which the pipe is safe from the above hazards.

In sandy and filled ground precautions must always be taken to guard against caveins and possible injury to workmen In such soils the weight of the earth thrown out should be kept back at least two feet from the edge of the trench and sufficient cribbing or bracing

Fig. 324. A Difficult Problem in Main Laying

used to insure safety Tight cribbing is usually unnecessary unless the trench is more than 6 ft. deep or the soil very treacherous in nature Generally either one or two sets of stringers parallel with the trench and held against the trench walls by the use of screw braces will suffice The foreman should, however, avoid taking chances.

Fig. 325. Two Compressor Outfits for Main Work

Trenching Machines—The use of trenching machines is to be recommended in suburban work where the length of main warrants. Tanking machines also have their place and pumping or air compresser trucks are often desirable.

Fig. 326. An Early Form of Trenching Machine

The following are average trenching costs for different sizes of pipe and kinds of soil. For depths of trench other than those shown in the table add or deduct a proportionate amount.

Width of Trench

Width of trenches	1′ 6″	1′ 8″	1′ 10″	2′	2′ 2″	2′ 6″
Size of pipe	2″	4″	6″	8″	10″	12″
Width of trenches	3′ 0″	3′ 6″	4′ 0″	4′ 8″	5′ 4″	
Size of pipe	16″	20″	2b″	30″	36″	

Trenching Costs

Kind of Soil: 1—Sand; 2—Hard Ground; 3—Sand with Pavement; 4—Hard Ground with Pavement.

Size of pipe, in	Soil	Width. feet	Depth feet	Cost per foot
2	1	.....	.....	$0.0577
	2	1′ 6″	2′ 2″	0.1375
	3	.....	.....	0.1622
	4	.....	.....	0.1980
3	1	.....	.....	0.0723
	2	1′ 6″	2′ 6″	0.1672
	3	.....	.....	0.1977
	4	.....	.....	0.2417

4	1	.....	.....	0.0761
	2	1′ 8″	2′ 6″	0.1760
	3	.....	.....	0.2062
	4	.....	.....	0.2541
6	1	.....	.....	0.1006
	2	1′ 10″	3′ 0″	0.2326
	3	.....	.....	0.2750
	4	.....	.....	0.3355
8	1	.....	.....	0.1160
	2	2′ 0″	3′ 2″	0.2667
	3	.....	.....	0.3162
	4	.....	.....	0.3850
10	1	.....	.....	0.1320
	2	2′ 2″	3′ 4″	0.3025
	3	.....	.....	0.3575
	4	.....	.....	0.4400
12	1	.....	.....	0.1595
	2	2′ 6″	3′ 6″	0.3685
	3	.....	.....	0.4372
	4	.....	.....	0.5335
16	1	.....	.....	0.2090
	2	3′ 0″	3′ 10″	0.4867
	3	.....	.....	0.5747
	4	.....	.....	0.7012
[illegible]	1	.....	.....	0.2321
	2	3′ 4″	4′ 0″	0.5335
	3	.....	.....	0.6325
	4	.....	.....	0.7700
[illegible]	1	.....	.....	0.2530
	2	3′ 6″	4′ 0″	0.5775
	3	.....	.....	0.6875
	4	.....	.....	0.8470
[illegible]	1	.....	.....	0.4537
	2	4′ 0″	5′ 0″	1.0456
	3	.....	.....	1.2360
	4	.....	.....	1.5106
[illegible]	1	.....	.....	0.5692
	2	4′ 8″	5′ 6″	1.3200
	3	.....	.....	1.5592
	4	.....	.....	1.8970

Fig. 327. A Typical Trench Scene in a Village

Laying Pipe—After the trench has been completed for a sufficient distance the work of pipe laying can commence. For sizes up to 12 in. the use of a derrick is unnecessary, the lengths being rolled to the edge of the trench and let in by the use of ropes. In this operation two ropes are necessary, one at either end of the pipe. A knot is tied in one end of the ropes, which are laid at right angles to the trench beneath the pipe. The men standing upon this stationary end of rope push the pipe over the edge of the trench and paying out the other end of the rope over the top of the pipe allow it to slowly roll into the trench. After it has landed on the bottom of the trench they should cross the ropes and with an equal force on each side of the trench raise the pipe enough for the ditch man to enter the spigot in the bell and send it "home." For pipes over 12 in. in size the use of a portable derrick is recommended. In this case the pipe should be rolled over the trench on skids in as near the position it is to occupy as is possible. The weight of the pipe being lifted with the derrick the skids should be removed and the pipe lowered in, after which the operation of landing "home" is the same as for smaller pipe.

Before any pipe is lowered into the trench it should be thoroughly swabbed out and, if cast iron, while hanging on the ropes should be sharply rapped with a hammer to detect cracks. A perfect length of cast iron pipe will ring clear when struck a sharp blow with the hammer, while defective lengths will give a dull, rasping sound.

Blocking should not be used to level up gas pipe. When grading has been properly done the pipe will rest upon undisturbed earth in the bottom of the trench. The engineer's level and grade stakes are important implements in properly laying pipe and should be used on all jobs large and small.

Screwed steel pipe may be put together on the bank in one continuous piece and let into the trench. Small welded pipe may be handled in the same manner. Large welded pipe may be let into and welded within the

scales and price of material
approximate in all ordinary
iron pipe joint is herein assu
data is compiled from Kepp
High and Low Pressure Gas

Cost of Laying and

Diam. of pipe, in.	Kind	Laying	Joi
2....	Welded	0.01	0.0
2....	Screwed	0.01	..
4....	Cast iron	0.0375	0.0
4....	Welded	0.0375	0.0
4....	Screwed	0.0375	...
6....	Cast iron	0.0425	0.0
6....	Welded	0.0425	0.01
6....	Screwed	0.0425	...
8....	Cast iron	0.0716	0.03
8....	Welded	0.0521	0.01
8....	Screwed	0.0521	...
10....	Cast iron	0.1042	0.05
10....	Welded	....	...
10....	Screwed	....	...
12....	Cast iron	0.1238	0.06
12....	Welded	0.1238	0.02
12....	Screwed	0.1238	...
16....	Cast iron	0.2643	0.09
16....	Welded	[illegible]	[illegible]

It is frequently convenient to make general estimates upon the cost of work when the exact conditions are not precisely known, and for this purpose unit figures save time and calculation. In the December 15 issue of THE GAS AGE the author contributed an article upon this subject (page 553), and discussed it at some length. Naturally any table constructed for this purpose should be revised to prevailing costs of material and labor; such revised costs can be very readily substituted in the accompanying tables. These figures have been found very useful by distribution engineers, and it was therefore decided to include them in a book in which this series of articles will appear.

It is assumed that a man will trench and backfill 9 cu. ft. of trench per hour, and that the cost of trenching is twice that of backfilling. The tables are constructed on the assumption that labor-cost per foot of length and depth is 1 cent per hour. The excavation for the joint was considered as being 8 in. outside the edge of the bell, and 18 in. long. Dividing this by 12 ft., or the length of the section of cast iron pipe, gives the excavation per foot, and multiplying this by 0.111 cent gives the unit of cost for the bell hole.

The labor involved in laying pipe includes the handling of pipe from the curb to the trench, swabbing out, inspection, and lowering into the trench, and for steel pipe also the labor involved in reversing couplings.

The explanations accompanying the table pretty clearly define what items the columns include. In a condensed form the tables referred to are herewith given:

Testing—Every joint made must be tested for leakage with soapsuds before the pipe is covered up. In small work this can be done by applying the ordinary gas pressure, but on large jobs, where the size of the main is 12 in. or over, air pressure exceeding the maximum that the main will ever be subjected to should be used. A power driven portable compressor, which

CAST IRON PIPE

(Bell and spigot, A. G. I. Standard, 12-ft. lengths)

Cost of Laying Pipe

(Assuming one foreman and a pipe weight of 425 lbs. per man-hour)

Diam. Ins.	Men	Wt. pipe Lbs. per ft.	Pipe laid Ft. per man-hour	Cost per foot Cents
4	2	19.33	21.98	0.0455
6	2	30.25	14.05	0.0711
8	4	42.08	10.09	0.0991
10	4	55.91	7.60	0.1316
12	6	73.83	5.75	0.1739
16	6	112.58	3.77	0.2652
20	6	153.83	2.76	0.3623
24	8	206.41	2.06	0.4854
30	8	284.00	1.49	0.6711

Cost of Pipe Joints

(Assuming 1 calker, 1 yarner, 1 leadman up to 20 in. diam.; beyond requires two yarners and calkers; 12.5 lbs. per man-hour and labor 1 cent per man-hour)

Diam. Ins.	Weight of lead — Lbs. — per joint	per ft.	Weight of yarn — Lbs. — per joint	per ft.	Joints per gang-hour	Ft. pipe per hour	Cost per foot Cents
4	6	0.50	0.37	0.0308	6.25	74.00	0.0405
6	9	0.75	0.47	0.0391	4.16	49.92	0.0601
8	12	1.00	0.56	0.0466	3.12	37.44	0.0801
10	16	1.33	0.65	0.0541	2.34	28.08	0.1068
12	22	1.83	0.75	0.0625	1.70	20.40	0.1470
16	36	3.00	1.06	0.0883	1.03	12.36	0.2427
20	50	4.16	1.34	0.1116	1.25	15.00	0.3333
24	62	5.16	1.60	0.1333	1.04	12.48	0.4006
30	75	6.25	2.00	0.1666	0.83	9.96	0.5020

Cost of Trenching and Backfilling

(Assuming depth of 1 ft. and man power of 9 cu. ft. per hour at 1 cent per man-hour or 0.111 cent per cu. ft.)

Diam. Ins.	Width Ins. A	Cu. ft. per foot — Trench B	Bellholes C	Cost per foot, cents — Trench D	Bellholes E
4	20	.166	0.405	0.184	0.045
6	22	1.83	0.459	0.203	0.051
8	24	2.00	0.513	0.222	0.057
10	26	2.16	0.540	0.239	0.060
12	30	2.50	0.594	0.277	0.066
16	36	3.00	0.702	0.333	0.078
20	40	3.33	0.783	0.369	0.087
24	44	3.66	0.864	0.406	0.096
30	50	4.16	1.000	0.461	0.111

Multiply column B by the depth in feet, add from column C and multiply this sum by the local wages in cents per hour.

Cost of Material—Cents Per Foot

(Assume storage at 4 per cent and general supervision and engineering at 10 per cent)

Diam. Ins.	Pipe at $1 per ton	Lead at 1c. per lb.	Yarn at 1c. per lb.	Drayage at $1 per ton-mile
4	0.966	0.50	0.0308	0.966
6	1.512	0.75	0.0391	1.512
8	2.104	1.00	0.0466	2.104
10	2.796	1.33	0.0541	2.796
12	3.691	1.83	0.0625	3.691
16	5.630	3.00	0.0883	5.630
20	7.777	4.16	0.1116	7.777
24	10.320	5.16	0.1333	10.320

STANDARD STEEL PIPE

Cost of Laying Steel Pipe

Screwed joints; labor 1 cent per man-hour; crew of 1 foreman and 2 pipemen, but 8 in. requires 4 pipemen

Diam. Ins.	Weight of pipe: Lbs. per ft.	Weight of pipe: Per man hr.	Feet of pipe laid: Per man-hr.	Feet of pipe laid: By gang	Cost per ft. Cents
1¼	2.28	237.5	104.2	312.5	0.0096
1½	2.73	236.4	86.6	260.0	0.0116
2	3.68	238.2	65.0	195.0	0.0154
3	7.62	278.9	36.6	110.0	0.0273
4	10.89	289.6	26.6	80.0	0.0576
6	19.19	303.2	15.8	47.5	0.0633
8	28.81	302.5	10.5	52.5	0.0952

Trenching and Backfilling

(Assume depth of 1 ft., man power of 9 cu. ft. per man-hour,

Diam., ins.	Width, ins.	Cu. ft. per ft.	Cost per ft., cents
1¼	18	1.5	0.166
1½	18	1.5	0.166
2	18	1.5	0.166
3	18	1.5	0.166
4	20	1.66	0.184
6	22	1.83	0.203
8	24	2.00	0.222

Cost of Making Screw Joints

(Requires 2 men or 3 men for 8-in. size. Cost includes entering and screwing up at 1 cent per man-hour)

Diam., in.	Work of gang per hour: No. joints	Work of gang per hour: Ft of pipe	Cost per ft. Cents.
1¼	9	180	0.0111
1½	8	160	0.0125
2	6	120	0.0166
3	4	80	0.0250
4	3	60	0.0333
6	2	40	0.0500
8	2	40	0.0750

may also be used for the pneumatic calking of joints, is recommended for this purpose.

Backfilling—After the pipe has been tested out it is ready to be covered with the earth taken from the trench.

The following table shows average costs of backfilling trenches by hand labor for various sized pipes and is based upon an average depth of cover of 3 ft.:

Cost of Backfilling

Diam. of pipe	Kind of soil	Cost per foot
2	Sand	$0.0288
	Hard ground	0.0637
4	Sand	0.038
	Hard ground	0.088
6	Sand	0.0503
	Hard ground	0.1163
8	Sand	0.058
	Hard ground	0.1333
10	Sand	0.066
	Hard ground	0.1512
12	Sand	0.0797
	Hard ground	0.1842
16	Sand	0.1045
	Hard ground	0.2433
18	Sand	0.106
	Hard ground	0.2667
20	Sand	0.1265
	Hard ground	0.2887
24	Sand	0.1512
	Hard ground	0.3427
30	Sand	0.1897
	Hard ground	0.44

Tamping around the pipe is the most important part of this work. Flat iron tampers with the weighted end at a slight angle to the handle should be used. All tamping should be done by hand to a depth at least 6 in. above the top of the pipe, after which a motor driven machine tamper is recommended on large jobs. The

Fig. 328. A High Pressure Test for Tightness

t should be shoveled into the ditch in alternate even ers not more than 6 in. deep. Where all hand tamp- is employed the backfillers should work in units of ee men each, one shoveler and two tampers.

Fig. 329. Trenching by Compressed Air

In sandy and loam soils the use of water is recommended for packing the earth back into the trench, but the water should not be applied until the earth has been hand tamped around and for 6 in. above the pipe.

Connections to Existing Mains—Where the new main laid is of large size or is a considerable quantity of a small size, the work of "tying in," or connecting to the existing main should be the last thing done after testing.

The operation of "tying in" may consist of joining the end of the new main with that of the old one, or it

Fig. 330. Cast Iron Pipe Connections

may consist of cutting a branch fitting in the old main to which the new is joined. The former operation is comparatively simple and usually involves a problem no more difficult than stopping the flow of gas in the old main by means of bags or stoppers, removing the plug from the end and then making the necessary connections to new mains, which as a rule means no more than cutting a piece of pipe to fit between the two ends and making final connection by the use of a sleeve.

The work of "tying in," where a branch fitting must be "cut in," is more difficult to accomplish. The old n must first be marked off properly for cutting and ee cuts should be diamond pointed around the cir- ıference of the pipe. Two of the cuts should be at extremities of the piece that is to be removed, ich must allow for at least 2 ft. more distance than fitting is to take up. The third cut should b3 4 in.

Fig. 331. A Nest of Cast Iron Pipe Specials

de of either of the end cuts. After the cuts have a diamond pointed very nearly through the pipe, all eady and the gas bagged off at either side, by the of a bull chisel and sledge augmented by wedges the cuts nearest together should be cracked apart and the 4-in. ring knocked or broken out. The longer piece, which should be supported in a safe manner by block and tackle or otherwise, can then be cracked off and removed. The operation that next follows is to insert the fitting on one end of the old pipe and connect to the other end by means of a short piece of pipe and a sleeve. To connect from the fitting to the end of the new main requires the same operation as that previously described for connecting two ends.

In small pipes up to 6 in. the third cut may be dispensed with if care is exercised to diamond point the

sioned by the use of the sleeve is not a sufficient disadvantage to afford taking chances on any size of pipe.

The work of making final connections very often involves working against time. This is especially true where temporary means must be employed of supplying gas to customers while the work is under way, or when the work done is on large feeder mains. In this event the importance of having everything in readiness before the cut-out is made should not be overlooked. Measurements should be checked and rechecked several times, and if possible by different men, and nothing in any manner resembling a chance should be taken. Plenty of equipment, tools and men should be on hand and

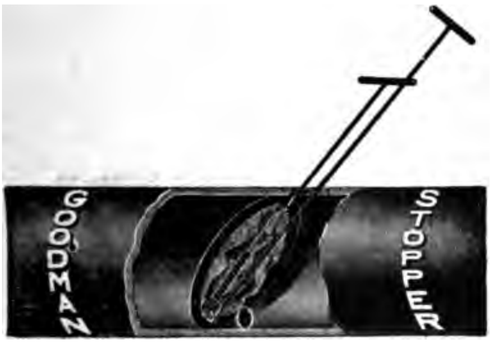


Fig. 333. Main Stopper in Position

each man should be previously instructed as to the particular duty he is to perform. Two wooden plugs of the size of main to be cut out and one of the size of new main must be kept closely at hand to use in case of bag or stoppage failure. In addition to the plugs a bundle of rags or old sacks and plenty of clay putty or soap should be on hand.

Where the new main is small of size or it is desired to supply new customers before the completion of the entire job, the connection to existing main may be the first thing done and the gas carried along as pipe is installed. This policy is not to be recommended if it can be avoided as there is a hazard attached to every length of pipe laid in the possible failure of bags and stoppers.

In bagging off or stopping the flow of gas temporarily in mains there are two methods in use: by means of collapsible rubber bags that are inflated with air after being inserted in the pipe and by means of expansive stoppers. Experience teaches that each have their particular advantages and disadvantages, while a combination of the two make an ideal arrangement. The gas bag is always liable to burst or become dislodged by excessive pressures, but is usually a gas-tight arrangement, while the stopper when properly set will not become dislodged, but is not as a general rule entirely gas tight. It is recommended that on all mains 6 in. and over in size a bag and stopper both be used together. The stopper against the flow of gas and the bag to prevent leakage. By this arrangement the advantages of each offset the disadvantages of the other.

Size of Holes for Main Stoppers

to the customers effected. In such cases temporary means must be employed of supplying service in a manner peculiar to the particular circumstance.

Purging of Air—After the main has been connected up and before the gas is turned on in consumer's premises or turned into other existing main systems the air contained in the pipes must be thoroughly expelled. In small mains this can usually be safely and thoroughly done by removing a plug at the extremity of the new system. In large installations this operation becomes

Fig. 334. Handy for Flooded Mains or Trenches

one of vital importance and of an extremely hazardous nature.

In purging large main installations a standpipe should be arranged in the hole to be used for "gasing" long enough to discharge over the heads of pedestrians. A controlling valve should be conveniently arranged in this pipe and a fine mesh wire gauze inserted near the top of the standpipe. All lights and fires should be kept away and in no case should an attempt be made to light or burn the escaping mixture. By the sense of smell and by calculation it should be determined when the gas is pure enough to turn into the system. Wher no dead ends exist in a new system and gas is suppli from either way, one bag or set of bag and stoppe

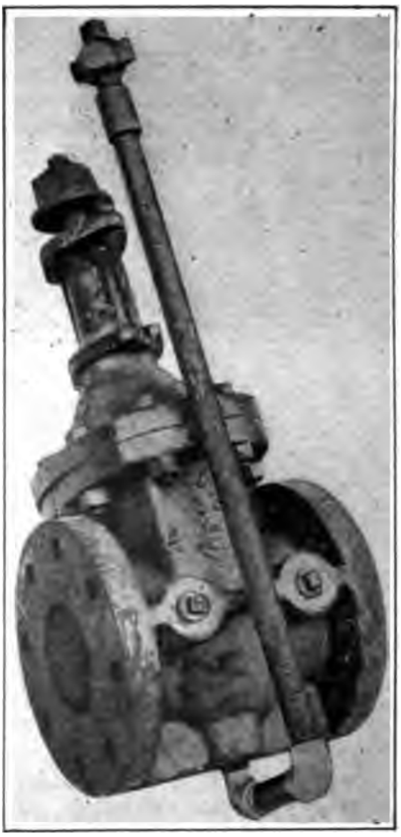


Fig. 335. Blow-off Pipe for Cleaning High Pressure Val

should be removed and the holes plugged and the t hole at the opposite end used as a purging hole, wi out removing the bag or stopper from that end.

Installing Drips—Drips are the necessary evils of gas distribution systems. Were the streets of a city perfectly level it would be possible to drain all condensation back to the gas works, but, as it is, provisions must be made for removing the condensation from the mains at all places where it is economically impossible to carry the established grade of the pipe.

Some cities are so unlevel that a great many drips are essential, while others have comparatively few, the number of drips required in any distribution system depending entirely upon local conditions. Unnecessary drips should not be installed, neither should necessary ones be neglected. When the installation of a drip is found necessary it should be installed in such a manner that the least amount of expense will be afterward incurred in operation and maintenance.

Main drips may be divided into two classes: line drips and end drips. The former are permanent while the latter may be used only until the main is extended and may consist simply of a section of pipe at least 10 ft. long, of the same size as the main, into the end of which a pumping stem is arranged. Line drips for use in cast iron mains usually consist of a cast iron cylinder containing a cover which is calked into place with lead in much the same manner as bell and spigot joints are made. Near the top of this cylinder and at opposite sides standard bells of the size of the main are cast. The method of installation is practically the same as for a special or fitting. The pumping stem should extend to within 2 in. of the bottom of the cylinder, while a tell-tale pipe should extend to the level of the bottom of the main. In welded steel pipe installations a line drip usually consists of a section of the pipe laid parallel with and under the main and connected by a welded nipple at one end to the bottom of the main and with the pumping stem arranged at the opposite end.

A cheap form of drip pot for cast iron mains consists of a cylinder 2 ft. in diameter and 18 in. long cast in one piece with reinforcements or bosses cast on the top side for tapping the connecting and pumping stem holes. The connection for joining to the main is made by tapping a 2-in. hole in the bottom of the main and connecting to the center of the cylinder by means of a long screw. A 1 in. hole should be tapped in the top of the main directly opposite the 2-in. hole and a tell-tale pipe run from the level of the bottom of the main. This tell-tale pipe being directly over the connecting pipe can be used for rodding out the drip connection. The pumping stem should extend up along side of the main.

Every drip should be provided with a tell-tale pipe as well as a pumping stem. When gas blows from the pipe it is certain that the main is clear. A drip pot should never be located away from the main, necessitating long connecting pipes or fittings as the danger of stoppage of these pipes with a consequent filling of the main with water is the inevitable result of such work. If the drip-pot is not a regular line drip inserted in the pipe line it should always be installed with a straight connection directly beneath the main. Long pumping pipes or pipes containing fittings are very nearly as hazardous as connecting pipes. The shorter and straighter the pipe connections to or from a drip-pot the least trouble will be experienced. It is recommended that on all paved and graded streets the tell-tale and pumping stem be extended straight up to the level of the street and then be enclosed within a valve box. Only where it cannot be avoided should the customary practice of extending drip pipes to the curb line be allowed. Brass caps should be used on all drip pipes and the size should be not less than 1 in. The use of brass caps insures their easy removal without injury to the stem.

Restoring Pavement—In most cities it is customary for gas companies to replace the dirt removed from the trench only, while the pavement is replaced by the city at the expense of the company. On surfaced or macadam streets, however, the company usually is called upon to restore the pavement to its original condition. On such streets it is necessary that the dirt be replaced in the trench in such a condition that settlement will not occur later. The surfacing material should be kept separate from and carefully free from dirt and must be well wetted and tamped down. It is possible to so handle this work, if the proper care is taken, that it is impossible to distinguish the trench in a short time after replacement.

In some cities the asphalt blocks taken up are replaced by the company, while in others the trench is planked until such time as the city desires to make repairs. Where the asphalt is replaced by the company great care should be exercised in taking it up. A wide, sharp and thin chisel should be used for cutting the asphalt into blocks. These blocks should be carefully laid aside until ready for replacement. After the concrete base is put in (the old concrete may be broken up and mixed with new cement) a thin grout of two parts sand and one of cement should be poured on top of it and the asphalt slabs laid in place. More of the grout should then be poured into the cracks and a plank long enough to reach across the trench and rest upon the solid pavement laid across the patches, which should then be pounded down until flush with the original pavement. All projecting cement should then be smoothed down and the patch protected from traffic for twenty-four hours. These patches are usually as permanent as the rest of the pavement.

The replacement of sidewalks requires the skill of a regular cement man, who may usually be found within the organization. The larger companies should retain such an employe as a regular member of the street department.

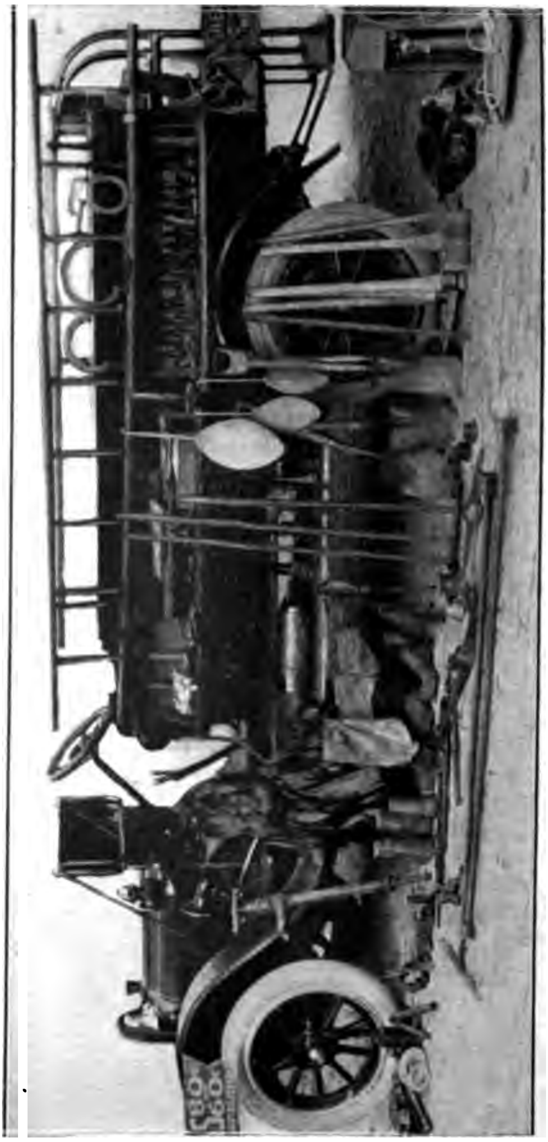


Fig. 336. Distribution Truck with Equipment of Tools

CHAPTER XV

SERVICES AND RECORDS

Improperly installed gas services have been the source of more complaints than perhaps any other one cause known to the gas business. A large proportion of the lost and unaccounted for gas may also be traced to faulty workmanship on gas services or other causes that might have been avoided to a large extent. The purpose of this article will be directed toward the mitigation of these evils by an attempt to follow the best rules of practice and pointing out the importance of this branch of street department work.

While the work of laying service pipes is not particularly difficult nor is the same relative degree of ability necessary in the service foreman as in the foreman of a large main construction gang, yet the fact must not be lost sight of that the total length of service pipes controlled by any gas company exceeds that of the main system. The importance of good workmanship and proper constructive features is therefore readily seen.

Location of Services—The first consideration in laying a service pipe is to determine the location. As the service is installed for the use of the consumer, and is usually for the greater part within his property, his wishes in regard to the location must be considered, but not to the extent of allowing a location to be made that would be detrimental to the interests of the company nor in any way hazardous or detrimental to either the property of the customer or the company.

Before a service order is placed in the hands of the foreman for execution it should be located and measured up by an inspector, who should consult with the owner, architect, contractor or agent of the property to be supplied, whose approval of the location determined upon should be recorded by his signature upon the order or inspection card. This method eliminates waste of time by the service foreman, who can start work immediately upon his arrival at the building, and insures a proper and satisfactory location from the standpoint of the company and customer, eliminates any chance of the service being changed once it is installed and allows the exact amount of material to be delivered to each job.

The location of each particular service depends entirely upon local conditions, but certain prominent rules should be observed in all cases. The first and most important rule is to bring the service into the building in the shortest and straightest line that is possible, avoiding all unnecessary bends and fittings. The second is to bring the service into a good meter location, avoiding coal cellars, vaults, furnace rooms or any location that would prove detrimental or dangerous, as previously shown in the chapter on "Meter Locations." Other rules to follow are: The avoidance of water and sewer connection ditches and pipes, and running into or through finished basement rooms. Care must also be exercised that foundation walls are not broken through at a point that might weaken them. The pipe should never run under a porch or foundation pier nor within three feet of a parallel wall or of a pier that does not extend below the depth of the service trench. Neither should the pipe be exposed to extremes of temperature as when running under porches or through areaways, or be trapped. Any apparent causes leading to a possible chance of injury either to the pipe or property or that might at any future time cause an interference to gas supply should be strictly avoided.

Size of Service Pipes—The size of the service pipe should be fixed by the inspector locating same and in no case in low pressure distribution systems should it be less than 1¼ in. This size is ample for the ordinary dwelling house or residence unless some special appliance having a large demand is to be installed. The installation of 1¼-in. services as a minimum size provide

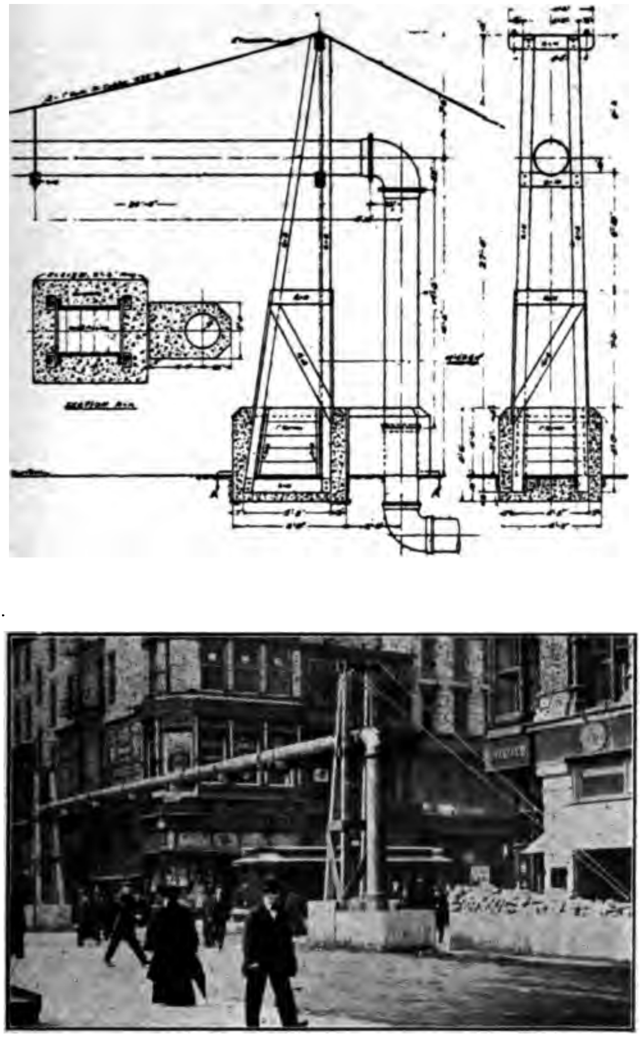


Fig. 337. Details and View of Temporary By-Pass

additional strength, allowance for partial obstruction and for future appliance installations which more than offset the slight additional material cost. All services supplying industrial consumers or within the business district of a city should be of a minimum size of 2 in. The possible demand of such buildings should be carefully estimated by the inspector before deciding upon the size of service pipe. It is a good policy for gas companies to establish a rule of laying service pipes of a 2-in. minimum size in all paved streets, at least for the distance between the main and curb line where a parking space is provided between the curb and sidewalk.

In the connections between the service pipe and main precautions must be taken to prevent weakening and possibly breaking the mains. Where service connections are made to mains smaller than 4 in., service saddles should be used for 1¼-in. services and tees cut in for larger sizes.

The following table shows the largest size tap that should be made in C. I. mains of a given size:

Diam. main inches	Diam. hole inches
4	1¼
6	1½
8	2
10	2
12	2½
16	3
20	4
24	4
30	4

If larger taps are required a service saddle, split sleeve or cut-in tee should be used. It should be remembered that the size of the tap hole does not necessarily limit the service pipe to that size. Two-inch service pipes may be safely run from 1¼-in. tap holes with the assurance of an ample flow of gas, the pressure drop through the slight length of the reduction

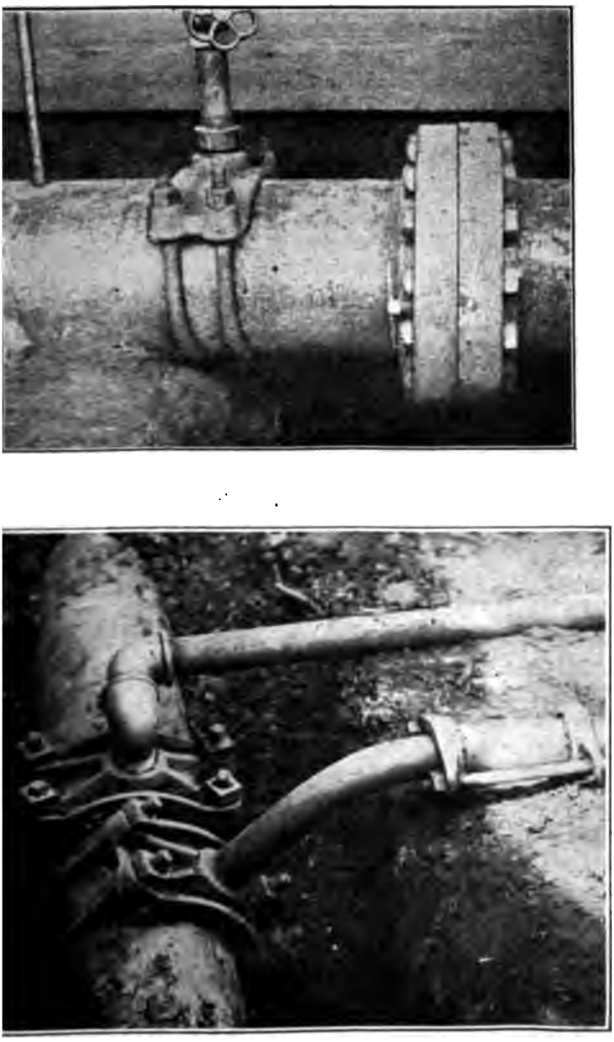


Fig. 338. Ways of Installing Service Saddles

being quite neglible. The length of the reduction connection should, however, be as small as possible. The use of reducing street tees, i. e., a tee having a reduced male thread, are recommended for this purpose.

Service connections to wrought iron mains of sizes smaller than 8 in. should be made by the use of a service saddle as the thickness of the pipe does not allow a sufficient number of threads for mechanical strength. In the larger sizes of wrought iron mains this objection is overcome unless the tap hole is to be of a large size when a saddle should also be used. When connecting services to a new section of wrought iron main an ideal way is to weld nipples permanently into the top of the main before gas is turned in.

Methods of Installing Services—Each individual service should be supplied from a separate tap hole. The tap holes should be made in the top of the main in all cases where it is possible to do so and service connections made by the use of a swing joint, i. e., a street tee and street ell. The swing joint affords a flexibility allowing for settlements of the main and a small amount of expansion or contraction in the service pipe itself. It also allows the pipe to be laid at angles in any direction such as is necessary in securing a proper grade, and which is a more difficult proposition when the tap is made in the side of the main and a rigid connection used.

The top tap allows a rubber plug, such as has been described, to be used in shutting off the gas while the pipe is being connected. The use of this plug is to b especially recommended as it has often prevente asphyxiation of workmen in close places such as are s often encountered in service work.

As has been previously stated, the line of service pi between the main and meter should be as short a direct as it can possibly be made. All unnecessa fittings and bends, except the street tee and street at the main, should be eliminated. Every fitting stalled in a service pipe is equivalent to a poss

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stoppage at some future time. If the line is straight it can be rodded out with little trouble in case of stoppage, while if a fitting exists in the line excavating is often necessary, and it will probably be at a time when the ground is solidly frozen, entailing a large expense.

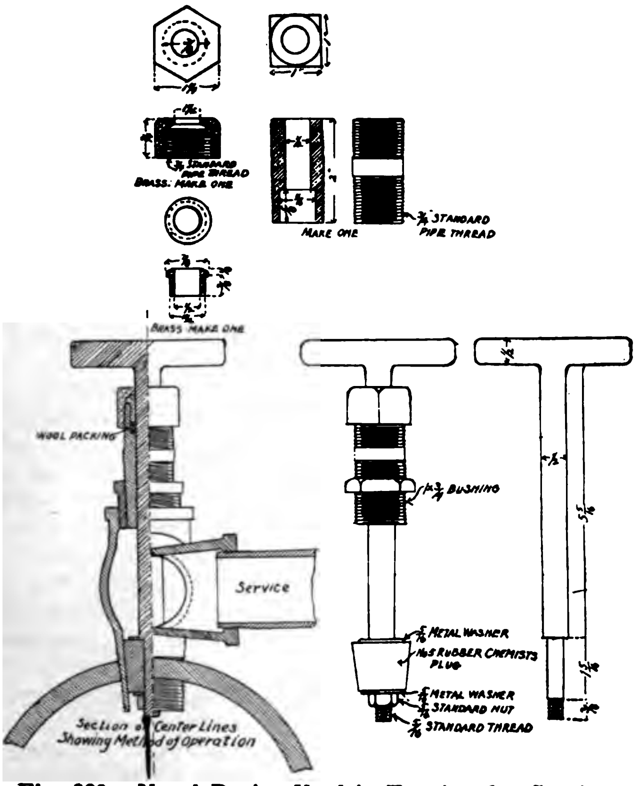

Fig. 339. Novel Device Used in Tapping for Services

The practice of running services along the curb before entering a building, such as too often is the case where stub services are installed during the pavement of streets, should be abolished. Such installations very often cause a maintenance expense far in excess of what the cost of a properly laid service in the pavement would be and in addition cause needless trouble and annoyance to the customer supplied thereby.

In terrace work a properly bent riser pipe connected by means of a long screw is recommended. Where these cannot be used 45 deg. ells should be substituted. The use of 90 deg. bends should be restricted to the minimum degree.

A service pipe should never be driven or forced through the ground as is often practiced. In addition to the danger of injuring the pipe, causing leakage, there is the possibility of causing a trap or sag by deflection. Tunneling under sidewalks, pavement and obstructions is a safe and satisfactory method that should be employed. The use of a tunneling spade making a hole but slightly larger than the pipe couplings is seldom any more expensive than driving or forcing and is a great deal safer.

The coating of service pipe is not a necessity in ordinary soils, while in those having a destroying action, the pipe will require a protection greater than any coating could give it. We would recommend the general use of uncoated pipe with individual study of conditions requiring protective covering and a suitable remedy prescribed in such cases. However, the threads of the pipe must be protected in some manner. In all cases the best method of insuring this protection is by the use of recessed fittings which completely cover the thread.

Except in extraordinary and unavoidable instances all service pipes should drain toward the main. If for any reason, which would be principally insufficient covering, this cannot be done a service drip should be installed at the curb and handled in the same manner as gas main drips. The installation of inside drips often cause undue annoyance to the customer. All services should be laid below the local frost line for their entire length.

Where the service pipe enters the building wall it should be encased within a piece of creosoted wooden pump tubing as long as the thickness of the wall or spaced centrally within a ferrule of larger sized pipe. The point where the service enters the building is often a place susceptible to freezing and corrosion when the pipes are embedded in the masonry of the wall.

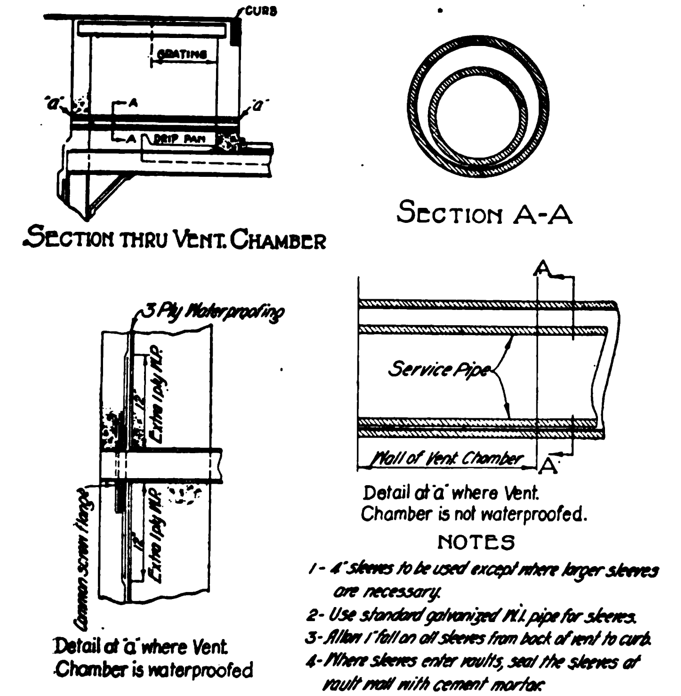

Fig. 340. Waterproof Conduit for Service Pipe

The most efficient and economical service work is done where the gang units consist of a working foreman and not over three men. The foreman being on the job all the time and working himself. The practice of having a number of service gangs in different localities supervised by one foreman is theoretically an efficient ararngement, but in actual practice is very liable to be uneconomical. The foreman can supervise but one gang at a time and while going from one job to the other, none at all. During his absence work will not go at top speed as it would were he there continuously and setting the pace for the men by his own efforts.

The service gangs should be provided with light, two wheeled tool boxes and no more weight carried than is absolutely necessary. These boxes should be moved from one job to another by the crew themselves where the distance does not exceed one mile and con-

Fig. 341. Check Valve in Line Liable to Explosion

ditions of streets are favorable. Where conditions are not favorable or the distance too great, means should be provided for moving the boxes, while the gang is sent on ahead to the job with tools to begin work. The cost of moving boxes and gangs should be carefully watched as much valuable time can be wasted where the men are compelled to pull the box long distances, through muddy streets or on hot days.

Service costs are a variable factor that are controlled by local conditions. No attempt will therefore be made to give detailed cost items, as such costs would be inconsistent for all companies.

Service Cocks or Valves—The matter of installing stop cocks and valves on service pipes has been an issue with gas companies for a great many years and has been a subject studied by various committees and commissions. A definite settlement of this question may be expected in the National Gas Safety Code now being gotten up by the United States Bureau of Standards. Until this code assumes a completed form there will be more or less of a difference of opinion among gas men as to just how this situation shall be handled and the purpose of this article will be the attempt to point out advantages and disadvantages and suggest a possible solution which is understood to be dependent upon the practice as recommended by the proposed National Gas Safety Code.

From a theoretical standpoint outside control of the gas supply on each service is desirable, but it brings up objections that are practically difficult to overcome. A great many companies started the practice years ago of installing stop cocks on each service pipe at the curb, afterward discontinuing the practice in certain districts or allowing the cocks to become unserviceable through disuse or neglect. At the present time it is very much the general practice to install shut-offs only on the services within business districts or on large services.

The primary purpose of the shut-off outside of a building is to quickly and safely discontinue the supply of gas in case of fire, particularly those occurring in basements. Unless these shut-offs are periodically inspected and tested they are very apt to be found useless when needed through the box being filled with dirt, covered by new walks, the core of the cock being stuck or no key available. In the larger cities this requires a tremendous expense for maintenance labor as well as a large initial investment that is hardly warranted by the number of basement fires where the gas cannot be shut-off at the service or meter cock. Any outside shut-off is a duplicate, as an inside service cock or meter cock should always be installed, and

...ergency, where
logically be used, that the c
when tried or it is not tried a
going directly to and remo
organized companies a trou
all fire alarms to attend to a
gas supply, as directed by t
It is seldom that these men
of the outside shut-off, prov
and it is a rare case where tl
moved after the supply of g
by the marshall.

The use of automatic dev
gas supply, which usually co
spring operated cock held op
impractical and not to be reco
ance of operation depends up
exact vicinity of the device an
a greater hazard by cutting of
tune time is ever a possibility.
probability of such devices be
needed through rusted, stuck o
The shutting off of gas suppl
controlled so that in emergenci
be created.

It is suggested that outside s
on services of sizes larger th

a record kept of the condition of and maintenance necessary on each valve.

Distribution Maintenance

Where the size of the company or the amount of maintenance work warrants, it will be found advantageous to maintain a force of maintenance men who attend to this class of work exclusively. The same principle of specialism applies here as in all other

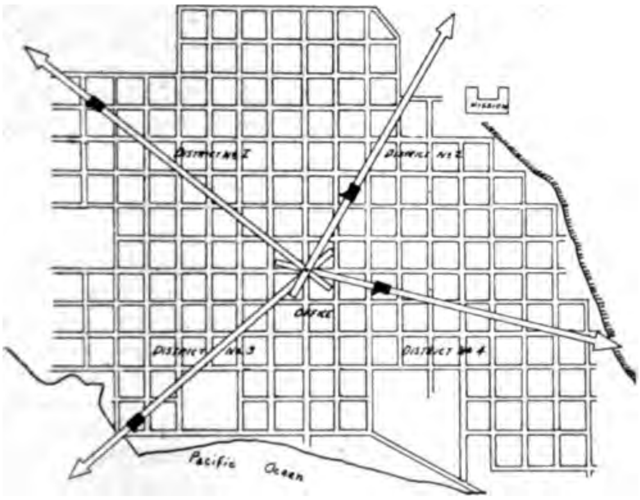

Fig. 342. Distribution Map Device for Locating Gangs

classes of gas company work, and to which the truism applies that "anybody's business is nobody's business."

The class of work done by these men would cover: Leaks in mains, leaks in services requiring excavating, main stoppage, service stoppage, that cannot be cleared by ordinary means; outside stop-cock and valve maintenance, district governor maintenance, repairs to drips, etc. This work may be divided into routine maintenance and emergency maintenance, and handled in such

[redacted]

a manner that the force of men made necessary by the size of the company is kept busy at all times, the routine work being used to fill in the intervals that will occur at certain times between emergency jobs.

Maintenance work can generally be best handled by crews of three men, comprising a working foreman and two helpers. When an unusually large job is experienced extra common laborers may be temporarily added to the regular units.

The crews should be furnished with a wagon or light work truck, containing tools and equipment necessary for making temporary repairs in case of leaks and for clearing stopped pipes and attending to routine work. It is important that the crews arrive at the destination of and attend to emergency work with the greatest expedience.

Included in the equipment of all maintenance crews should be a Wrigley sewer cleaner, which consists of a bit, similar to an augur, attached to the end of a 50-ft. length of flexible transmission. The transmission is wound upon a reel which may be rotated as it revolves, thus imparting a rotating motion to the bit as it is pushed through the pipe. Different sized bits may be used for the various sizes of service pipes. By the use of this apparatus the most obstinate stoppages may be removed at a slight expense as compared to other methods and the necessity of renewing services through failure to clear practically eliminated. In using this apparatus, or any other equipment for a similar purpose, the service should be cut outside of the building to prevent the escape of gas into the building while work is in progress. It has been found that mechanical strength cannot be obtained in transmissions more than 50 feet in length without an increase in cross-section prohibitive to its use in ordinary service pipes, therefore, where services exceed this length the pipe should be cut at a point allowing the cleaner to be pushed through each section separately.

A record should be kept of all routine maintenance work done, showing date and class of attention given. All valves and shut-offs should be kept in condition for emergency use. Those which are ordinarily kept open should be closed and those ordinarily closed should be opened at periodic intervals. When a valve is closed a test should be made for tightness if it is possible to do so. All valves of outside screw design should be kept oiled or greased and wrapped with cloth, but not in such a manner that time would be wasted removing such wrappings in case of extreme emergency. The use of creosote or "tar oil" can be recommended for use on underground valves for preventing and arresting

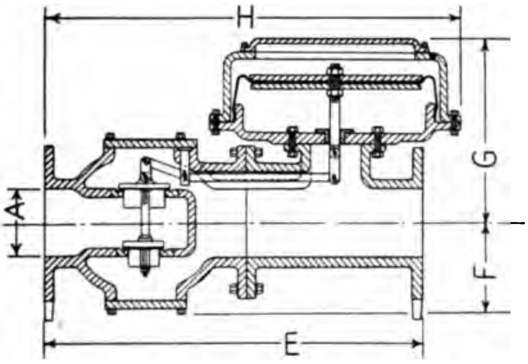

Fig. 343. Distribution Pressure Governor

corrosion. All valves should be tapped in the bonnet so that the oil can be injected onto the disk guides or screw of inside stem valves. A liberal dose of creosote at inspection time, say once each month, accompanied with the opening or closing of the valve at that time, will insure its operation at any time required.

Handling Condensation From Gas Mains—The subject of condensation from gas pipes and the necessity for drainage to and removal from a receptacle conveniently arranged has been discussed, so that under this heading will be shown methods of handling the

[redacted]

condensation from main and service drips and the importance of this part of distribution work.

The drips in a distribution system should be divided into various classes dependent upon their proximity to gas works, and importance in relation to area of main drained and gas flowing. Some drips will need pumping every day, while others may be pumped semi-weekly, weekly, semi-monthly, monthly, semi-yearly, yearly or some intermediate division of time. Each drip should be numbered and catalogued in the class to which it belongs and a regular schedule or pumping time maintained. It should also be considered that at certain times of the year, practically in the spring and fall, condensation will be obtained in greater amounts than at other times, therefore requiring greater attention or more frequent pumping. By keeping a permanent record of the date and amount of condensation taken from each drip a schedule may be arranged, varying with the seasons if necessary, which will insure the clearness of the mains at all times.

The importance of keeping drips in good working condition, pumping them religiously on schedule time and keeping an accurate and permanent drip record must not be overlooked or considered lightly, as carelessness or negligence in any part of this work will inevitably be followed by trouble on the line affected which may assume serious aspects by causing a cessation of gas supply.

A trouble experienced by many companies is the failure to record new drips installed, which is followed by a section of main becoming shut-off by condensation sometime afterward. This trouble is not, as a rule, attributable to the foreman installing the main, but to the system of office records, and the fact that the importance of a drip record is not fully understood. A main construction work order should contain space for recording the measurements of drips, if any are installed, moved or abandoned. After this data is recorded upon the office record a copy should be sent the street department in charge of drip pumping. The order sent this department should be signed by the proper authority, after recording the data on the working record, and returned to the office. This provides a check between the working record and that of the office. Pumping slips should be provided showing date, number of drips, and amount of condensation removed from each, which should be filled out by the operator and sent to the office each day for recording. This record may prove of importance in more ways than one, as an abnormal increase in condensation from some particular drip may denote a leak in the main drained thereby, while an abnormal decrease may indicate a stoppage.

The operator pumping drips should report any irregularity discovered or repair needed to the general foreman, who should investigate the same without delay.

A tank wagon or truck should be provided for pumping into and conveying the condensation from drips. In several of the larger cities motor driven pumps are used in conjunction with motor propelled vehicles. The size of the company would regulate the necessity for such equipment, but where it is warranted it will be found economical and efficient and should be used. Regardless of the size of the city, however, some form of a closed vehicle should be used and tight connections made between the pump and tank so as to eliminate spillage while pumping. The greatest of care should be exercised in handling drippage so that offensiveness to the public is reduced to the minimum.

Condensation from gas mains contains inflammable hydro-carbons or oils in varying quantities, so that an explosion and fire hazard accompanies its handling at all times. Due precautions must be observed to prevent accidents by keeping lights and fire away. Pumping or dumping into public sewers should not be practiced as explosions or contaminations of waterways might result. City ordinances usually prohibit such practice. The proper method of disposal should be to haul all condensation to the gas works where the hydrocarbons may be separated and made use of, while the waste water is disposed of in a manner creating no offense to the city or public.

Pressure Regulation and Surveys

Every well regulated company should be kept informed in regard to pressure conditions existing along its lines of distributing mains and on the extremities

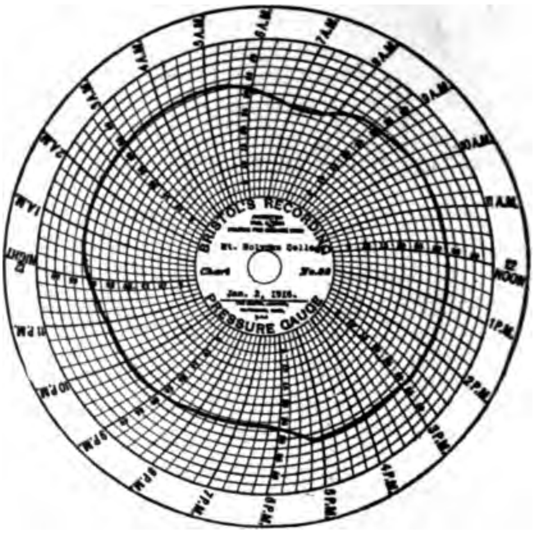

Fig. 344. Chart from Recording Pressure Gage

of its system. This should be realized through the use of recording gages installed permanently at determined points, and by taking frequent surveys of the entire distribution system. No company is too small to observe this requirement of efficient service. The permanent gages are the means of regulating the pressure carried at the sources of supply to maintain efficient utilization pressures while the periodic surveys point out the need of additional or larger feeders, the

necessity of changing the location of permanent or regulating gages, or the extension of service governor districts.

The number of permanent gages required by a company for efficient pressure regulation depends entirely upon the size and local condition of the company and may vary from two to several hundred or more, as the

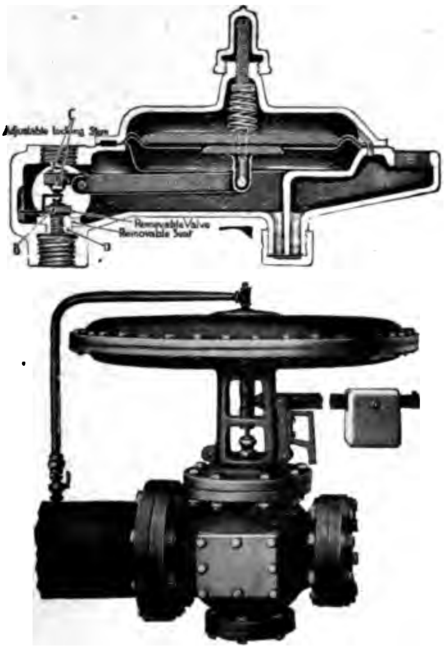

Fig. 345. Two Forms of Consumers' Pressure Gage

divisions of the distributing system and consequent low points or extremities vary.

The use of the Unison Telemetric Gage can be especially recommended as a means of efficiently aiding in pressure control. In such cases the transmitters are located at the extremities or low points of the distribution system, and pressures are varied at the source of

control to maintain a constant predetermined pressure at these outlying points as shown by the indicators at the control points. With the use of these instruments a standard of service measured by efficient pressure regulations can be attained, approaching very near to perfection, while it is often difficult, and in some cases practically impossible, to arrange a predetermined schedule of pressures to take care of erratic fluctuations in the demand without their use.

Pressure surveys of the entire distribution system should be taken at least twice each year. The starting point should be at the gas plant and holder stations, and each transmission and feeder main should be fol-

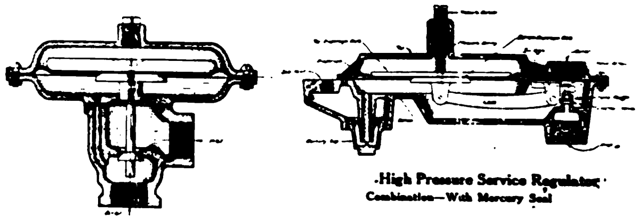

Fig. 346. For Regulating Supply in High Pressure Line

lowed to its end, taking pressures at each branch or reduction point and at suitable intermediate locations.

Surveys may be made by the use of recording gages or U gages, preferably the former, as they allow the pressures for the entire 24 hours of the day to be noted. Where U gages are used readings at five-minute intervals during the peak hour should be taken, the lowest reading during the time of highest initial pressure being used for comparison. As many simultaneous readings as is possible should be obtained in following out a line of main. Theoretically the survey of the entire system should be made at one time, but this is usually impracticable owing to the number of gages or readers available. Where a survey is carried through several succeeding days a correction should be

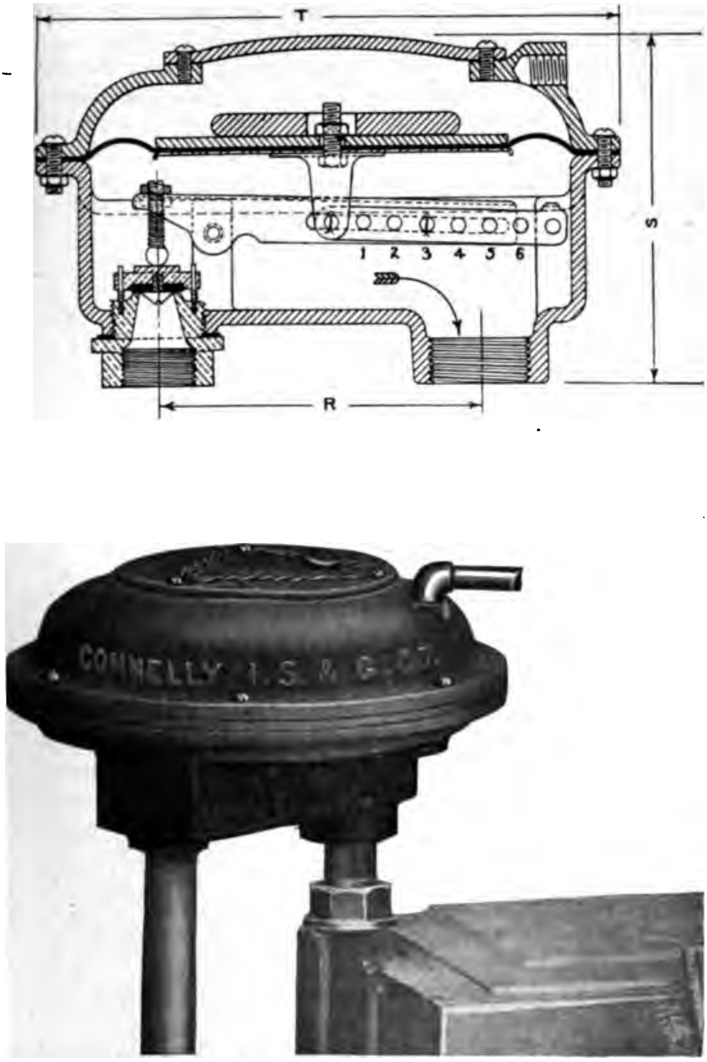

Fig. 347. Regulator in Section and Attached to Meter

made of all readings to a standard, as shown by the first day's pressure. This can be done by allowing the last gage on the line to remain at the same place for the succeeding day, being jumped by all the other gages and becoming the first gage in the line on the next day.

Illustrating this point let us suppose there are five gages in use spread out along a line of main. The location points will be known as Nos. 1 to 5. On the first day the readings are: No. 1, 10 in.; No. 2, 9 in.; No. 3, 8 in.; No. 4, 7 in., and No. 5, 6 in. On the second day No. 5 is left at the same location, being known as No. 1, while the other gages are moved along. The pressures shown on this day are: No. 1, 8 in.; No. 2, 7 in.; No. 3, 6 in.; No. 4, 5 in., and No. 5, 4 in. It is seen that No. 1 gage on the second day registers two inches higher than on the previous day at the same location. This would more than likely be due to a decreased demand. Correcting to the first day's standard the pressures would be recorded as follows: No. 1, 6 in.; No. 2, 5 in.; No. 3, 4 in.; No. 4, 3 in., and No. 5, 2 in., and so on for each succeeding day, adding or deducting the difference between the corrected reading and actual reading on the first gage to or from the readings of the other gages. While this method is not technically correct it is close enough for all practical purposes.

The time of taking reading should be given careful consideration. If recording gages are used each clock should be in unison while if U gages are used the timepieces of the readers should be similarly set.

After the readings are all taken they should be recorded on a skeleton map of the distribution system after corrections have been made for the difference in elevations as compared to that of some standard point, usually the gas plant. Pressure drops can then be noted and studied and necessary improvements intelligently planned.

Gages for taking pressure readings should, where possible, be located on unused services, or on services that are not heavily drawn upon during the time readings are taken. Before installing the gage it must be ascertained that the service is thoroughly clear and is not overloaded. The gage should be connected to the service pipe preceding the meter and service governor, if the latter is used, and as near to the main as is possible. Permanent gages should be connected to individual services from which there is no consumption. It is recommended that they be installed on posts or in vaults in the street and not on consumers premises.

Work Orders, Reports and Records

It will not be the purpose of this article to prescribe any particular forms of work order, report or record as that subject may best be handled separately entirely from this series. There are no reasons why a standard form of work order and system of reporting and recording cannot be adopted for the use of all companies with slight modifications to suit local conditions or necessities.

Work orders, reports and records are of equal value in distribution work, and are to a large extent interdependent upon each other for their actual value to the company. Distribution work, as a general thing, is hidden from view upon its completion by a covering of earth or pavement, but it is possible for the records of such work to be kept in a manner that the handicap of invisibility is overcome completely. This should be the aim of all companies and is a matter of such vast importance, in view of future trouble and expense, that no pains can afford to be spared in making all reports and records as complete and perfect as ability is possible of doing.

The work order going from the office to the foreman should contain all information obtained from the permanent office records that would be of benefit in carrying on the work to completion. This should include measurements from property lines, locations, of fittings, size and depth of main, direction of drainage, kind of soil and pavement, materials needed and any other data of particular value to the foreman doing the work, a sketch of the proposed work should also be a part of the order. Upon the work order should be spaces for a complete report of the finished work which would include in turn all measurements and data of value as a permanent record of the job. A sketch of the completed work should be a part of this report. The foreman of distribution work should bear in mind the importance attached to an accurate record or knowledge in after years of all underground piping and work done by a company and should spare no pains to make their report complete to the most minute detail. It is much better to include some information that may be proved of no particular value than to neglect to report some very important, though seemingly obscure detail, that might in future cost a large sum of money to locate or verify.

The matter of a perfect system of office records should be given unlimited attention by any company. We have seen good reports become useless through an inefficient recording system, or through the use of no system at all. The most common form of inefficiency is where foreman's reports are filed for an indefinite period and then when the files become filled or a housecleaning spirit enters the office, they are tied up in a bundle promiscuously and consigned to the basement and possibly later to the furnace, and with them is destroyed thousands of dollars worth of costly effort. How often have we seen an old employe carrying the entire records of a company distribution system in his head or imagining at least that he was doing so, and to the extent that he was held indispenable to the company. It is ludicrous to think of such a state of affairs existing at the present time, and deplorable where true. We have seen these living records put to the test and have seen them fail utterly through the fact that no living man can keep the record of everything he does inviolate against the erasure of time. Companies have attempted to secure a permanent record by recording the data given up by an old employe with the result that it was little better than no record at all. We have spent days and many dollars digging for lost pipes that could have been saved by a system of records. And it might be stated before proceeding further that the best system in the world is useless unless kept up to date and complete in every respect. It is here seen how important and inter-dependant are efficient work orders, reports and records to each other.

Fig. 348. Device for Muffling Pressure Pulsations

A system of plat records for mains and services will be found indispensable to any company. These may be section plats, bound together in book form, or kept in floor files and supplemented by a wall map divided into sections corresponding to the plats and bearing a corresponding number. A location desired is found within a certain section of the wall map which is designated by the number of the plat wanted. The plats should be drawn to some convenient scale, say 1 in. = 50 ft.

Upon the plats should be drawn in from the foreman's report on each work order the size and location of mains, size and location of services, house numbers of services, depths of mains, direction of drainage, location and size of fittings, valves or governors, location and number of drips, kind of soil and pavement, work order number and any other data that might prove of even remote value in future.

A handy form of record for small companies will be found in the insurance maps gotten out by the Fire Underwriters' Association, and which are corrected once each year by the association. These maps are sectional and bound in book form and contain a true record of street and property layout, in addition to the contour and class of all buildings within the city. They make a very complete record when the mains are drawn in to scale and the services located accurately into the buildings shown. Even inside extensions can be accurately shown.

Stock, Tools and Equipment

In addition to the plat system all work orders should be permanently filed and never destroyed. When the office files become filled and additional filing room is not available storage files should be used. These storage files may often be conveniently located at the company warehouse along with other old office records.

All stock and tools used by the distribution department of a company should be in charge of the company storekeeper, and when convenient to do so kept in the general warehouse or on open property considered as a part of that institution. Stock and tools should be requisitioned as needed by the head of the street department and all surplus returned and credited

A certain amount of equipment such as tool boxes, tapping machines, picks, shovels and small tools must remain in the hands of the working force of this department at all times, but not any more than is necessary to carry on the work at any particular time. All such equipment should be listed by the storekeeper and charged up to the street department, inventories being taken at regular intervals and replacements of defective articles promptly made.

The importance of keeping good tools and equipment in the hands of the workmen at all times must not be overlooked. Accidents are very likely to result from a failure to observe this rule, as well as a great loss in working efficiency. A particularly hazardous tool to use when old or defective is a gas bag for shutting off the supply of gas in mains. Serious and even fatal accidents may result from carelessness in this respect. A supply of gas bags and safety stoppers should be kept on hand in the warehouse and drawn only when needed, being promptly examined, cleaned and returned when the work demanding their use is finished. At least three bags and two stoppers of each size of main in the distribution system should be kept on hand by even the smallest company, while the larger ones should be governed by their mileage of mains and the amount of work being done. No rubber bag should be used after one year from date of purchase. All bags being identified by tag or otherwise showing date to be discarded. Replenishment to this stock should be made by telegraph in cases of destroyed bags and and in ample time when they are naturally discarded for age that they will arrive before the date of expiration of safe use arrives.

Transportation Facilities—The use of automobile trucks can be recommended in this department for all work necessitating transportation facilities, such as the delivery of materials, moving tool boxes, trouble work, maintenance work and pumping drips.

A great saving is being made in some of the larger companies by the use of automobile drip tanks, using the motor of the vehicle for operating the pump. By this means a great many more drips can be visited and a much larger quantity of condensation handled than with the horse-drawn tank vehicle and hand-operated pump.

The superintendents, inspectors and those engaged in operation work requiring principally the covering of ground should be provided with light runabout automobiles.

"Safety first" should be a slogan of all gas companies. Every effort should be made to safeguard the workmen and public and the property of both customer and company. The subject of "Safety First" has been given a great deal of attention in recent years by utility corporations with great success, and much literature is now available which will prove of value to

Fig. 349. A Safe Place for Gas Pipe on Busy Streets

gas companies. The safeguarding of open trenches is a feature particularly effecting the street department, and it should be given unlimited attention by the foremen in charge of all construction work. The erection of safety barricades, the display of warning signs, and the use of plenty of red lights at night should be an ironclad rule of practice, and any precautions should be taken that would eliminate even the most remote possibilities of an accident.

CHAPTER XVI

ACETYLENE WELDING

The joining of metal parts by fusion or welding is not new, but its application to joining the ends of gas pipe and mains through the use of an acetylene-oxygen torch is a somewhat recent development. By the older methods of welding and brazing, the oxidized iron or scale was washed out of the heated junction by such

Fig. 350. Welding Steel Main with Oxy-Acetylene Torch

easily melted substances as borax or other easily fusible metals or compounds, and the pure iron surfaces were successfully pasted together by pressure or hammering. Autogenous welding differs by filling the gap with a good quality of iron instead, and the joint thus made may even be stronger than the original pipe.

The need for a better method of joining metals without the aid of machine tools developed such successful processes as autogenous, thermit and electric welding, of which the former has the wider application in the gas industry. In fact, its use has become general in all but the simplest routine work. Whenever special fitting is required without loss of time the oxy-acetylene torch is now used for both the cutting and welding, and the position of the method in the industry is well established today.

On page 770 of the September 15, 1911, issue of Progressive Age mention was made of the possibilities of acetylene welding, the editorial concluding with: "The welding of gas pipes also is not difficult before laying. It is a subject worth keeping an eye on." This suggestion was justified by developments at the time, the first mains being welded that year. Among the important articles published by Progressive Age and The Gas Age were the following:

Jones, Leon B.—Welding of High Pressure Pipe Lines—Nov. 1, 1912, p. 924.

Keppelmann, D. E.—The Automobile in Modern Gas Distribution—Nov. 15, 1913, p. 467.

Harding, H. P.—Welding and Cutting of Metals—May 1, 1914, p. 435.

Keppelmann, D. E.—Welding in Gas Distribution—Oct. 1, 1914, p. 311.

Shattuck, J. D.—Welding of High Pressure Mains—Nov. 16, 1914, p. 470.

Welding of Gas Main Joints and Specials (with data)—Feb. 1, 1915, p. 121.

Young, D. J.—Some New Practical Methods of Laying Welded Pipe—Dec. 22, 1915, p. 388.

Hall, A. S.—Welding of High Pressure Mains at Springfield—March 1, 1916, p. 259.

Hadley, F. L.—Welding of Joints in Gas Main Construction—June 15, 1916, p. 695.

Sutton, C. R.—Spanning Brazos River with 10-in. Welded Mains—Aug. 1, 1916, p. 120.

Keppelmann, D. E.—Distribution of Gas Under High Pressures—Nov. 1, 1916, p. 453.
Sibley, F. H.—Oxy-Acetylene Welded and Screwed Pipe Tests—June 1, 1917, p. 608; May 1, 1917, p. 443; Jan. 1, 1918, p. 50.
Wilde, Charles—Oxy-acetylene Welding—Proc. Am. Gas Inst., 1916, Pt. 2, p. 1069.

A book upon the subject, entitled "Oxy-acetylene Welding," was written by S. W. Miller in 1916. In

Fig. 351. Cutting Torch in Operation in Shop

1915 Theodore Kautny's work on "Autogenous Welding and Cutting" was published and in 1914 Richard N. Hart revised his book on "Welding; Theory, Practice, Apparatus and Tests," which had been first published in 1910. Since practically nothing is said by the latter book about welding gas pipe, it may be assumed that the practice was not well known at that time. The most recent work is "Oxwelding and Cutting," issued

1918 by the Oxweld Acetylene Co. A study of the above references will repay the student of oxy-acetylene pipe welding.

Apparatus Required

The operation of welding and cutting of metals requires the following apparatus:

Oxygen tank holding about 200 cu. ft. under 1,800 lb. per sq. in. pressure.

Acetylene tank holding about 300 cu. ft. of gas under 250 lb. pressure and filled with acetone charged porous brick for dissolving the gas. Or an acetylene generator with a capacity for 25 to 50 lb. of carbide for the portable type capable of producing from 25 to 50 cu. ft. of gas per hour during a half day of operation.

For both the oxygen and acetylene cylinders are required an attachment to the discharge fitting, carrying a tank pressure gage, a torch supply pressure gage, a pressure regulator reducing to 30 lb., and 12 ft. of hose leading to the torch, red for oxygen and black for acetylene.

Welding torch with ten tips having orifices the size of which is proportioned to the weight of the work to be done.

Cutting torch designed for the work.

Colored spectacles, instructions for operating, connections, wrenches, etc.

Variations from the portable equipment exist in shops or permanent locations for work such as yard work. For this larger acetylene generators are used and compressing machinery provided to charge cylinders. It is not within the scope of this treatise to enter further into the technology of this process further than necessary for a clear general understanding, but the practical information regarding the equipment given in the handbook entitled "Oxwelding and Cutting," issued by the Oxweld Acetylene Co., may be read with profit. For example, regarding the equipment the author says:

Oxygen—It has no odor and is invisible. It is usually supplied in steel cylinders or tanks. The standard cylinders hold 200 cu. ft. of oxygen. The oxygen is pumped into these cylinders at 1,800 lb. pressure. The amount of oxygen in a cylinder can be determined by looking at the high pressure gage of the regulator.

Fig. 352. Portable Acetylene Generator and Oxygen Tank

In general, for every 9 lb. pressure below the filling pressure of 1,800 lb., there will be 1 cu. ft. less of oxygen in the cylinder. A mixture of oxygen and gas, being explosive, should be avoided in the presence of a flame. Oxygen also will combine with grease, oil, or other inflammable materials with explosive violence.

linder valve, always first "crack" the valve (open e valve slightly) both to clean out the valve and to e that it is operating properly.

Acetylene—Acetylene is the gas that burns in the y-acetylene flame. When it is burned alone, without ıy previous mixture of oxygen, it produces a yellow-h, smoky flame. When mixed with oxygen, it produces bluish white flame. It is an invisible gas, but has a stinct odor. Acetylene is made by dropping calcium ırbide into water. The acetylene bubbles up through .e water, leaving a white sludge of slaked lime at .e bottom of the vessel.

Fig. 354. Automobile Welding Equipment

It is not practicable to compress acetylene at a high 'essure into an empty tank, as is done with oxygen. his is because acetylene at a high pressure may ex-ode. For this reason a different style of tank is used. ıside the tank is placed a material that is porous. his material is soaked in liquid acetone. Acetylene ill be dissolved by this liquid just as sugar is dis-lved in water. When acetylene is pumped into a tank ' this kind, it is safe. It is never pumped up to a 'essure above 250 lb. The tank of acetylene usually ıntains 300 cu. ft. of gas.

No blowpipe that will empty it in less than 7 hours should be used on any acetylene tank. If the tank is emptied in a shorter time than this, the liquid will be drawn out of the tank. Do not drop or jar an acetylene cylinder. Handle it carefully. Always keep an acetylene cylinder in as cool a place as possible. Do not stand it near a fire. If possible, it should be kept out of the hot sun.

Before connecting an acetylene regulator to a tank, be sure that the cylinder valve is operating properly and that there is no leakage around the nut of the stem. Because acetylene is inflammable, all leaks in the cylinder valve, hose and connections should be avoided. If there is a cap supplied for the tank vâlve, always see that this is in place before moving the cylinder. Do not transfer acetylene from the cylinder to an empty tank. Avoid large volumes of acetylene under pressure. Acetylene will act on pure copper so that it will produce an explosive compound. Because of this, never use copper in the acetylene equipment. Brass or bronze, however, can be safely used. Do not attempt to locate a leak in the acetylene connections with an open flame. To locate a leak use soap and water with a brush. When the leak is located, bubbles will appear.

Because acetylene is not compressed in an empty tank like oxygen, but is dissolved in a liquid, it is not possible to determine the amount of acetylene being used by the gage readings. This may be determined, however, by weighing the tank before and after the job. There are 14½ cu. ft. of acetylene to a pound.

Regulator or Reducing Valve—A regulator or reducing valve is used in an oxy-acetylene unit to reduce the pressure of the gas and to keep this pressure constant or even. The regulator is a delicate device, very sensitive, and must be handled very carefully. Never drop or jar it. Do not use oil, grease or such material for lubrication in connection with the oxygen regulator. Keep as much dust and dirt out of it as possible by inserting the dust plug when the regulator is not in service. Do not change the regulator from one cylinder to another without taking the pressure off the diaphragm, which can be done by turning the handle to the left. A regulator should not be repaired by any but skilled workmen. Do not replace diaphragms, valve seats, spring,s or other wearing parts, except with those actually manufactured for the regulator.

Welding Blowpipe—The blowpipe is the instrument

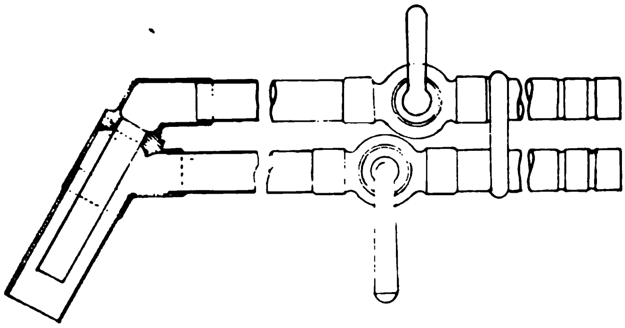

Fig. 355. A Handy Preheating Torch Using City Gas

which is used for welding. It is designed to be easy of control and manipulation. It consists of a tubular handle, in one end of which is a valve body carrying both the oxygen and acetylene valves. On the other end is a head into which are inserted welding heads or tips of different sizes. The mixture of gases occurs in these tips. If the blowpipe is handled properly, it

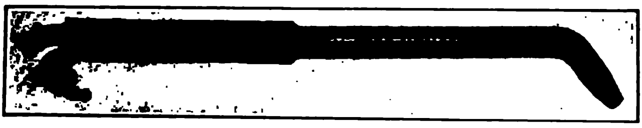

Fig. 356. Welding Torch for General Use

should not require a great amount of attention. It should only be necessary to clean the removable and working parts and occasionally the tips and passages of the welding heads. The tips should never be cleaned out with anything but a soft copper or brass wire. If something harder is used, the hole will become larger and the head will not work so well. Occasionally dirt can be blown out of the head by means of high oxygen pressure. If the flame is not properly adjusted, or the tip becomes clogged, the blowpipe may backfire. When this occurs, close the acetylene valve for a few seconds. Then opens this valve fully and relight the blowpipe. If the backfire continues, close both the acetylene and oxygen valves, then re-light the blowpipe. If the blowpipe becomes heated, it may be cooled by plunging it into a bucket of water. When this is done, be sure that the acetylene has been shut off and a small quantity o foxygen is passing through the blowpipe.

Welding Heads--There are 10 sizes of welding heads supplied with a blowpipe. Each of these heads gives a certain size flame adapted to a given thickness of metal. The acetylene pressure for all the heads is the same—namely, 1 lb. The oxygen pressure varies, ranging from 9 to 30 lb., according to the size of the head.

Oxy-Acetylene Flame—When the oxy-acetylene flame has just the right proportion of each gas, it is called neutral. This is shown by a clearly defined central cone, bright bluish green in color, surrounded by a bushy, weak flame, purplish yellow in color. When too much oxygen is used, this central cone or jet becomes bluer in color and loses the greenish tinge; it is not so clearly defined. When too much acetylene is used, the jet becomes bluish white and is streaky. The neutral flame should always be used. The student should test his flame from time to time as he is welding. This is done by turning on a slight excess of acetylene, by means of the acetylene valve, and then trimming it down so that a neutral flame is produced.

Preparation of Welds

The success of oxy-acetylene welding depends, to a very great extent, upon the proper preparation of the parts to be welded. While the preparation of a weld depends very much upon the particular location and condition of the parts to be welded, there are nevertheless certain general rules that must be followed.

The preparation should be given as much consideration by the welder as are the proper selection of welding rods, fluxes and size of blowpipe head. The weld that is not prepared properly will usually offset any skill

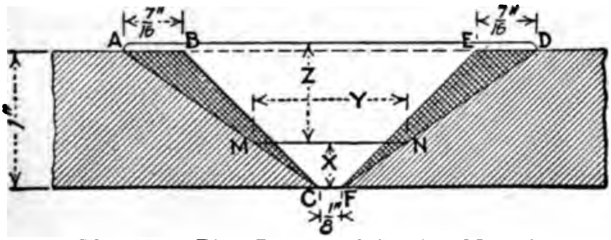

Fig. 357. Pipe Bevel and Section Melted

that the welder may have. Careless preparation has caused many failures.

Bevelling—In making an autogenous weld, it is necessary that fusion penetrate entirely through the metal. In order to aid this the pieces are usually chamfered or beveled with an air hammer, a grinder or cold chisel. By bevelling is meant the grooving or chamfering of

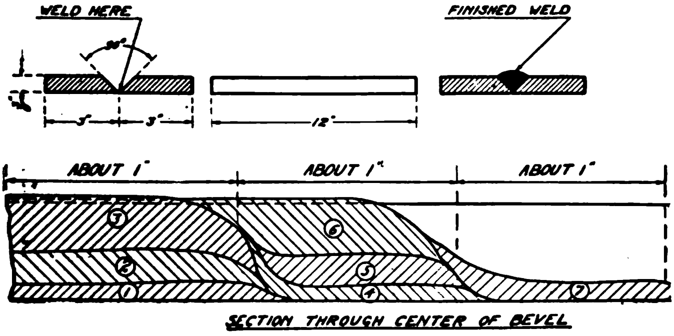

Fig. 358. Progressive Steps in Filling of Bevel

the metal at the line of the weld, the depth of this groove or V being equivalent to the thickness of the metal.

Bevelling is not required on castings or plates lighter than ⅛ in. in thickness. From ⅛ in. to 3/16 in. in thickness a narrow chamfer only is necessary; one in which the angle opening is 90 deg. is sufficient. From 3/16 in. up to the maximum thickness weldable by the oxy-acetylene blowpipe, an angle opening of from 60 deg. to 90 deg. is sufficient, the angle being dependent somewhat upon the nature of the material and the location of the weld.

Fig. 359. Clamp for Holding Pipe Ends

It is not sufficient to merely separate the edges, because in this case the upper corners will be melted down and will flow into the space between the pieces, adhering to the sides rather than fusing intimately. This does not produce a weld in any sense, as experience speedily shows.

Under certain conditions it is possible to use an oxygen cutting blowpipe for bevelling. In case this is done, care must be taken that all the oxide produced on the surfaces cut by the blowpipe be removed before welding.

Setting Up Work—Before starting to weld, it is necessary to adjust or arrange the parts to be welded, so that during the operation they remain in relatively the same position. It is a common fault of inexperienced welders to overlook this important item, and consequently the strength of the weld, as well as the progress of the work, will be seriously affected. In lining up a piece it is essential that the deviation from the original lines, caused by expansion and contraction, must be thoroughly understood and cared for.

In repairing castings of nonmalleable nature, the adjustment before welding should be very carefully done. This adjusting is usually carried out by means of straight edges, jig clamps, keys, wedges and other devices.

Character of Flame

The combustion of acetylene in oxygen produces a two-phase flame. The luminous cone or jet indicates the following re-action:

$$C_2H_2 + O_2 = 2CO + H_2$$

The oxygen in this reaction is supplied from the cylinder. It is at this point that the endothermic energy of acetylene takes place.

The bushy non-luminous envelope indicates this re-action, the oxygen in this phase being supplied by the atmosphere:

$$2H_2 + O_2 = 2H_2O$$
$$2CO + O_2 = 2CO_2$$

The character of the oxy-acetylene flame depends upon the proportion of oxygen and acetylene contained in the mixed gas as it issues from the tip of the blowpipe. This proportion is controlled to some extent by regulators or other devices installed with the equip-

[redacted]

ment. The final adjustment, however, should be with the needle valves of the blowpipe. The proportion of oxygen is approximately regulated by adjusting the oxygen regulator to the proper pressure. The acetylene is also regulated when using a medium pressure generator, or dissolved acetylene from tanks, by means of regulators and regulating devices. In the use of low pressure acetylene generators it is not necessary to use devices such as this, since the correct amount of acetylene is drawn into the blowpipe by means of an injector in the welding head or blowpipe.

The proportion of the gases may produce three divisions in the character of the flame—called reducing or carbonizing, neutral and oxidizing. The welder should at all times observe carefully the type of flame produced, and any divergence from the type desired should be instantly detected and corrected.

Reducing or Carbonizing Flame—When the blowpipe is first lighted the acetylene is greatly in excess. The flame produced is of abnormal volume, a dirty yellow color, and of uniform consistency. This is the reducing type in an exaggerated degree. By increasing the oxygen pressure the size of the flame is lessened, and gradually a white zone of greater luminosity appears near the blowpipe tip. This luminous zone is not yet clearly defined. The flame is still of abnormal size, is streaky in appearance, and a brilliant white. The extent of the reducing or carbonizing action of the flame is judged practically by the size and definition of the luminous zone. When the luminous zone becomes more clearly defined and takes the form and color of a bluish white incandescent cone or pencil, the streakiness is diminished and the flame approaches neutral. The reducing flame is used to some extent on certain alloy steels, aluminum and nonferrous alloys.

Neutral or Normal Flame—When acetylene and oxygen are ignited in the correct proportions a neutral flame is produced. The appearance of this flame is characteristic. It is made up of a distinct and clearly defined incandescent pencil or cone of bluish green in color, surrounded by a faint purplish yellow secondary flame or envelope of bushy appearance. The incandescent pencil or cone may be from $\frac{1}{4}$ in. to $\frac{5}{8}$ in. in length, and is usually rounded or tapered at the ends. The maximum temperature of the oxy-acetylene flame is $\frac{1}{8}$ in. to 3/16 in. beyond the extremity of this jet. In establishing a neutral flame the jet should be of the maximum size for the particular blowpipe head in use. This flame is established by gradually increasing the oxygen supply until the point at which the incandescent jet is of the greatest clearness is just passed, and then finally adjusting by decreasing the oxygen supply until the desired condition is obtained.

This type of flame is the one most extensively used, and no welder is proficient until he is thoroughly familiar with its appearance

Oxidizing Flame—When an excess of oxygen exists in the welding flame it is called oxidizing. The effect of too much oxygen is to diminish the size of the flame, blunt or blur the incandescent cone, and produce a weak, streaky or scattering flame. The oxidizing flame has neither the size nor the illuminating qualities of the reducing flame, but the incandescent flame is slightly more pronounced. It is a pale violet color. In some blowpipes the incandescent cone is not only diminshed in size, but is slightly bulged at its extremity as compared to the normal flame.

Manipulation of Blowpipe

The blowpipe must be grasped firmly in the hand. It is not good practice to hold it in the fingers, because it is impossible to manipulate the flame with as great regularity and control, nor will it be possible to do as heavy work without tiring.

Occasionally the hose is thrown over the man's shoulder. In this case the weight of the blowpipe is suspended and held by the tubing. so that it is only necessary to impart the typical welding motion to the blowpipe, which can usually be done by the fingers. The movement of the welding flame is hindered, however; and this method is therefore not recommended, and should be used only as a relief when the work is of long duration and the operator's wrist and forearm become tired.

The head of the blowpipe should be inclined at an angle of about 60 deg. to the plane of the weld. The inclination of the head should not be too great, because the molten metal will be blown ahead of the welding zone and will adhere to the comparatively cold sides of the weld. On the other hand, the welding head should not be inclined too near the vertical, because the preheating effect of the secondary flame will not be efficiently applied.

There are certain cases, however, where the con-

Fig. 360. Finished Joint and Service Stub

ductivity of the metal is such that it is not necessary to utilize this preheating; also certain metals have the property of absorbing the gases of this flame. Consequently, in these cases it is best that the flame impingement be concentrated to as small an area as possible.

The motion of the blowpipe should be away from the welder and not toward him, as closer observation of the work can be obtained and greater facility in making the weld will be experienced.

Where thin sheet material is being welded and it is not necessary to use a welding rod or wire, a weld may be produced by moving the blowpipe in a straight line. It can readily be seen that this does not apply to welds which have been bevelled, and which require the use of filling material, for in this case a swinging motion must be imparted to the blowpipe to take in both edges of the weld and the welding wire at practically the same time.

In comparatively light work a motion is imparted to the blowpipe which will cause the incandescent cone to describe a series of overlapping circles, the overlapping extending in the direction of the welding. In order that the weld be of a good appearance this must

Fig. 361. Welding Equipment Used in the Field

be constant and regular in its advance. The width of this motion is dependent upon the size of the material being welded and varies accordingly with the nature of the work.

In heavier work, if the above system were used, a great deal of the motion would be superfluous. Consequently either an oscillating movement, or one in which the jet of the blowpipe will describe semi-circles, should be used. This confines the welding zone; and while

[redacted]

the progress is not so fast, it is more thorough than the other system for this class of work.

To the average beginner the regular control of these motions is difficult, and considerable practice is required to become skilled. It is the regularity of these motions that produces the characteristic even-rippled surface of good autogenous welding. The progress of a welder and the quality of his work can be determined to some extent by the skill witn which he produces this effect.

After the swinging motions of the blowpipe have

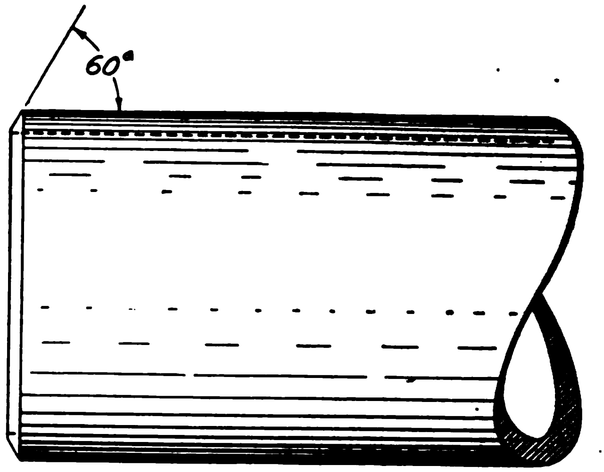

Fig. 362. Proper Chamfer for the End of Gas Pipe

been mastered, the next step will be to introduce the welding rod into the weld in such a manner that the regular advance of the blowpipe will not be hindered nor retarded. It can be seen that there is quite a little attention needed to secure perfect co-operation between the two hands, one controlling the blowpipe and the other adding the welding rod.

The welding rod should be held inclined at about 45 deg. In this position sufficient quantity of metal may be added at the right time. With the welding rod held in a vertical position or horizontal, the possibility of the addition of an excess of metal, part of which is not fused, is great. In adding this metal, care must be exercised that the edges of the weld are in the proper state of fusion to receive it. If the metal is not sufficiently hot, the added material will merely stick to the sides and fusion will not exist. It is therefore

Fig. 363. Proper Manner of Holding Torch and Rod

necessary that, by the motion of the blowpipe, fusion be produced at the edges of the weld equal with that of the welding rod.

The usual faults of the beginner are failure to introduce the welding rod at the proper time into the welding zone, to hold the rod at the wrong angle, or to fuse either too little or too much of the rod. The filling material when melted should never be allowed to fall into the weld in drops or globules. When the proper time arrives to add it, the welding rod is lowered into the weld until it is in contact with the molten metal of the edges. When in this position the flame of the blowpipe is directed around it, and thus fusion is produced.

It is customary to add metal in excess to that of the original section. There are several very important

Fig. 364. Welding the Under Side of a Gas Main

reasons for doing this. First, the weld is reinforced and the strength is accordingly increased. Second, in case a finished surface is desired a sufficient stock must remain to allow for finish. Third, small pinholes or blowholes may be found just under the surface of the weld, which do not extend to any depth and may be removed by filing or machining.

The application of the acetylene-oxygen blowpipe to welding gas mains is an important development which can be applied to both emergency and routine work. One of the pioneers in this work, J. D. Shattuck, of Chester, Pa., stated in THE GAS AGE (Nov. 16, 1914, p. 470) that "when a gas engineer comes to realize how great the leakage can become on a screw joint line or a rubber expansion jointed line, he will not be satisfied with anything less than a welded line." In the same article he gives the following practical details derived from their experience:

Welding Gas Mains

"Pipe in 40 ft. lengths is now available, both I. D. and O. D. The method of proceeding with the welding

Fig. 365. Expediting the Welding of a Joint

of pipe is simply the rolling of lengths and butting of the ends together in a fairly straight line. This can be done on a smooth roadway or on skids over the trench. After a few lengths are welded together the skids may be removed from the point of beginning and the pipe slowly reeled into the trench as the work proceeds, or the pipe can be welded in sections, with two or more gangs working at the same time, then dropped into the trench, and the final connection welded.

"The more snake-like horizontally the pipe is laid in the trench, the better, as it will tend to relieve what contraction strains may occur later. The pipe should be carefully graded, however, as in low pressure work. No care is necessary in dropping the pipe into the trench. The weld is as strong or stronger than the pipe itself, and if the falling of the pipe into the trench is going to break a bad joint, obviously we are glad to discover such defect.

Fig. 366. Turning Pipe While Welding

"The advantage of welding on top is that the pipe can be slowly turned, thus enabling the welder to always work on the upper diameter of the pipe. The pipe can be welded underneath if necessary, as the fluxed material does not tend to drop but tends to hang to the pipe. By placing chain tongs on the pipe there is no difficulty in obtaining twist enough in the pipe to get sufficient roll, either forward or back, to make welding easy.

"The end of a pipe of 2 in. diameter and over should be slightly chamfered about 30 deg. from the diameter of the pipe, so that when the ends of the pipe are butted there is a 'V' groove formed. This 'V' should not be more than ¼ in. across the top. As the thickness of the metal becomes greater a good rule to follow would be that up to plates of ¾ in. the width of this 'V' should about equal the thickness of the metal to be welded, but beyond that, the opening would not need to be in quite the same ratio.

"Chamfered pipe can be purchased at an additional

Fig. 367. Rollers for Bringing Lengths Together

cost per length of 3½ cents for 2 in., 4¼ cents for 3 in., and 8 cents for 4 in. pipe. To offset this, there is a 2½ per cent saving in cost of plain end pipe over screw end and coupling. In welding two ends of pipe together Norway iron is used. It is necessary to make the pipe fairly straight to weld a small portion on one side of the pipe, and then a small portion directly on the opposite side, thus tacking the pipe together and then completing the weld.

"A welder and two assistants, the assistants to roll the pipe, are all that is required to make the joint of ordinary sizes. After the completion of the weld the welder, by means of a small hand truck, moves his two tanks forward to the next job, while the helpers are rolling the next pipe into position. We have designed a small galvanized truck, which can be locked at night, and shades the tanks from the hot sun during the day.

"If a small hole is burned in the main ream it out and drive a steel plug in the hole, and with a little care it may be welded over. To make sure there is no leak in the welding of the socket to the main, the latter

Fig. 368. Bending Welded Pipe on the Job

can be connected to the oxygen tank and pressure put on the socket, or a cylinder of compressed air can be carried for testing services.

"A number of interesting experiments were made to determine the effect of burning holes through the main. With a small hole the gas was easily extinguished by the use of a wet blanket. With a large hole, where the flame spreads so that it is not safe to approach close to it, a piece of 4-in. or 6-in. pipe, large enough in diameter to cover the hole, and 12 ft. to 15 ft. long, is held upright over the flame, combustion then taking place at the end of the pipe. The pipe can be thrown over quickly or moved horizontally away from the line, thus carrying the flame with it, and extinguishing the fire at the main. A ⅛-in hole in the main at 3 lbs. pressure will blow out the low pressure torch. A ¼-in. hole requires about 10 lbs. to blow out the torch.

"In case the line is under asphalt or expensive pavement, a split sleeve can be employed. With this steel

Fig. 369. Adaptability of Welding to Intricate Problems

sleeve the expansion joints may be completely covered. The sleeve is welded horizontally, first on one side, then turned and welded on the other, and then completed at the ends without interruption of service.

Strength of Welds

"The Testing Bureau of Swarthmore College made a number of tests for us of pieces of pipe welded in the field by our men without any special care. They found that not only is the weld stronger than the pipe, but the stretch in the pipe without rupture is a great many more times than any possible temperature contraction force that would occur to this pipe after it was welded and in the ground. In other words, no provision need be made to take care of temperature contraction in a welded line so far as the line itself is concerned. If steel valves are used, the valves will stand the strain. The bolts, however, that bolt the flanges to the valves may stretch enough to cause a leak unless some provision is made at this point. Slack should be forced

Fig. 370. Welding Main Before Lowering Through Ice

into the line at and near valves. The best way to make sure that such extra length has been forced into the line is to lay the line, bolting the valve flanges together without the valves, and then lifting the line back of the proposed valve location until the flanges are separated far enough to insert the valve. After inserting the valve drop the line back into the trench.

"According to the Bureau of Standards at Washington the coefficient of expansion of welded boiler tubes between 0 deg. C. and 200 deg. C. was found to be:

Charcoal iron	0.00001235
Bessemer steel	0.00001258
Seamless open hearth steel (hot finished)	0.00001239

"The expansion of lengths of 100 ft. pipe, given by the Practical Engineer (January, 1911), up to temperatures and including 125 deg. Fahr., are as follows:

Temperature	Cast iron	Wrought iron	Steel
50 deg. F.	0.36 in.	0.40 in.	0.38 in.
100 deg. F.	0.72 in.	0.79 in.	0.76 in.
125 deg. F.	0.88 in.	0.97 in.	0.92 in.

"The physical properties of ordinary steel are as follows:

Fig. 371. A Portable Windshield Is Often Desirable

Tensile strength...52,000 to 62,000 lbs. per sq in.
Elastic limit ...... Not less than 30,000 per sq. in.
Elongation in 8 in........Not less than 20 per cent.
Reduction in area ....Not less than 50 per cent.

"The tests made by Swarthmore College show that the contraction of a long length of pipe would have to occur at one point to cause a rupture of the pipe. Therefore I feel that we are fully justified in not providing for expansion in laying welded lines under ordinary conditions, where the temperature changes at 3 ft. below the ground cannot be greater than from 32 deg. minimum to 75 deg. maximum, a range of only 43 degrees.

"We have used lead gaskets under service saddles and between valve flanges. Welding the service to the main will do away with these lead gaskets. In very cold climates where the frost gets down to the saddle, every year a number of companies have had leaks at this

Fig. 372. A Welded Cross Made in the Field

point, and outside of the money saved, I believe welding of services will do away with this other element of leakage. It is a question whether the gaskets used on the valve flanges should not be of some other material than lead. This is the only point where we have not thoroughly eliminated the possibility of leakage on the mains. Companion valve flanges are made up with short pieces of pipe welded to the flanges to avoid screwed joints.

"Wrought iron or steel pipe 12 in. and smaller can be bent cold in the field, provided the radius of the bend is not less than given in the following table. Any radius less than that is apt to cause the pipe to buckle.

Safe Radius of Bend

Size of pipe,	Advisable	Maximum	Size of pipe	Advisable	Maximum
2½ ...	15	10	10 ...	60	40
3 ...	18	12	11 ...	66	44
3½ ...	21	14	12 ...	72	48
4 ...	24	16	13 ...	84	60
4½ ...	27	18	14 ...	90	68
5 ...	30	20	15 ...	100	76
6 ...	36	24	18 O. D.	125	90
7 ...	42	28	20 O. D.	158	120
8 ...	48	32	22 O. D.	163	132
9 ...	54	36	24 O. D.	180	144

In his excellent article upon "Welding in Gas Distribution (THE GAS AGE, October 1, 1914, p. 316), D. E. Keppelmann, of San Francisco, gives many practical details derived from their extensive experience and his description of their methods may very properly find a place here.

Welding Operations

"The oxyacetylene welder must select the proper size of torch and heat back on the metal far enough to retain full welding heat on the edges and by slightly tipping the torch avoid overheating of the thin parts, at the same time supplying the excess heat to the thicker parts. He should also apply his filling material at as low heat as possible, or more correctly, fill in new material only when the edges of the scarfs are sweating or fused properly. This is especially important in welding heavy material. It will often prove of value even in steel welding to arrange a suitable method of preheating in order to check the loss of the heat, either by a row of gas or oil burners placed on each side of the weld, or a charcoal fire extending over the inside lower part of the object welded.

"A horizontal weld can be done many times faster than the vertical or overhead weld where the material must be carefully spread and filled drop by drop. An experienced boilermaker, for instance, can and must be able to fill in his metal without losing molten metal, as a failure in this respect in a cramped and close position may mean serious burns.

"The ability to make a thoroughly sound overhead weld without a spill of molten metal can be considered

Fig. 373. By-pass and Welded Sleeve

a satisfactory test of a steel welder, it being impossible for him to accomplish this task without a sufficient knowledge of welding wrought steel. Welding of cast iron requires special flux and filling rods, exceptionally clean and rich in silicon. Cast iron can be welded very satisfactorily, the greatest difficulty being in properly taking care of the expansion and contraction.

In large installations open as long a trench as the law will permit. Pipe in sizes 2 in., 3 in. and 4 in. should be welded beside the trench; 6 in., 8 in., 10 in., 12 in.

and 16 in. must be welded directly over the trench on timber laid across the trench; two by fours for 6 in., four by fours for 8 in. and 10 in., and six by sixes for 16.

"Assuming 8 in. pipe, 40 ft. to the length, the pipe is placed length after length upon the cross timber over the trench, for the entire distance of the trench. The first two lengths are butted together square, end to end, care being taken that both lengths are level. The

Fig. 374. A Welded Branch on High Pressure Main

pipe being chamfered about 45 deg. forms a groove when the lengths are brought together. If the pipe is not chamfered, leave a space between the end of the pipe, varying from $^1/_{16}$ in. to ¼ in., according to the size of the pipe being welded. All pipe, however, should be chamfered, to insure a better and more economical weld, requiring less labor, oxygen, acetylene and welding steel, and insuring a fusion to the inner wall of the pipe.

"The operator now applies the flame to both ends of the pipe at the bottom of the groove, bringing it to a cherry red heat, as well as both ends of the pipe a distance of ½ in. back of the groove, simultaneously applying additional Norway or Swedish iron, which is furnished in the shape of rods $^{3}/_{16}$ in. in diameter—that about 4 ft. long being the most convenient. The operator continuously applies the flame in an oscillating or rotary movement, causing a fusion as between the ends of the pipe and the rod of iron, which gradually melts into a puddled molten mass, filling in the groove. Care must

Fig. 375. Lowering a Welded Length into the Trench

be exercised, never permitting the steel rod to be removed from the pipe during fusion, as it would be quickly burnt.

"The welding is done on the top surface of the pipe and gradually rolled by two helpers, located on each far end of the pipe. As the operator welds, the helpers roll the pipe on the timber, permitting the operator to weld, on the top surface of the pipe at all times, which permits of the weld being done with great rapidity. The weld completed, the two lengths welded together, has reached the end of the timbers across the trench, when

[redacted]

another length is added, the helpers rolling the pipe on the timbers as the operator welds, which, after the weld is again completed, brings the pipe back to the opposite side. This operation is continued, adding as many lengths as desired.

"Always roll the pipe away from the operator, this being preferable, for the reason that the force of the flame piles the molten metal into a semi-circle over the

Fig. 376. Rolling Long Pipe into the Trench

joint, making a stronger weld; the flame held at an angle of about 45 deg. having a tendency to do so without any particular assistance on the part of the operator. This method of procedure will also drive any possible existing impurities to the top of the molten mass in the form of slag, which readily scales off when the weld cools. Lengths of pipe are added until an obstruction occurs in the trench which would not per-

Fig. 377. Examples of Welding in the Fitting Shop

Fig. 378. Clamp for Holding Work in the Shop

Fig. 379. Circle-Cutting Compass Torch

[redacted]

mit of the pipe being laid, or until the length is too great for the helpers to turn. Two helpers with chain tongs will turn as much as 30 lengths of 8 in. pipe, or 1,200 ft. welded together.

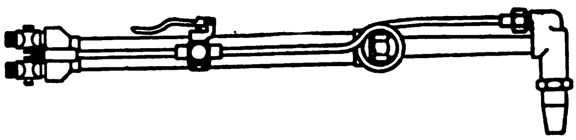

Fig. 380. A Useful Form of Cutting Torch

"When an obstruction occurs, or the lengths are too many for further rolling, the timber is pulled from beneath the pipe, the pipe falling to the bottom of the

Fig. 381. Welded "Y" Branches of Large Size

trench. No care is exercised; rather the pipe is deliberately thrown into the trench, it being desirous that any imperfect welds show up at this time. At the end of these great lengths a bell hole is dug of sufficient

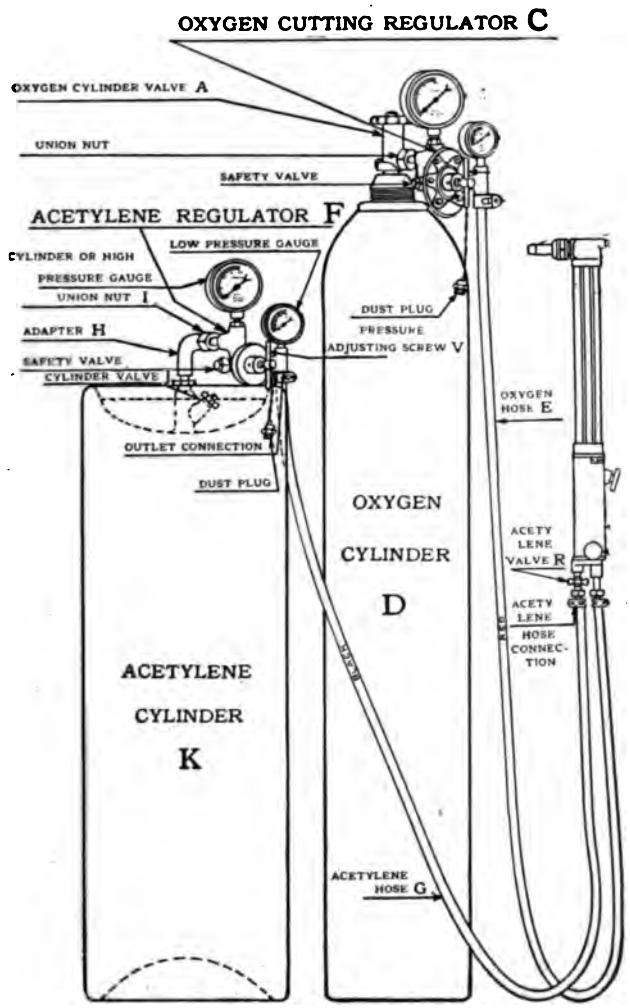

Fig. 382. Diagram of Cutting Outfit

size to admit the operator who welds the lengths together.

"When it is impossible to turn the great lengths, the operator is compelled to weld around the pipe as it lies in the trench. One would imagine, when the operator is welding on the bottom of the pipe in the trench, that the molten metal would drop away from the contemplated weld. Such, however, is not the case; not a drop is lost, for the intense heat of the flame quickly melting the rod, the force of the flame drives the molten metal into position, and the operator con-

Fig. 383. Examples of Complicated Pipe Welding

tinuously moving the blowpipe permits the weld to partially chill, sufficiently so to hold the metal in place.

"Welding in the bell hole is done just as well as on top, although, quite naturally, not as rapidly as welding continuously on top. To expedite the work, the operator is materially assisted by mounting the tanks on an inexpensive carrier, the frame of which consists of pipe welded together and mounted on wheels, or if at any great distance, the entire outfit may be placed in an automobile. A long length of welded main in the trench will appear in a snake-like position; no attempt should be made to straighten it out, for this is a feature essential to provide for any possible expansion or contraction. No other provision for expansion or contraction is made, it being deemed unnecessary, and our past experience proves this contention.

Lateral Mains

"When laterals are necessary, a pipe is welded to the main line at any angle required, eliminating special fittings. Herein is a tremendous saving in installation costs. No specials are required in advance, no delays

Fig. 384. A Welded Drip of Unusual Size

incurred waiting for specials and no leaks encountered after specials are installed. These fittings are made of the pipe at the time required and welded into position at 50 per cent less cost. Invariably special fittings are made of pipe that had been previously junked and apparently useless; with welding, however, nothing is wasted.

"All welded pipe is subjected to a test with air at a pressure of 150 lb. to the sq. in. After gauge readings, showing the line to be tight at the end of 24 hours, the usual soapy water is applied to each joint for further assurance of the absolute tightness of each joint.

Welding Meter Connections

A consumer was desirous of moving four 300-light meters from one location to another, a distance of 100 ft. The meters were disconnected, a cutting torch was used, and the entire existing distributor, both inlet and outlet sides remaining intact, moved to the new location, 100 ft. of the O. D. pipe welded together and placed into position, filling in the gap. The O. D. pipe slipped into the end of the I. D. distributor and welded, completing the inlet connection. The house rise was cut off the necessary 100 ft. and welded to the existing piping at the new location.

"Our former practice of fitting and screwing pipe would have required several days' hard work at a cost of over $200 and necessitating the plant to shut down at considerable loss and inconvenience to the consumer. With our welding process, the total cost of the job was $75, completed in one day, a Sunday, with no loss or inconvenience to the consumer whatsoever.

"Heretofore consumers objected to the setting of meters, excepting in the most out of way places, on account of their unsightliness; however, with a welded distributor, the only eyesore is eliminated and prejudice overcome, for it does present a neat, clean, workmanlike appearance."

WELDING IN THE NATURAL GAS FIELD

The following was prepared by C. P. Clampitt, who describes some new and interesting developments in welding gas mains in the Oklahoma natural gas field in THE GAS AGE for October 15, 1918:

It is safe to say that in the last eighteen months more casinghead and absorption gasoline plants have been built in the Mid-Continent oil fields, Oklahoma and Kansas than in all other fields combined. Production from these plants has been speeded up and increased probably more by the welding process than any other one thing. For some time it has been next to impossible to obtain pipe and fittings. Welding solved the problem. Many gas companies and gasoline manufacturers used second-hand three and four-inch boiler flues for city and field lines. Fittings and specials were constructed on the job, or in the shop, with the welding and cutting blowpipes from crop ends of pipe or the good part of defective lengths. The accompanying illustration shows a high pressure line and station constructed with 4-inch boiler flues.

Welding Outfit

The apparatus for all pipe line and plant work

Fig. 385. Connections Made Out of 4-Inch Boiler Flues

should be the very best obtainable and include both a welding and a cutting blowpipe, the latter being as essential as the former, especially in laying city lines where frequent service connections must be welded in.

A complete outfit should consist of both blowpipes, regulators, hose, wrenches, etc. The hose lengths for each gas should be from fifty to one hundred feet, giving a working limit of one hundred to two hundred feet, as the case may be, without taking time to move the outfit.

If dissolved acetylene in cylinders is used, the complete outfit should be mounted on a light but strongly built high wheeled truck, as shown in Figs. 2 and 3. However, acetylene may be generated on the job at a much lower cost than dissolved acetylene. Such a generator should be of not less than fifty pounds carbide capacity and mounted on a four wheeled truck with low center of gravity as shown. The generator should be a strictly portable type, so that carbide and

Fig. 386. Truck for Carrying Cylinders

water will not come into contact when the generator is moved.

Care should be taken to prevent the generator being overtaxed by drawing the gas off in excess of the rated cubic feet per hour. Most apparatus manufacturers furnish such tables, including the hourly gas consumption of the different sizes of welding heads and cutting nozzles.

It is safe to say there is no emergency in laying a gas line or constructing a gasoline plant that cannot be overcome with a welding and cutting outfit. It is a fact that plants have been built with no blue prints or layout of any kind for the lines and connections coming into the plant. Standard lengths of pipe were used and cut and welded as necessary to connect with the pumps and compressors which had been installed first.

Typical Operations of Interest to Gas Companies

Nearly all gas companies use a great many saddles

Fig. 387. Tank Cart and Welding Outfit

and collar leak clamps of various sizes. This expensive method of tapping and repairing a line may be entirely eliminated by a welding and cutting outfit without so much as shutting off the gas in the main being tapped, especially in case of a low pressure line. There will be comparatively little gas fire while the work is being done.

Instead of tapping the line by the use of a diamond-point tool, and thus consuming considerable time under difficult working conditions, a hole may be cut in a matter of only seconds and a nipple of proper size welded in place in several minutes, the entire operation costing but a few cents. One gas company saved in a year's time, by this method, several thousands of dollars.

One gasoline company tapped an 8-inch gasoline line and welded in a connection while the line was nearly half full of crude gasoline. The operator who

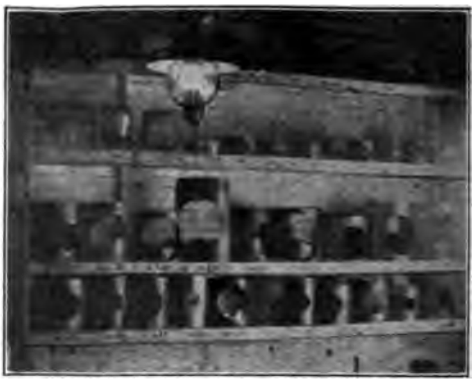

Fig. 388. Templates for Marking Connections Before Cutting

did the work explained, however, that there was "some fire" and that he could not recommend such work as regular practice. Such an undertaking cannot be classed as a typical application of the welding and cutting process, yet it serves as an illustration of what can be done and has been done in an emergency. The only danger from such work would be injury to the operator by burns when the gas or gasoline came into contact with the outside air. The absence of air and the pressure in a gas line and the vapor tension in a gasoline line will not allow any flame to travel in the pipe.

[redacted]

Work in the Shop

Opinions on what work shall be done in the shop and in the field vary. The construction of certain specials, headers, drips, etc., can usually be accomplished at less cost in the shop, but if care is not taken, especially in headers and drips, to overcome expansion and contraction, they will not fit properly when put in place. It is good practice to have a special jig for this work to hold the pieces in alignment.

Fig. 389. Portable Acetylene Generator and Tanks

To facilitate work in the shop, a set of sheet iron patterns as shown should be made up for the more standard diameters of pipe used in the construction of the common fittings. Considerable time is lost if the operator attempts to cut the pipe by guess and even by laying his work out by angles, to say nothing of the waste of oxygen and acetylene, occasioned by the necessary trimming to make the joints fit properly.

Some engineers and construction superintendents of gasoline plants prefer to set their condensing coils and

[redacted]

then weld the headers to them, claiming there is less trouble encountered in fitting them. This would seem bad practice, inasmuch as the cutting and welding cannot be done as easily nor as economically. Strains are more liable to be set up than if the headers were constructed in the shop, under proper conditions and with care that proper alignment is assured. As these coils carry from 250 to 300 pounds per square inch pressure and are also subject to a certain vibration from the compressors, it is very important that they be as

Fig. 390. Wedges for Lining Up Pipe to Make Joint

free as possible from strains. Leaks are not only very costly, but very dangerous.

Work in the Field

Field work presents about the same problem everywhere, depending on topography of the country, whether conditions and temperatures, transportation of material, supplies, etc. Expansion and contraction cannot be overcome, therefore some means of providing for it must be established.

Taking things in the order of operation, the pipe must first be strung or trench dug; it does not matter much which is done first, although having the trench or a field line, where the country permits of easy trucking or teaming, by using an acetylene generator, where the pipe is unloaded from cars or in the pipe yard, and welding two lengths together; then hauling them to the desired points along the line. The advantages of this method are twofold. The welder works under more agreeable conditions and will turn out more welds

Fig. 391. Lowering the Welded Sections of Main

per day than in the field. Also, a generator being used to better advantage, will supply acetylene at approximately one-half the cost of tanked gas. When starting work it is common practice for a welder in the field to lay aside as an empty acetylene or oxygen tank often containing quite a few feet of gas, rather than to consume the entire contents and then change to a full tank. These tanks should be carefully accounted for from an economical standpoint and the contents ready to receive the pipe when welded is generally considered the better way.

Practically any size of line can be laid with one or more crews of three men each, one man to line up the pipe, one to turn it and one welder.

The simplest method of lining up the pipe and un-

Fig. 392. Slack in Main Forced into the Trench

doubtedly the best is to use 2 inch x 4 inch timbers or wedge blocks. The pipe should be lined up and welded at the side of the trench and far enough from it to permit of the pipe being turned half its circumference toward the open trench. Twenty standard lengths or about 400 feet of 8-inch or 1000 feet of 4-

inch can be turned by one man with chain tongs, without putting too much strain on the weld. Such a length of pipe, of course, could not be handled over rough country. The pipe should be turned half its circumference each way, towards and away from the trench.

A line up to 10 inches diameter may be laid without expansion joints although 4-inch, 6-inch and 8-inch are more flexible, permitting more readily sufficient slack to be pushed back or "snaked" into the trench, to take care of all expansion and contraction, which might otherwise cause the line to break. Sizes above 8 inches should have an expansion joint about every eight lengths or 160 feet.

A great saving in cost can be effected on a city line completely exhausted. The main idea is to consume every cubic foot of gas furnished the job and so far as possible keep the welders working every minute of the day.

Specials

There being practically no limit as to what may be done with welding and cutting equipment on pipe line and plant construction work, little need be said as to its value in the construction of specials. From a general survey of the process, it is self evident that any fitting or special may be constructed on the job at less than a substitute would cost f. o. b. at the mills.

Welded fittings are less liable to damage, from one cause or another, than are cast fittings. Should they be damaged, barring complete destruction, they may be easily and cheaply repaired.

Cost

Plain end pipe should be beveled at an angle of 30°, making a 60° groove when butted for welding. The mills ordinarily will furnish pipe prepared in this way at no additional cost. The following tables are comparatively accurate:

[redacted]

Material and Labor

Diameter pipe: inches	Time: minutes per weld	Welds per day	Oxygen per weld: cu. ft.	Acetylene per weld: cu. ft.	Wire: lbs. per weld
4	7	80	3.84	3.65	0.15
6	10	50	6.9	6.57	0.24
8	18	30	10.1	9.64	0.45
10	24	21	14.4	13.72	0.79
12	32	18	19.2	18.29	1.10

Cost

Diameter pipe: inches	Labor 64½ cts. hour	Oxygen 1¾ cts cu. ft.	Acetylene 3 cts. cu. ft.	Wire 14 cts. pound	Total cost per weld
4	0.076	0.0672	0.1095	0.021	0.2737
6	0.11	0.12	0.1971	0.0336	0.4607
8	0.198	0.1767	0.2892	0.063	0.7269
10	0.264	0.252	0.4116	0.111	1.0386
12	0.352	0.336	0.5487	0.154	1.3907

Welding Data (Oxweld Acetylene Co.)

Thickness of metal—in.	Oxygen pressure, lbs. per sq. in.	Welding speed: shop—ft. per hour	Gas used per lin. ft.: cu. ft. per hour — Oxygen	Acetylene	Welding wire lbs. per foot
1/64	5	26	0.14	0.13	0.005
1/16	10	17	0.39	0.37	0.02
⅛	12	11.5	0.94	0.89	0.04
¼	16	7	2.74	2.62	0.15
½	21	3	12.00	11.40	0.60
¾	25	1.5	35.20	33.60	1.40
1	30	1	69.70	66.30	2.40

Cost of Welding Pipe (Davis-Bournonville Co.)

Diam. in.	Thickness of metal—in.	Cu. ft. gas used — Oxygen	Acetylene	Wire used, oz.	Cost
4	15/64	2.84	2.49	5	$0.1819
6	9/32	5.68	4.98	8	0.3472
8	5/16	7.58	6.65	12	0.4766
10	5/16	8.53	7.48	16	0.5462
12	21/64	12.32	10.81	20	0.7746

Note—Labor, 42 cents per hour; oxygen and acetylene, 2 cents per cu. ft.; wire, 10 cents per lb; No. 6 tip; oxygen pressure, 12 lb.; acetylene pressure, 6 lb.

Cost of Cutting Pipe (Davis-Bournonville Co.)

Diam. ins.	Thickness ins.	Oxygen cu ft.	Acetylene cu. ft.	Cost
4	15/64	0.781	0.125	$0.0224
6	9/32	1.087	0.174	0.0313
8	5/16	1.775	0.300	0.0520
10	5/16	2.118	0.355	0.0618
12	21/64	2.625	0.420	0.0756

Note—Four cuts made of each size. Oxygen pressure, 20 lb.; acetylene pressure, 3 lb.

Cost of Welded Joints (J. B. Hirst, Chicago)

Diam. in.	Labor	Acetylene	Oxygen	Filling iron	Total
4	$0.17	$0.23	$0.18	$0.03	$0.61
6	0.27	0.36	0.29	0.07	0.99
8	0.41	0.52	0.44	0.14	1.51
12	0.75	1.09	0.77	0.17	2.78
16	1.02	1.38	0.88	0.22	3.50

Cost of Welded Joints (Charles Wilde, Chester, Pa.)

Diam. in.	Time—Min.	Acetyline cu. ft.	Oxygen cu. ft.	Filling iron oz.	Total cost
1.5	3	1.25	1.50	0.9	$0.08
1.5	2	1.00	1.00	0.8	0.06
2	5	2.00	2.25	1.1	0.13
2	3	1.25	1.50	1.0	0.10
3	7.5	3.00	2.50	2.45	0.19
4	14	...	...	...	0.55
6	20	...	...	...	0.70
8	..	...	...	...	1.10 to 2.81

Cost of Welded Joints (Pacific Gas & Elec. Co.)

Diam. in.	Time, min.	Labor, incl. placing, turning	Total cost
2	3	$0.09	$0.18
4	6	0.165	0.34
6	10	0.245	0.25
8	15	0.330	0.70
10	16	0.365	0.80
16	40	0.460	2.50

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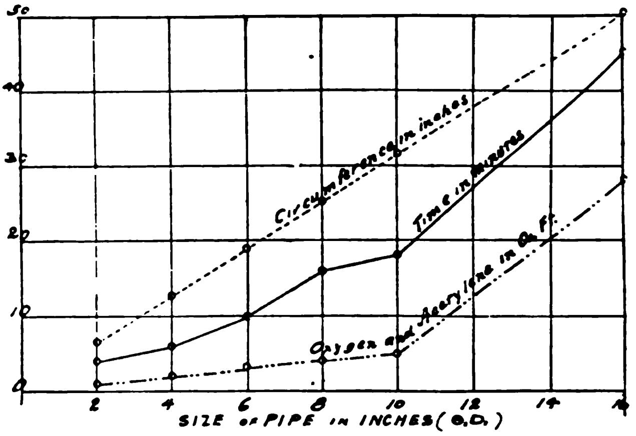

Fig. 393. Time and Material Required per Joint

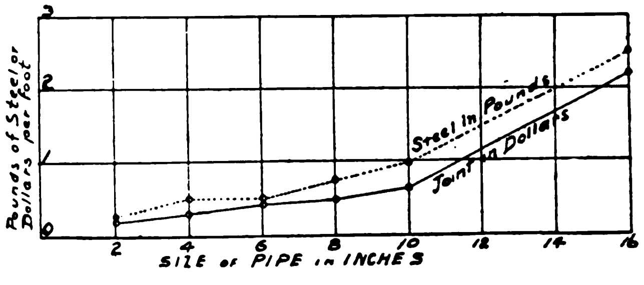

Fig. 394. Jointing Steel and Cost of Welded Joint

CHAPTER XVII

STOREROOM AND FITTING RULES

A properly located and operated storeroom is as essential to the economical running of a gas company as perhaps any other single department. The purpose of the storeroom is to provide a place for keeping a supply of the different stocks used by the company, where they can be received, stored and disbursed in the most efficient and economical manner.

THE GAS COMPANY STOREROOM

In order that the materials may be conveniently received and unloaded, the storeroom should be located near a railroad siding and if possible have a switching track to the building. It should also be located where trucking can be done and have every facility possible for unloading and handling materials. To properly store the stock and materials the building must be designed or reconstructed for warehouse purposes and should be as near fireproof as possible. Provisions for the disbursement of materials to the various departments should be made so that every precaution is taken to prevent loss or waste of materials or effort.

Purpose—The real purpose of any storeroom is to provide a compensating medium between supply and demand. The supply, in the case of gas company storerooms, representing the manufacturer or jobber while the demand is represented by fitters and others who use the materials. Economy could not be practiced if every time a fitter wanted a fitting the company would go out to the local supply house and purchase it or when a range was sold an order must be sent to the factory to supply it. Savings are made per unit cost of materials by buying in reasonable quantities so that a stock is kept on hand, which represent lower fac-

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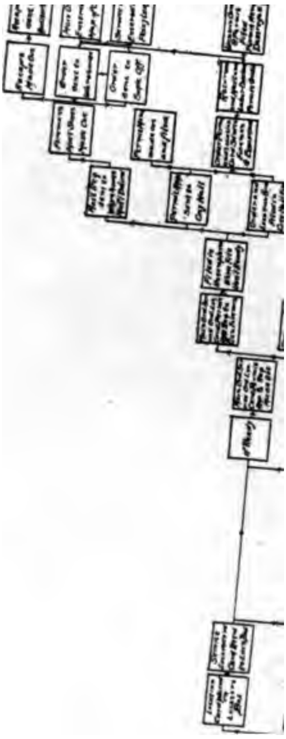
tory or first cost and lower transportation rates, the supply houses or middleman's profit being thereby eliminated. However, no economy is to be found in carrying too large a stock of any materials or large quantities of an expensive stock or one that is in small demand.

As the purchase of materials is so closely related to their storage and use, it would seem that the properly operated storeroom should be under the direct charge of a purchasing agent, rather than an operative head. Under the generally accepted practice, waste of material is often found where inferior goods have been purchased because they were cheap, by an over zealous purchasing department with no thought of the value of good goods in doing work. In other cases an over abundance of stock or a quantity of dead stock point toward the ambition of a purchasing agent to distinguish himself by saving money in buying in large quantities when the market was down. If the purchasing agent had direct supervision over all materials in storage he would know when to buy, what to buy and the proper quantities. He would know the amount of stock to carry of each kind by knowing the conditions of disbursement demand, and could intelligently plan purchases to take advantage of market conditions. He would be in intimate touch with all of the details of the storeroom department and could keep dead stock eliminated by judicious substitution or by sale. It would be his duty to watch the amount of money tied up in stock and balance the interest charge thereon against savings to be made in the purchase price of large quantities of material. In the smaller companies where the activity of purchasing agent is usually part of the duties of a manager or superintendent this recommendation is automatically applied, but in the larger companies there is cause for a consideration of the suggestion. In the latter instance the operating heads should act in an advisory capacity, specifying the kind of material.

Another idea that might be worked out in syndicate or group companies, where the plants are closely situated, is that of a central or joint storeroom. In that case the storeroom should be located in the most central or most conveniently situated city and supplies purchased and stored at this point for the use of all. A small local storeroom for each company would be all the facilities needed there.

The man in charge of the storeroom department should have supervision over all materials used by the company excepting office stationary and gas making supplies. He should keep a record of all materials received and disbursed and return to the auditing department an accurate statement of all transactions upon proper forms provided for that purpose. He should also keep a stock record, either in the form of a stock ledger or card system, whereby a fairly close approximation of stock on hand is available at all times without resorting to an inventory. Inventories should be taken of all stocks at least twice each year, and oftener to those of popular classes. At such times discrepancies between inventories and stock record should be adjusted. He should keep the different stocks replenished and order same in ample time that none become depleted. To prevent running short a minimum amount for each kind of stock should be established. To arrive at this minimum figure the disbursement demand of the article must be taken into consideration, also the time required for delivery and a time quantity must be used in arriving at the proper amount to be ordered.

Materials such as large main pipe and fittings or special appliances should not be carried in stock unless in the latter instance they are used for display purposes. Such materials represent a large outlay in investment and space required for storing and had best be ordered after their requirement is assured. On the other hand ordinary appliances such as gas ranges and water heaters, small pipes and fittings should be pur-



chased in seasonable quantities that advantage may be taken of a reduction in unit cost.

Methods of Keeping and Handling Stock

When material is received in the storeroom that is to be put in stock it should be charged to the proper account in the stock record. It is advisable to carry a number of different stock accounts instead of charging everything into one. As for instance there should be a gas main stock, including pipes and specials of sizes above 2 in., a pipe stock, including threaded pipe of a size 2 in. and under, a fitting stock, including the small sized threaded fittings, an appliance stock, a fixture stock, a lamp stock, which should include glassware and mantles and a miscellaneous stock covering all materials not specifically classified. The stock accounts may be further divided if desired but the above enumerated classifications will cover practically everything handled in the ordinary gas company storeroom.

In the stock record there should be arranged a page or card for each kind of material, showing date received, name, stock account number, price per unit quantity, quantity disbursed and date of disbursement, account number to which disbursement was charged and the balance on hand. By periodic inventories the stock is checked and discrepancies corrected.

All materials kept in stock should, so far as is possible, be kept in the unbroken packages as received which greatly facilitates taking inventories of the stock on hand. In the case of pipe a good way to prevent measuring all lengths every time an inventory is taken is to measure the pipe as it is received and place it in layers in the storage racks with strips of wood between each layer. A record being kept of the amount in each layer it is only necessary to measure the pipe in the top one at inventory time. In the same manner counted fittings should be kept in barrels or boxes, except a supply for immediate disbursement in the bins. It is a good plan to have every package containing stock marked or tagged, showing the name of the article and the number which the package contains.

A quantity of fittings and material that is in much demand should be kept in conveniently arranged bins close to the point of disbursement. All bins should be legibly marked by stencil or card showing the article contained.

In order to spread inventory time over the whole year and prevent its being a stupendous task at any particular time, it is good practice to inventory certain stocks each month. The gas main stock, for instance, might be taken in January and July, the pipe stock in February and August, the fitting stock in March and September, the appliance stock in April and October, etc. If there are more than six stocks two or more could be taken in the same month, but it is not necessary by this method to take a complete inventory at any one time.

All supplies should be disbursed on requisitions or work orders showing the proper account number to which the material is to be charged. In order to verify the account number it is good practice to provide a space wherein the use of the material is specified on the requisition or work order.

No attempt will be made to go into details of storeroom accounting except to advise that the system used be as simple and efficient as possible. Red tape should be avoided at all costs and transactions reduced to the minimum. It has been found that the most complicated systems of storeroom accounting often prove inefficient while the most simple system, in the hands of an efficient storekeeper, gives greatest security at a much lower cost. The entire purpose of storeroom accounting is to afford the company an accurate and undeniable record of goods received, disbursed and on hand. When this purpose is served all other transactions become superfluous.

It should be no trouble for a storekeeper in a medium sized company to save his salary to the company in the sales of waste and scrap that is usually burned up or thrown away.

Selling Waste and Scrap Materials

In all gas companies there is an accumulation of waste and scrap material that is too often considered of no value and thrown away. By the proper application of effort this material may be made to return a substantial profit over handling expense. Most of the goods received in the storeroom is contained within some form of wrapping or packing material. The seller always includes the cost of this wrapping material in the price of the goods, but we seldom think of it as having a value to us after it has served its purpose of containing or protecting a shipment. Packing cases, cartons, waste paper and excelsior can all be readily sold. It is advisable, in the larger companies, to install a baler, or paper press, for baling the wrapping paper from around appliances and the excelsior used in packing materials. In this form a good price may be obtained and it can be safely and conveniently stored until a "worth while" quantity is obtained. Scrap metal should also be saved until a sufficient quantity is on hand to warrant obtaining bids. Even condemned gas meters will bring twenty-five cents each from the junk dealer, as value for the solder and white metal contained.

FITTING RULES

All piping within the franchise area of a gas company, that is to be used at any future time for the conveyance of gas to a point of utilization, should be under the jurisdiction of the supplying company and its installation subject to the supervision or inspection of that utility. The company often, and rightfully, maintains efficient service at the burner by attending to any and all complaints detrimental to efficient service, which includes those caused by the housepiping as well as the service pipe and meter. Theoretically the gas company's jurisdiction ends at the outlet of the consumer's meter, but practically to enforce such a method would curtail the use of gas to a prohibitive extent by forcing the customer to have necessary maintenance work done by inexperienced and uninterested parties or by exorbitantly high priced mechanics, or causing them to neglect necessary ork, thereby obtaining unsatisfactory service or to discontinue the use of gas altogether.

As satisfactory service is the best salesman any company could employ a reasonable amount of money can well afford to be spent in the ordinary maintenance of housepiping. To reduce this expense to the minimum the company may rightfully demand that all gas piping installed be subject to certain rules and regulations as laid down by the company and that parties engaged in the work of installing gas piping on the premises of the customer be compelled to observe such rules or regulations before gas will be turned into the piping.

Purposes of Rules, General Policies

The purpose of rules may be said to be the protection of both the customer and the company. This protection applies to the customer in the efficient service supplied by properly installed gas piping and in the safety factor which is thereby guaranteed. From the standpoint of the company the protection takes the form of a guarantee against curtailment of revenues through unsatisfactory service as well as insuring a minimum expense for the maintenance of good service.

The outside gas fitter who installs a job of housepiping has no further interest in the installation after his work is done and the bill is paid. The gas company assumes an indefinite responsibility or interest in the installation from the time gas is turned on. It is therefore a simple matter to choose the one who should be intrusted with the duty of designating the size of and manner in which the pipes are to be installed for the most efficient service. Proper rules and methods are not matters of guess work or opinion, but are consistent physical laws that are drafted by able gas engineers and are therefore unrefutable.

The policy of a gas company regarding piping rules should be reasonable. Nothing should be demanded of outside gas fitters that is not consistent with good service or is not practiced by the company's own fitters. The good will of the gas fitting fraternity is to be desired and the best way to obtain this is by fairness and impartiality in all cases. At the same time, however, a firmness of purpose must be exercised that will cause the gas fitter to hesitate before purposely violating any rule or regulation of the company.

Standard Practice

Most of the larger and important gas companies of the United States have adopted a standard practice for the government of gas fitting within the area supplied by their mains which is in accordance with certain rules and regulations enforced by the particular company. Within such cities all gas fitting is assumed to be done according to the standard practice of the gas company. With proper rules and a strict enforcement practiced nothing more could be desired, but too often a revision of the rule book to conform with the best standard practice and modern progress is neglected or enforcement is lax or dilatory, with the result that the practice considered as standard by a particular company is obsolete when compared with the best modern standard practice in use today.

The study of a number of rule books used by as many companies shows that in a majority of instances copies have been made and adopted of the rules and some one company presumed to be unrefutable in its knowledge and practice and which have been accepted without question, while others show a wide variance and no uniformity in a great many details. The lack of an ideal code has been apparent for years, and while a great deal of preliminary work leading toward the adoption of a uniform standard practice in gas fitting has been undertaken by companies and associations nothing definite has come forth until quite recently, when the U. S. Bureau of Standards undertook in their National Gas Safety Code to accomplish the purpose. In Part 4 of the bureau's code, which may soon be secured by writing to Washington, D. C., for a copy, is to be found a composite collection of the opinions of expert gas men and engineers from the entire United States as to the best rules and methods to be used in the installation of gas piping. The adoption of this code as standard practice by every company will definitely settle all difficulties now encountered in obtaining the most efficient installation of gas piping and will be a great benefit to the industry in general.

In drawing up this national code several of the most eminent gas engineers in the country assisted the bureau's engineers in drafting a tentative copy. The American Gas Institute and other well known institutions rendered valuable assistance by appointing committees to whom the tentative code was submitted for study and constructive criticisms. This tentative code was then revised and submitted to a much larger group of gas men and engineers comprising practically every official of note in the country, who in turn submitted it to their subordinates. The resulting code may be considered as the last word in standard gas fitting practice of the present day and should be adopted by every company, both large and small, as the rules and methods to be followed in all gas fitting work. It is also to be desired that municipalities and commissions recognize this code as standard and pass such ordinances or rules of order as is found necessary to enforce its recommendations. Gas companies should endeavor in every way possible to obtain such assistance from state and municipal authorities as being a means of materially lightening the present burden of obtaining proper work and inspection.

The Piping of Buildings

In previous chapters will be found articles pertaining to modern gas lighting which prove that no property owner can afford to neglect the important detail of piping

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the building whether it is to be used as a factory, store, office or residence. Gas companies should keep watch on every new building erected and exhaust every effort to have gas piping installed. They should not even stop at this, but see that every building, new or old, located within the franchise area is fitted with gas piping. Influence should be brought to bear upon architects and builders with a view of interesting them in the installation of gas piping in every building under their jurisdiction. The cost of piping buildings during erection is negligible when compared with that of installing the pipes later or with the possible loss encountered where gas is not available for prospective tenants. The Consolidated Gas Company of New York present the following arguments to architects,, builders and plumbers under a slogan of "Pipe all buildings for gas":

"No building can be considered modern or complete unless it includes a complete gas piping system. Buildings of the loft or office type are coming more and more to number among their tenants those engaged in many diversified trades and professions. The application of gas to the uses of such trades and professions are likewise increasing. There are already more than one thousand distinct and separate uses for gas and this number is growing rapidly.

"To give a list of business in which gas is used for lighting, heating or fuel operations, or power purposes would be to give the classified headings of a metropolitan business directory. From the office of the dentist with his furnaces and laboratory burners to the establishment of the big clothing manufacturers with his pressing irons, singeing burners, dry kettles, etc., each has its definite place and its special advantages. Gas is used by jewelers, assayers, embossers, chemists, engravers, electrotypers, physicians, photographers, barbers; in the retaurant or kitchen which is usually found in the modern office buildings, and in a host of other places where work is done.

"The cost of a complete gas piping system is negligible. It will be found as a rule to be but a fraction of one per cent of the total cost of the building. Is it wise to omit so important a part of the equipment of a modern building?

"The large buildings of today will outlast generations; the character of the occupancy may change with the character of the locality. If a gas piping system is installed at the time the building is erected any demand for gas that may arise can be readily met at any time.

"It has frequently been found necessary to install a gas piping system after the building has been completed because there has arisen an unforseen demand for gas. The inconvenience and added expense thereby entailed need not be impressed upon the architect or builder.

"The more modern the building the more attractive it will be to the prospective tenant. No matter if first indications are that there will be little or no demand for gas, pipe the building. The added value of being able to provide a gas supply to the occupants will amply repay the slight expense of installing the piping system.

"The rental value of a building depends upon its equipment and conveniences. Ought the slight additional cost of a gas piping system be allowed to keep it out of a building when its many advantages and conveniences for the future occupants of the buildings are considered?"

In addition to interesting the architect, builder or owner in piping the building for gas, it is of utmost importance that they be interested in seeing and knowing that the building is adequately and properly piped. This can be done through co-operation with architects, builders and others in securing a strict enforcement of gas company rules. It is usually as big a job to reconstruct inefficient piping as it is to install it new, so that a building improperly or inadequately piped may as well not be piped at all. In the rule book of up-to-date companies will be found a paragraph reading about as follows: "Architects, owners of buildings and builders are requested to refuse to allow any bill for gas piping unless accompanied by the company's certificate of inspection."

A report of the committee on supplying large buildings with gas of the American Gas Institute shows that they have a plan in mind of printing a booklet for distribution among architects, builders and others setting forth the advantages of gas supply for large buildings and providing data and information relating to gas supply. This will no doubt prove a great help in interesting architects, builders and owners in the desirability and necessity of having buildings piped when erected.

They also advise the maintenance by gas companies of a staff of engineers or inspectors who are competent to advise architects and builders on piping and installation work and who are able to intelligently give information as to the advantages of gas in all its uses, costs and methods of piping, etc. It is recommended that these men keep in close touch with building operations and to use every effort to interest the erectors in piping every building for gas.

In a paper read before the N. C. G. A. Convention in 1916, abstracts of which follow, Mr. W. J. Rasch of the Consolidated Gas Company of New York ably covered the subject of adequate piping of buildings with a detailed description of how this matter is handled by the New York company.

The adequate piping of buildings is the first and most important feature to be considered in promoting the utilization of gas and of devising means and agencies for increasing its consumption. It is a subject the importance of which cannot be overestimated, and, strange to say, one which has received insufficient attention from the gas industry at large.

How are we to increase the sale of our product if building are not properly and adequately piped for gas? We can go on perfecting appliances, seeking new and hitherto undiscovered uses for gas and designing and testing appliances to meet their requirements, but in the end our time, energy and money will have been only of partial value to us, unless our energies are also directed to securing the complete and adequate piping of all buildings for gas at the time of their erection?

The fact remains that our supreme confidence in the superiority of our product is not being shared today by

[redacted]

the architects and the building interests, not that gas for fuel or lighting has been superceded by a superior, more economical and more efficient fuel and light, but rather because the newer method has been the more actively exploited, and our competitors have reaped the natural reward of aggressive effort. It is our duty now to set aside this confidence and to demonstrate finally and conclusively that gas for light, heat and power has certain pre-eminent characteristics and to deprive a building of such pre-eminence by the omission of gas piping means the curtailing of its producing or renting value.

A concerted effort should be made by all members of the gas industry to bring the matter of gas piping to the attention of all who either design or erect buildings.

In dealing with the architects, the small cost of piping the building during construction is emphasized. This cost varies from 0.128 per cent to 0.65 per cent of the total cost of the structure for a loft building, with its small number of outlets, to the most elaborate piping of a modern office building. This is comparatively negligible, and the architect's attention is directed to the trouble, inconvenience and great expense the owner would be put to if he was compelled to pipe a building after completion, in order to secure a desirable tenant whose industry requires a gas fuel service.

Cases may be cited where structures, even though designed for a specific purpose which in its operation did not require a gas service, had to be piped to meet the demand caused by a change in the character of the occupancy requiring gas service.

It is seldom indeed, if the matter is properly placed before the architect, that the desired result is not obtained, but if after all arguments and urging he has failed to be convinced of the necessity of piping a particular structure you may rest assured that the structure will sooner or later be one of the concrete examples to quote to other architects of an owner's lack of foresight and erroneous conception of economy.

It may be necessary to visit an architect several times before he can be seen, and even after an interview it may require several calls before his decision can be ascertained and the question finally settled. Once a project has been entered upon there must be no let up until it is finally settled one way or the other. At times it means calling at the job, visiting the plumber to ascertain the size of risers he contemplates installing, and at times calling the owner's attention to the insufficiency of gas riser lines being installed by the plumbers, especially when the architect has only been commissioned to draw up the plans.

If one-half of the information in the possession of the gas companies, as to the safety, economy and efficiency of their product for lighting, heating and fuel purposes was in the possession of those who designed and erected building structures, there would be little difficulty in having them adequately pipe all buildings for gas.

Inspections and Enforcement of Rules

Two inspections should be made by the gas company of every job of gas piping installed by outside fitters; a preliminary before the piping is concealed and a final after the building is plastered. The former is to ascertain if the piping has been laid in accordance with the rules and regulations of the company governing size of pipes and methods of installation, while the latter is to ascertain if the job is tight and that risers are run to the proper locations and openings and drops properly projected. At each inspection the piping should be subject to air pressure in accordance with the National Gas Safety Code recommendation. If the code is not observed the company rules should provide that the piping be subjected to at least six inches mercury column, which it must maintain for at least thirty minutes.

The reason may not be plain to all why a second test is necessary if the piping was found tight on the preliminary inspection. It is to provide against the contingency of broken pipes or fittings during construction operations since the preliminary inspection was made, alterations or uncapped openings. Often in large buildings a period of several months or a year may elapse between the preliminary and final inspection during which many things may occur to the piping which would prevent its remaining tight. Uncapped openings might also be left, concealed by plaster or other obstacles, that would prove a serious detriment when the building was finally ready for gas.

If the gas piping has been laid in accordance with the company's rules and regulations, as ascertained by the

APPLICATION FOR INSPECTION

App. No. ____________

Certificate No. ____________ Denver, Colo. ____________ 191__

The Denver Gas and Electric Light Co.
Gas Engineering Department
Room 206 G. & E. Bldg.
Gentlemen:

The gas piping in the building at No. ____________

Street owned by Mr. ____________ will be ready for {Preliminary / Final}

inspection at ______. M. ____________ 191___. I agree to hold The Denver Gas and Electric Light Co. free of liability because of such inspection and report and to pay them the sum of $1.00 for each and every inspection, over the one preliminary and one final inspection allowed free of charge, made necessary thru faulty workmanship or material or failure to be ready for inspection at the appointed time.

Signed ____________ Owner / Gas Fitter / Contractor / Owner

Fig. 396. Card Record of Inspection Applications

preliminary inspection and is found tight at final inspection the company should issue a certificate of inspection. No certificate, however, should be issued until after the piping has been found tight on final inspection.

The company should make free of cost one preliminary and one final inspection. If any other inspections are made necessary by defective or faulty work, or by reason of the piping not being ready for inspection and test at the time specified a nominal fee should be charged for each one of such inspections. This fee should be collected before a certificate of inspection is issued. The purpose of this fee is to act as a penalty for violations of

Form [illegible]

PRELIMINARY INSPECTION REPORT.

App. No.__________

Prelim. Rep. No.__________ ________________191___

Building____________________St.

____________________ Owner.

____________________ Contracting Gas Fitter.

This is to certify that The Denver Gas & Electric Light Co., thru the undersigned Authorized Inspector has made preliminary inspection of the gas piping in above building and found same________tight and ________laid in accordance with the Company's rules.

Illuminating riser ________In. Openings________________

Fuel riser ________In. Openings________________

Application must be made for final inspection after building is plastered, which inspection will be made free of charge. Application for any further preliminary inspection on this same piping must be accompanied by a fee of $1.00.

This report is not a certificate of inspection.

*Signed:*____________________*Inspector.*

(Remarks on Back)

Fig. 397. Report of Inspection

the company's rules and to aid in their enforcement and is a provision that should be rigidly adhered to.

Written applications for inspections should be made upon blank forms furnished by the company, signed by the contracting fitter or owner of the building and filed

Form [illegible]

FINAL INSPECTION CERTIFICATE.

App. No.__________

Prelim. Rep. No.__________ ________________191___

Final Certificate No.__________

Building____________________St.

____________________Owner.

____________________Contracting Gas Fitter.

This is to certify that The Denver Gas and Electric Light Co., thru the undersigned authorized inspector has made final inspection of the gas piping in above building and found same ________ tight and________acceptable by this Company.

Application for any further final inspections on this same piping must be accompanied with a fee of $1.00.

The Company does not assume any responsibility for this piping thru its inspection or the issuance of certificate thereof.

Preliminary Inspection passed__________191___

*Signed:*____________________*Inspector.*

(Remarks on Back)

Fig. 398. Final Certificate of Inspection

in the company's office at least twenty-four hours in advance of the time inspection is desired.

Meters should not be set or gas turned into any piping whatsoever unless a copy of the certificate of inspection is on file in the company's office. As this is the company's prerogative to enforce its rules it should never be waived under any circumstances. The company's fitters should be instructed to watch for new piping, which might be installed as an extension or part of an existing system unknown to the company, and to report such discoveries to their superior without setting the meter or turning gas into such piping. A good plan for companies to follow is to have the inspectors attach a gummed label to all piping for which a certificate of inspection has been issued. This label, which may simply contain the name of the company and the word "passed" should be attached in a conspicuous place to the piping nearest the meter location. The use of tags for this purpose is not recommended on account of a liability of their being torn off or removed.

Copies of the preliminary and final inspection reports signed by the inspector making such inspections should be kept on file in the company's office. On these reports should be shown, in addition to the address, class of building and date; the number and size of risers and openings, conditions found and the result of inspection and test. These serve as a record of conditions in case an installation is not accepted or for future reference in case a certificate of inspection is issued.

The company should render assistance at any time to gas fitters desiring aid in laying out piping or locating risers and where unusual circumstances make compliance with the company's rules difficult consistent concessions should be made if the same are not of serious consequence. However, concessions should never be made unless requested by the gas fitter in regular form at the office of the company. Fitters who violate the rules in any manner without consulting the company should be penalized regardless of how unusual the circumstances might have been.

Outside fitters should be given to understand that the company has no desire to be unreasonable in its demands, but that it simply desires protection for itself and its customers. The fair-minded gas fitter will recognize in company rules and regulations an aid to him and his business by keeping unauthorized and incompetent persons from installing piping to be used for gas. He should readily see that he has nothing to fear from the enforcement of the rules, as in most cases there is nothing to be gained from a financial standpoint in endeavoring to avoid such rules.

The Relation Between Plumbers and the Gas Company

The relation between plumbers or outside gas fitters and the gas company should be of a most cordial and co-operative nature, but too often it is entirely the opposite on the part of the former, who consider the gas companies as interlopers or trespassers upon the rights of the gas fitting fraternity through the fact that the company maintains its own force of fitters for its particular work. Another cause for ill feelings on the part of the plumbers is a mistaken misunderstanding of the enforcement of rules and regulations pertaining to the installation of gas piping in buildings.

Considering the matter from the standpoint of the plumber perhaps the gas companies are oftentimes to blame for the lack of harmony existing. We know of cases where the companies appear too autocratic in the enforcement of rules and where rules are wilfully violated by company fitters to the knowledge of the plumbers. The plumber, as a matter of fact, does the larger part of his work by contract and must often bring his profit to the breaking point in order to meet competiton. It is only natural that he should desire to make a fair profit on his work and we must blame human nature rather than a desire to injure the gas company if he is often indiscretious. He looks at the matter very much in this way: "If the gas company can run 75 ft. of ¾-in. pipe when their rules specify a maximum of 60 feet, then why should I bear the extra expense of running 1-in. pipe?"

When the company on inspection refuses to issue a certificate of approval there is naturally hard feelings on the part of the plumber, and when the company makes it stick they are branded as autocrats. Can we blame them? Much can be done to increase the feeling of cordiality now existing generally between plumbers and gas companies by getting closer together and by a system of instruction to teach the plumber that the gas company's interests are his interests and of mutual benefit.

If the plumbers were taught, and made to understand, that the installation of proper gas piping promoted the use of gas and thereby increased his business by the demand for gas piping, while the allowance of improper work curtailed, or in fact crippled the business, thereby producing a decrease in the amount of gas piping required, every plumber of consequence would become a booster for the gas company and would obey their rules and regulations to the letter. Every city has some plumbers who see the light already in this respect, as is evidenced by certain plumbers who ask advice and obtain assistance in laying out their work and who obey the quent utilization. When his work is not accepted by the company he thinks he is abused or discriminated against.

The aim of gas companies should be toward the education of the competent and reliable plumbers so that they thoroughly understand why rules and regulations are necessary, and above all things the promotion of a mutual benefit policy. They should strive to eliminate the feeling of autocracy and promote a feeling that what is good for the gas lighting business is likewise good for the gas fitting business, which would literally mean co-operation between gas companies and those engaged in gas fitting work.

Work Done by Gas Companies and Plumbers

Practically every gas company in the country maintains its own force of fitters who do certain classes of work for the utility. Most companies extend the scope of the work done by their own men to include the connection of all kinds of gas consuming appliances, while some even pipe buildings for lighting purposes. The tendency is becoming greater every year for the companies to sell and install all of the appliances used by the customers, and as the uses for gas are continuously increasing this work requires the expertness and skill that can only be attained by the fitter, who is in the gas business exclusively and who is vitally interested in the promotion of the use of gas by the efficiency of the operation of the consuming appliances.

In the early days of the gas business very little work was done by the companies except the installation of mains, services and meters. When the fuel appliances started coming on the market they were usually installed by a plumber in accordance with his own opinion of how it should be done. Until quite recently the plumbers and most hardware dealers carried a line of different gas appliances that were connected on sale and which were sold just as any piece of merchandise is sold—for profit. As the gas companies began to realize the enormous possibilities of their product they awakened to the fact that its future depended upon efficient utilization which in turn was dependent upon the efficiency of the appliance used. The importance of handling the appliances was then apparent, and it did not take the customers long to realize that the proper place to buy a gas appliance was from the company which was most interested in its future efficiency and use. At the present time practically all of the gas companies maintain elaborate display rooms where every kind of appliance can be purchased, while the larger companies maintain testing laboratories and shops where the efficiency of various appliances is proven and special appliances made to suit any purposes required.

The sale of a proper appliance is but one step toward efficient utilization of gas; the other step is proper connection. The gas company, realizing the importance attached to proper connections from an operating and maintenance standpoint, is the one best fitted to perform the work of installation.

A factor that must enter largely into the question of

It would be difficult to draw a line of distinction between the class of work that rightfully belongs to the plumber and that which should be done by the company. If the company's rules are observed there should be no objection to the plumber doing any part of the gas fitting work required on a customer's premises beyond the outlet of the meter provided the customer is willing to pay the difference in cost between the plumber's price and that of the gas company. On the other hand, there is no reason why the company cannot rightfully use their advantage in cost for the benefit of the customer on all such work. As the company is not in business to make profits from gas piping, but their efforts are directed chiefly toward the sale of gas, or rather service, it is advisable to divert to the plumber all work the nature of which does not have a direct bearing upon revenue or service. Such work as repairs or alterations in the consumer's piping may be included in this class.

The piping of new buildings should be done by plumbers, but in the case of old houses it is often necessary for the gas company to handle the work themselves in order to obtain the revenue from the sale of gas. Campaigns for the piping of old houses for light would be out of the question if the company did not handle the work, and in no manner can be construed as infringing upon the right of the plumber, as the business is gotten usually upon solicitation by the gas company and then only through the inducement of small profit to be made on the work.

CHAPTER XVIII

GAS COMPANY RULES

All of the important gas companies of the country have sets of rules and regulations governing their installation of gas piping and appliances. The rules of the different companies do not differ as greatly as do the degree or method of enforcement. In some cases the municipality aids in the enforcement of company rules by means of laws or ordinances, which is often a great benefit to the company in securing proper gas piping and connections. There is no doubt but that the adoption of the Bureau of Standards Gas Safety Code by all companies, with proper assistance rendered in its enforcement by state and municipal authorities, will be a boon to the gas business.

The rules used by some of the larger gas companies and which are are typical of good practice follow:

pressure and made tight before calling inspector. Ample notice, not less than six hours, must be given by gas fitter to Rochester Railway and Light Co. of actual time when inspector is desired. Inspector will test all work with an air pump and mercury gage with pressure of not less than 5 lbs. for at least ten minutes.

The following rules have been adopted for the general guidance and benefit of all parties. If these rules are closely followed, as they should be in all cases, it will insure an ample supply of gas to the occupant of the building, and free him from any annoyance that may otherwise occur. If not followed, the consumer will be liable to never-ending annoyance from leaks, lack of pressure, stoppage of pipes, flickering of lights, etc.

4. Gas piping and gas fitting, from the street mains to the meter, when meter sets in basement, including the meter connections, will be done by the Rochester Railway and Light Co. Beyond the meter the piping may be done by any competent gas fitter, but consumers, property owners or contractors having piping done should require for their own protection that such work be done according to the following rules, and that it shall not be paid for until the Rochester Railway and Light Co. have given a report of approval to gas fitter doing work.

5. All piping should be inspected on completion and before lathing the building. When examined and passed upon by the Rochester Railway and Light Co.'s

CERTIFICATE OF INSPECTION

No..........

Rochester, N. Y...................19....

Rochester Railway and Light Co., through the undersigned, its inspector, has examined the gas piping and fittings, and workmanship done by.................. Gas Fitters, at..................and found it to conform to the "Suggestions to Gas Fitters," as published by the Rochester Railway and Light Co.

.... Inspector.

inspector the company is warranted in issuing a report on the form preceding. Blank request for inspection will be furnished upon application.

Illuminating System

6. The following table shows the proportionate size and longest length of pipe to be used, with the greatest number of burners allowed:

$\frac{3}{8}$-in. pipe.......	15 feet......	3 burners
$\frac{1}{2}$-in. pipe.......	25 feet......	6 burners
$\frac{3}{4}$-in. pipe.......	40 feet......	20 burners
1-in. pipe.......	60 feet......	25 burners
$1\frac{1}{4}$-in. pipe.......	100 feet......	50 burners
$1\frac{1}{2}$-in. pipe.......	150 feet......	75 burners
2-in. pipe.......	200 feet......	150 burners

When one-fourth the length of pipe is used the number of burners may be doubled.

7. The riser in any building must in no case be of less than $\frac{3}{4}$-in. pipe and must in all cases be run on inside walls, and not less than 4 ft. from any outside wall. Extensions from the same to the meters must be so run that the meters shall be conveniently located for reading the index, and such extensions and places for meters must be so located as to insure protection from frost or excessive heat.

8. All openings from the riser must be securely capped when the work is finished and tested.

All drops and openings for wall brackets must be fastened with gas hooks or straps. Fastenings with nails will not be allowed.

9. When outlets are close to studding or joist a notched wooden crosspiece must be securely fastened to secure the same.

10. Broken and defective fittings, split pipe, sand holes or leaks at joints must not be repaired with gas fitters' cement, dope or solder. When cold, it is liable to crack off; when near hot air flues or steam pipes, it

will melt. Unions not allowed in concealed piping are R. & L. or lock nuts.

11. Piping must be run as direct as possible, without sag and with a true grade and fall toward riser or meter. This is necessary to prevent accumulation of condensation or water and consequent shutting off of gas supply.

Grade of pipe can be determined by spirit level.

12. Drips will not be allowed.

13. Tests will be made under air pressure of 5 lbs. to the square inch, or 11 in. of mercury.

14. Risers for bracket lights must never be put in place until after the studding for partitions is firmly secured, and pipe will not be tested until outlets are firmly fastened, as noted in suggestions 7 and 8.

Concerning the Location of Meters

15. Meters must be located where they will not be exposed to extremes of temperature and where they will be easily accessible to the meter readers.

They must not be located near a furnace or boiler or too near a steam pipe. They must not be placed in a coal bin or where something may be thrown upon them.

Meters located in basements should be placed on any inside wall not less than 4 ft. from the outside wall. In houses of two flats the meter for each flat should be placed in that part of the basement set apart for that particular flat.

In apartment buildings meters are to be set so that they will be accessible without entering the apartments.

In running house pipe for fuel or illuminating purposes, where a number of meters are to be set in a row, a space of 15 in. should be left between the openings of service and risers. The service to be on the left and riser on the right.

When locations are provided contrary to the above rules the necessary changes will have to be made at the owner's expense before meter will be set.

[redacted]

16. To govern the size of piping to be used in piping for fuel systems the following rules should be followed:

a. Consider that each fuel appliance will be used at its maximum capacity, and all appliances at one and the same time.

b. Assume as a basis for figuring pipe, that a

Four-hole range uses 60 ft. per hour;

Six-hole range uses 80 ft. per hour;

Each gas fire or log uses 50 ft. per hour;

Each water heater uses 40 ft. per hour.

(If in connection with range add 25 ft. to consumption of range.)

Smaller appliances, 25 ft. per hour.

c. Figure each length of pipe between openings separately, commencing at the meter. Use the table given below and adopt the size of pipe given in the table of capacity to pass the required amount for given length.

d. If exact capacity required is not given in the table use the next larger size of pipe.

Capacity in Feet Per Hour

Size of pipe	Length in feet									
Diameter	10	20	30	40	50	60	80	100	150	200
½ in...	60	40	...	...	...	...	...	...	...	...
¾ in...	120	80	60	50	45	...	...	...	...	...
1 in...	250	170	140	120	110	100	80	...	...	...
1¼ in...	450	320	240	200	180	160	170	140	...	...
1½ in...	800	600	480	360	320	270	240	210	180	...
2 in...	1,500	1,100	800	700	625	560	520	480	400	320

f. Do not run over 20 ft. of ½ in.
Do not run over 50 ft. of ¾ in.
Do not run over 80 ft. of 1 in.
Do not run over 100 ft. of 1¼ in.
Do not run over 150 ft. of 1½ in.
Do not run over 200 ft. of 2 in.

17. Openings in side walls for fuel appliances should as a rule be 12 in. from the floor and project 1½ in. clear from the finished wall.

18. All other rules for piping and inspecting not

inconsistent with these will be the same as for the illuminating system.

19. The right is reserved to amend or rescind at any time all or any of the foregoing rules and regulations. It is the intention of the Rochester Railway and Light Co. strictly to enforce the above rules, and no certificate of inspection will be given when they are not complied with.

Oakland (Cal.) Gas and Electric Co.

The Oakland division of the Pacific Gas and Electric Co. issue the following circular of instructions to gas fitters, architects, carpenters and contractors. It first went into effect in 1902 and was reissued in 1908. The district supplied has a population of about 330,000 and the rules are printed on a sheet 6.2 x 12.4 in. in size:

This company's inspector is instructed to observe the following rules and the attention of all parties concerned is particularly called to them:

On the back of these circulars the gas fitter must make all plans of work with the length and sizes of pipe marked with figures.

All applications for examinations and inspections must be made at the office between the hours of 8 and 9 a. m., when a time will be appointed by the inspector to attend to such application.

A charge of one dollar will be made for every unnecessary visit of the inspector.

Before making any alteration or extension if an unlighted building, application must be made to the inspector, who will allow such work, if found to be proper or desirable.

All drops must be square bends or offsets; no soldered drops allowed.

The pipe must be run according to the following table. To estimate the number of burners allow one burner for bracket-lights, three burners for half-inch drop, and one burner each for hall, bathroom, porch and pantry.

[redacted]

Diam. of pipe inches	Length allowed feet	No. 5 ft. burners
½	30	6
¾	50	20
1	70	35
1¼	100	60
1½	150	100
2	100	200

Gas Stove Runs—Allow for each outlet 6 burners for heating stove, 20 burners for kitchen stove, or 35 burners for water heater connections.

Gas Grates—No gas grate will be connected to unless it has a flue outlet of at least 6 x 6 in., or such size as prescribed by municipal ordinances, discharging into chimney or into atmosphere through side or top of building.

No drop less than ½ in. in diameter will be allowed or more than 1½ in. below plaster.

No horizontal pipe smaller than ½ in. will be allowed.

For bracket-risers or drops 7 ft. of ⅜-in. pipe in one piece only will be allowed; in excess of 7 ft. the entire drop or riser must be ½ in.

Where risers running from first to second floor offset or run over at point of riser to second floor, use tee with nipple and cap. On running pipe from front to rear, whenever pipe is lowered, use tee with nipple and cap, and avoid all unnecessary drips. End of riser must be not less than 2 ft. from floor when inside of building, but when practicable risers must be under front of building or under front steps.

For new concealed work a plan must be furnished the inspector as soon as the pipe is put in, who will examine the work within three days. No riser pipe is allowed less than ¾ in. in concealed work. The pipe can be proven after the first course of plaster has been put on. The pipe must be run in a workmanlike manner so as to avoid stoppages, and it must be well secured—no union or gas fitter's cement allowed. Ample space should be left for meter and well ventilated.

Gas fitters will run their gas pipe to the left of door to allow for electric meter board to be placed to right of meter door.

No gas fitter will be allowed to run any pipe between the meter and the main of the company without permission in writing from the office.

In all buildings where extensions are made care must be taken to extend from a point where the rule for size of pipe can be maintained.

Where necessary for building service provide header (same size as service) with an opening for each riser.

Where risers are in groups openings must be not less than 12 in. apart.

When meters are grouped or where located in rear of buildings, such as apartment houses, office buildings or store buildings, gas fitters must run building service to property line.

All pipe placed under ground must be galvanized and run according to the following table:

Diam. of pipe inches	Length allowed feet	No. of openings for meters
1¼	110	4
1½	150	8
2	200	16

The pipe must be tested with a column of mercury, not less than 12 in. in height, the final test to be made with gage furnished by gas inspector. No concealed work is allowed to run underneath the beam or across studding.

To avoid complications, gas fitters should consult gas inspectors before locating risers in large buildings and apartment houses.

If the rules are not clearly understood concerning size of pipe or if unusual conditions are met with, communicate with the gas company's inspector.

Owners, architects, carpenters and contractors should, before a final settlement, obtain a certificate of inspection, as a meter will not be set until certificate is given by the inspector that the work is appproved.

Denver (Colo.) Gas and Electric Light Co.

The following rules have been adopted by The Denver Gas and Electric Light Co., governing the piping of buildings for the distribution of gas for light and fuel:

GENERAL RULES AND SIZES

Domestic and Office—For gas piping laid to supply lights in dwelling houses, flats and office buildings.

Diam.	Greatest length allowed, feet	Greatest No. of ⅜" openings allowed
⅜-in.	15	1
½-in.	30	3
¾-in.	60	10
1-in.	75	15
1¼-in.	100	30
1½-in.	150	60
2-in.	200	100
2½-in.	250	200
3-in.	300	300

If the above lengths are exceeded, use next larger size.

No ¼-in. pipe will be allowed.

Risers must not be less than ¾-in.

Public Buildings—For gas piping laid to supply lights in stores, churches, halls,, schools, hospitals, factories, etc.

Diam.	Greatest length allowed, feet	Greatest No. of ½" openings allowed
½-in.	20	1
¾-in.	60	8
1-in.	75	12
1¼-in.	100	20
1½-in.	150	35
2-in.	200	50

Piping must be carried full size to last opening taken off.

No drops or openings must be less than ½-in.

Industrial—For gas piping laid to supply fuel apparatus.

Diam.	Greatest length allowed, feet	Greatest No. of ¾" openings allowed
¾-in.	60	1
1-in.	75	2
1¼-in.	100	4
1½-in.	150	7
2-in.	200	15

For mantels, grates and small heating appliances for heating space not to exceed 1,728 cu. ft., or for bunsen burners used by dentists, doctors and chemists, 30 feet of ½-in. pipe may be run for one opening only and two such openings are considered as one ¾-in. opening.

No piping or opening smaller than ¾-in. shall be allowed for any cooking appliance or for any other purpose.

All concealed gas piping laid to supply fuel apparatus must be laid independently of gas piping supplying lights and concealed fuel piping must be carried to where meters are to be set and there connected to light risers by R. and L. couplings, unions or long screws.

Concealed fuel piping with openings left for lights, or with any other openings, except for such fuel apparatus as will be installed, will not be accepted.

All risers must be extended to within two feet of the location provided for meter.

Where two or more risers are run together, they must be spaced not less than 15 in. apart at meter location.

All risers must be run inside walls where they will not be exposed to atmospheric changes, and not less than 3 ft. from an outside wall. Vestibule walls will not be considered as inside walls.

The burr left upon the inside of gas piping by the cutting-off tool must in all cases be reamed out, so as to insure the effective area of the pipe.

Tees must be provided on the bottom of all risers,

... under the s
spector.
All drops supplyi
bends offset at least
gas pipe supplying t
sidered a main gas pi
straight pipe screwed
All drops must projec
2 in. below the plasteri
to joists or upright stu
nailed between the joi
Side lights must be
the floors below lights
above lights. Square l
jecting not less than or
inch beyond plaster, a
studding or pieces nail
must be used.
Gas piping notched int
not be accepted.
No split pipes, cemente
will be accepted.
In remodeling or exten
tions must be made wher
accordance with the foreg
extensions be made from
cannot be maintained fro
be ...

er's property through regularly installed services. Where underground piping is installed by the property owner it must be done with a full understanding on the owner's part that the company is automatically released from any liability for interruption of service or any other trouble that may occur in or through the underground piping. Such piping must be installed subject to acceptance by the company in accordance with the following rules: No pipe smaller than 1¼ in. must be used. All piping must be laid not less than 3 ft. underground, free from traps and sags and properly graded to an accessible location, where a drip must be provided, consisting of a piece of 1¼-in. pipe, not less than 18 in. in length, containing a 1¼ x ¾-in. reducer and ¾-in. plug for the removal of condensation. The piping must be inspected and tested by the company's inspector before being covered.

Consumer's piping laid under cement floors, as in fireproof buildings, garages, etc., may be installed subject to the same rules and regulations as for piping concealed under wooden floors.

Supply for gas engines must be separate and an independent service will be required. The following table will apply to piping run for gas engines:

Size of engine	Size of opening, inch	Greatest length allowed, feet
1 H. P.	1	60
2 H. P.	1¼	70
5 H. P.	1½	100
7 H. P.	1½	100
12 H. P.	2	140

Where larger engines are to be installed the company should be consulted regarding proper sizes of piping to run.

No stop cocks must be placed in any gas line beyond the meter, except those provided at appliances for turning gas off or on. The company will install and maintain necessary cocks or valves on its service pipes and meters for shutting off the supply of gas to the premises of consumers.

To avoid complications, outside gas fitters should consult the company before locating risers in corner buildings or in any other case where doubt exists as to the possible location of gas supply.

SERVICE EXTENSIONS AND HEADERS

For building services run from basement wall where company's service enters building to room provided for meters.

Diam.	Greatest length allowed, feet	Greatest No. of ¾" openings allowed
1¼	100	4
1½	150	6
2	200	12

All openings in building services and headers to be of same size as risers to be supplied therefrom, and in no case are they to be less than ¾ in. Building services installed by outside gas fitters must be carried from a point not less than 2 ft. nor more than 3 ft. of where the company's service enters building to a point not less than 2 ft. nor more than 3 ft. to the left side of the first riser to the left when facing wall where meters are to be located. The building service must be capped at both ends and no openings or tees will be allowed except those contained in the header installed by the company. The company will inspect, test and make connection to their service. Building services shall be under the control of the company for as long as they shall remain connected to the company's service pipes.

Underground work put in by outside gas fitters between company's mains and meters or connections made to any service pipe or meters will not be allowed. The company will install and maintain all service pipes and meters except in such cases where meter rooms are located above the basement where the company's service enters building, when building services may be installed by outside fitters in accordance with rule 26. The company reserves the right, which it will rigidly enforce, of making all connections to its service pipes and meters.

Openings in meter headers must be spaced not less than 15 in. nor more than 24 in. to the left of the risers to be supplied from such openings. Where meters are grouped in tiers, the openings for the upper tier must be not less than 30 in. above the opening for the lower tier. All risers and openings in services and headers must be located not less than 30 in. nor more than 8 ft. from the floor.

Service pipes will not be run under cement or parquet floors unless a conduit is provided making the pipe readily accessible in case of stoppages or leaks.

A separate service pipe from the company's main will be required for buildings, not connected by the same roof, which may be divided by sale. This rule may be waived by the company in the business portion of the city where service extensions may be run open through adjoining basements with the consent of the owners thereof. Buildings situated upon the rear of lots and not having frontage upon any street may be supplied from services entering buildings on the same lot having street frontage, preferably through service extensions installed by the company.

Stop cocks or valves will not be installed on services at curb except on those of larger size than 2 in., in which case a valve located in an iron curb box will be provided. On all other services supplying more than one meter or where the meter location is more than 10 ft. from the point where service enters building, a cock will be provided just inside the building wall in a readily accessible place where the gas may be turned off of entire building in case of fire. Single meter installations where the location is within 10 ft. of the point of entrance of service into building will be taken care of with the cock located at meter inlet.

METER LOCATION

The company reserves the right to determine the location of its meters, which must be placed where

[redacted]

they will be easily accessible, not exposed to extreme heat (as near steam pipes or furnaces), dampness, frost, sudden changes of temperature or liability to damage by having things thrown on them.

Meters will not be set in coal cellars under any circumstances, nor under the deck of show windows, or in small closets if any other location can be provided. If such a location is unavoidable, means must be provided for thoroughly ventilating the space around the meter to eliminate any danger from explosion of escaping gas.

Meter locations will not be accepted where the apparatus to be supplied therefrom is below the level of the meter (as for instance a meter located on the second floor of a building supplying apparatus on the first floor), thereby producing a trap in the gas piping. The meter location must be the low point in all piping installations, except in the case of fuel installations where the meter is located on the same floor level but at a height above the apparatus to be supplied, in which case a minimum length of exposed piping may be drained toward apparatus with a suitable tee arranged for removal of condensation or rust.

In flats or store buildings where no meter rooms are provided the meters must be set in the respective basements or on the premises supplied by the meter.

Outside gas fitters and all other persons not an authorized agent of the company are prohibited from connecting or disconnecting the company's meters or service pipes, turning gas on premises where it has been turned off, or in any way altering or interfering with the company's meters or service pipes. The company will promptly, upon receipt of notice, attend to any work required in connection with its meters or service pipes.

Where unusual circumstances make difficult compliance with the foregoing rules and regulations, the company should be consulted in laying out the gas piping.

INSPECTIONS AND TESTS

(a) The company assumes no control over the gas piping of buildings beyond the meters, and will not be responsible for any imperfect material or defective or faulty workmanship, or for any loss or damage arising from such imperfect material or defective or faulty workmanship in any job of gas piping inspected by its inspectors, but for its own protection and for the benefit of its customers the company has adopted the foregoing rules and regulations, and it will hereafter refuse to turn gas onto any premises where the gas piping does not conform to these rules and regulations as shown by reports upon written applications for inspecting such gas piping, on file in the company's office and duly signed by the contracting gas fitter or owner of the premises.

(b) The company will require two inspections to be made on each job of gas piping. The preliminary inspection must be made before the gas piping is concealed, to ascertain if the piping has been laid in accordance with these rules and regulations. The piping will at the same time be subjected to an air pressure of at least 6 in. mercury column, which it must maintain thirty minutes without any drop. The final inspection will be made after the building has been plastered, at which time the piping will again be subjected to an air pressure of 6 in. mercury column which it must maintain without a drop for thirty minutes.

(c) If the gas piping has been laid in accordance with the foregoing rules and regulations, as ascertained by the preliminary inspection, and is found tight at final inspection, the company will issue a certificate of inspection. No certificate of inspection will be issued until after the gas piping has been found tight on the final inspection.

(d) The company will make, free of cost, one preliminary and one final inspection. If any other inspections are made necessary by defective or faulty work or by reason of the gas piping not being completed and

ready for inspection at the specified time, a fee of one dollar will be charged for each one of such inspections, and the fees will be collected before a certificate of inspection will be issued.

(e) Written applications for inspections must be made upon blanks furnished by the company, signed by the contracting gas fitter or owner of the premises, and filed at the company's office at least 24 hours in advance of the time when inspection is desired.

(f) Architects, owners of buildings and builders are requested to refuse to allow any bill for gas piping unless accompanied by the company's certificate of inspection.

(g) The company reserves the right to rescind or to add to the foregoing rules and regulations as it may deem necessary for the improvement of its service and the protection of its business.

(h) Applications for inspections should be made, and will be kept on file, accompanied by the reports of preliminary and final inspections, in the office of the gas engineering department of the company.

Portland (Ore.) Gas and Coke Co.

The revised house piping rules adopted by the Portland Gas and Coke Co. of Portland, Ore., on August 1, 1910, follow:

1. **Pipes**—Best quality of welded wrought iron or steel pipe, of sizes to conform to the scale given below, free from splits, flaws or other defects, shall be used.

No second-hand pipe will be allowed in concealed work.

2. **Fittings**—No union fittings allowed. All fittings, such as sockets, elbows, bends, tees, crosses, reducers, etc., under two inches shall be heavy malleable iron fittings.

3. **Joints**—All pipes and fittings shall be put together, perfectly gas tight, with screw joints and red or white lead.

SIZES OF PIPES

4. All rising, distributing and branch pipes shall be of ample and sufficient size to supply the total number of outlets indicated on plans.

No riser or main outlet from meter shall be less than ¾-in. pipe.

No pipe shall be less than ½ in.

5. The gas fitter or plumber shall proportion the size of risers, distributing line and branches by the following scale of piping.

6. The following tables show the proportionate sizes and lengths of piping allowed.

Size and Length of Piping Allowed

Diam. of piping inches	Greatest length allowed, feet	Greates No. of ½-in. outlets allowed for lights
½	30	3
¾	60	10
1	70	15
1¼	100	30
1½	150	60
2	200	100
2½	200	200
3	300	300
	Stores, Hospitals, Schools, etc.	
½	20	1
¾	60	8
1	70	12
1¼	100	20
1½	150	35
2	200	50

BUILDING SERVICES

In running service pipe from front wall to meters the following rules will apply:

Diam. of outlet inches	Greatest length allowed, feet	Greatest No. ¾-in outlets allowed
1¼	100	3
1½	150	5
2	200	8

All outlets in service must be equal to the size of riser, which in no case must be less than ¾ in.

Diam. of piping inches	Greatest length allowed, feet	Greatest No. of outlets allowed, all sizes
¾	60	2 ¾-in. or 4 ½-in.
1	70	1 1-in. or 2 ¾-in. or 4 ½-in.
1¼	100	1 1¼-in. or 2 1-in. or 3 ¾-in. or 6 ½-in.
1½	150	1 1½-in. or 2 1¼-in. or 2 1-in. or 4 ¾-in. or 9 ½-in.
2	200	1 2-in. or 2 1½-in. or 3 1¼-in. or 4 1-in. or 7 ¾-in. or 16 ½-in.

For mantles, grates and small heating appliances, for heating space not to exceed 1,728 cu. ft., 30 ft. of ½ in. pipe is allowed for one outlet only, and two such outlets are considered as one ¾-in. outlet.

7. To estimate the number of outlets figure as follows:

Range and water htr. is equiv. to....	4 ½-in. outlets
Gas arc is equiv. to.................	1 ½-in. outlet
Hotplate is equiv. to................	1 ½-in. outlet
Radiator or heater is equiv. to........	1 ½-in. outlet
Parlor fixture is equiv. to............	1 ½-in. outlet
Dining-room fixture is equiv. to......	1 ½-in. outlet
Kitchen, bedroom, hall is equiv. to....	1 ½-in. outlet
Bracket fixture is equiv. to..........	1 ½-in. outlet
Drop for stores, church and halls is equiv. to......................	1 ½-in. outlet

8. Instantaneous water heaters shall have an independent fuel run from meter, and shall not be less than 1 in. for No. 3 heater, 1¼ in. for No. 4, 1½ in. for No. 6 and 2 in. for No. 8 heater.

9. Gas engines shall have an independent meter and an independent service to meter. Sizes to be determined according to size and kind of engine.

FOR GAS ENGINES

Size of engine H. P.	Size of outlet inches	Greatest Length allowed, feet
1	1	60
2	1¼	70
5	1½	100
7	1½	100
12	2	140

10. Underground work, by gas fitters, plumbers or others, not employes of the company, between mains and meters will not be allowed, unless inspected in the open.

RISERS, BUILDING SERVICES AND HEADERS

11. All risers, building services or headers must be brought within 6 in. of front wall of building.

12. Where the basement does not extend to front wall of building a building service of not less than 1¼-in. pipe shall be run from riser which must be in excavated part of basement to within 6 in. of the front wall of building.

13. Where there is more than one riser in a building the risers shall be brought to the front wall of building, grouped 18 in. apart, each riser tagged designating what it supplies, and a header, with openings on the left-hand side of riser, put in and extended to within 6 in. of front wall of building.

14. Where service is already in building, riser, building service or header must be extended to service.

15. Riser, building service or header opening for meters must not be less than 20 in. nor more than 8½ ft. from floor.

16. In no case will a meter be set where it is not accessible nor where it is exposed to frost, dampness or liable to injury from any cause.

17. Before locating risers in houses situated on the corner of streets secure information from the office of the company as to the size and location of the main. This will avoid complications and delays.

[redacted]

18. No riser, building service or drop lines shall be built in brick or concrete work; walls must be recessed to receive them.

DISTRIBUTING AND BRANCH PIPES

19. In all cases pipes must be laid above or between floor beams; where pipes under floors run across wooden beams the latter must be cut, notched or bored.

20. No gas pipes on any account are to be placed across the bottom of floor beams which are to be lathed and plastered, where they would be inaccessible in case of leaks or alterations.

21. When exposed piping is placed across the bottom of wooden beams the latter must be cut, notched or bored and all outlets or drops must be wing fittings and securely fastened with screws.

22. All pipes must be graded to drip to risers and securely supported and fastened with straps, gas hooks or hangers to prevent sags or pockets. No pipes shall be fastened with nails.

23. When building conditions make it impossible to avoid trapping a gas pipe, set a tee with a nipple and cap at the bottom of the trap, and so arrange that it will always be accessible to remove condensation.

24. All pipes and fittings run in reinforced concrete buildings shall be galvanized iron and where drops are screwed in the joints must be made up with litharge and glycerine.

25. No pipe shall be so laid as to support any weight (except fixtures) or subject to any strain.

26. All branch pipes must be taken from the side or top of distributing lines; never below.

27. In remodeling or extending old gas piping, make connections to make sizes and lengths correspond with tables given; do not make extensions from small pipes, if necessary run new riser from meter.

OUTLETS

28. All outlets for range and water heaters shall be not less than ¾-in. opening.

29. All drop outlets in stores, churches, schools, large halls and parlors shall be $\frac{1}{2}$-in. openings.

30. No outlets for burners shall be placed under tanks, back of doors or within 4 ft. of any gas meter.

31. All drop outlets must be bends and must project at least 1 in. and not more than 2 in. beyond the plaster; must be perfectly plumb and rigidly secured either to the floor beams or to cross pieces nailed between beams. In old houses nipples will be allowed only when bends are impossible, but see the inspector first, and they must be made up with litharge and glycerine.

32. All outlets for wall brackets shall be made with bends or long drop ells; outlets made with elbows or nipples will not be allowed.

33. All outlets for wall brackets shall be at least 2 ft. below the ceiling and must be perfectly plumb and so rigidly fastened in place that they will not work loose with the use of the fixture attached to it.

34. Outlets for wall brackets must not project more than 1 in. beyond plastering.

35. If the rules concerning the size or running of pipes are not clearly understood in each case, or unusual conditions are met with, which the rules do not cover, secure further information at the office of the company.

INSPECTION AND TESTING

36. The company will not permit the use of cement, acid water or other materials to repair or locate leaks.

37. All pipes before being concealed shall be inspected by the inspector of the company and forty-eight hours' notice must be given at the office of the company when any pipe is ready for first or final inspection or test. In rough inspection plumber will be required to have gage on ready for test, and in flats or apartments a helper for the inspector will be required. The helper to be furnished by the plumber.

38. All outlets and risers must be capped and a $\frac{3}{8}$-in. opening to test pipe from, with room to swing a gage, must be left by party performing work.

[redacted]

39. All completed work shall be tested with an air pressure equal to not less than a 10-in. column of mercury; and no pipe will be passed as gas tight unless it will hold this pressure thirty minutes without any drop.

40. After the rough inspection and final test of completed work the inspector reports all pipes and fittings tight and run in accordance with the foregoing rules and specifications and that the lengths, sizes and outlets correspond with tables given, the company will issue a certificate of approval thereof.

41. In no case will a meter be set on any piping upon which a certificate of approval has not been issued.

42. The company will make inspections and tests and furnish certificates of approval.

43. Architects, builders and owners are requested to allow no bill for gas fitting unless accompanied by a certificate of approval.

44. The foregoing rules and specifications go into effect and operation August 1, 1910; all previous rules are hereby annulled.

Laclede Gas Light Co., St. Louis, Mo.

The Laclede Gas Light Co. rules are approved by the Association of Master Plumbers of the city of St. Louis

All gas fitters are requested to inform customers moving from one location to another to apply in person at office of the company or in writing and arrange to have gas supply shut off at old location and turned on at new address.

By giving such notice the customer will be protected against anyone using gas in his name at the old location and from becoming responsible for gas used by former occupant of the new location.

Plumber must not undertake to blow out house pipes until meter has been disconnected by the gas company.

In preparing plans and specifications for piping new buildings, provision should be made for at least one illuminating opening in each room. Failure to provide adequate piping has, in many instances, caused great expense to owners in running additional lines after the building has been completed.

RULES GOVERNING GAS PIPING

Architects, builders and owners of buildings are requested to embody in their specifications for gas fitting that all work must be done in accordance with the rules and regulations of the Laclede Gas Light Co.

Feet of Pipe Permitted in Office Buildings, Dwelling Houses and Flats

Diam.... ⅜ in. Outlets No.	⅜-in. ft.	½-in. ft.	¾-in. ft.	1-in. ft.	1¼-in. ft.	1½-in. ft.	2 in. ft.	2½-in. ft.	3-in. ft.
1	20	30	50	70	100	150	200	300	400
2	..	25	50	70	100	150	200	300	400
3	..	18	50	70	100	150	200	300	400
4	..	..	50	70	100	150	200	300	400
5	..	..	50	70	100	150	200	300	400
6	..	..	33	70	100	150	200	300	400
8	..	..	24	50	100	150	200	300	400
10	..	..	13	35	100	150	200	300	400
13	..	..	..	21	60	150	200	300	400
16	..	..	..	16	45	120	200	300	400
20	..	..	..	..	27	65	200	300	400
25	..	..	..	..	17	42	175	300	400
30	..	..	..	..	12	30	120	300	400
35	..	..	..	..	..	22	90	270	400
40	..	..	..	..	..	17	70	210	400
45	..	..	..	..	..	13	55	165	400
50	..	..	..	..	..	..	45	135	330
65	..	..	..	..	..	..	27	80	200
75	..	..	..	..	..	..	20	60	150
100	..	..	..	..	..	..	..	33	80
125	..	..	..	..	..	..	..	22	50
150	..	..	..	..	..	..	..	15	35
175	..	..	..	..	..	..	..	..	28
200	..	..	..	..	..	..	..	..	21
225	..	..	..	..	..	..	..	..	17
250	..	..	..	..	..	..	..	..	14

[redacted]

Feet of Pipe Permitted in Hospitals, Schools, Churches, Warehouses and Factories

Diam.... ⅜ in. Openings No.	½-in. ft.	¾-in. ft.	1-in. ft.	1¼-in. ft.	1½-in. ft.	2-in. ft.	2½-in. ft.	3-in. ft.	4-in. ft.
1	27	50	70	100	150	200	300	400	500
2	..	50	70	100	150	200	300	400	500
3	..	24	70	100	150	200	300	400	500
4	..	13	50	100	150	200	300	400	500
5	..	..	35	100	150	200	300	400	500
6	..	..	21	60	150	200	300	400	500
8	..	..	16	45	120	200	300	400	500
10	..	..	..	27	65	200	300	400	500
13	..	..	..	17	42	175	300	400	500
15	..	..	..	12	30	120	300	400	500
18	..	..	..	..	22	90	270	400	500
20	..	..	..	..	17	70	210	400	500
23	..	..	..	..	13	55	165	400	500
25	..	..	..	..	..	45	135	330	400
30	..	..	..	..	..	27	80	200	350
35	..	..	..	..	..	20	60	150	300
40	..	..	..	..	..	17	50	125	250
50	..	..	..	..	..	..	33	80	100
65	..	..	..	..	..	..	22	50	80
75	..	..	..	..	..	..	..	35	60
100	..	..	..	..	..	..	..	28	55
112	..	..	..	..	..	..	..	17	40
125	..	..	..	..	..	..	..	14	35
150	..	..	..	..	..	..	..	..	30
175	..	..	..	..	..	..	..	..	25
200	..	..	..	..	..	..	..	..	20

Feet of Pipe Permitted in Stores

Diam of Pipe.	Greatest Length Allowed.	Greatest No. ⅜ inch Openings Allowed.
½ in.	25 ft.	1 opening
¾ in.	60 ft.	8 openings
1 in.	70 ft.	10 openings
1¼ in.	100 ft.	20 openings
1½ in.	150 ft.	35 openings
2 in.	200 ft.	50 openings

When piping stores for illuminating gas, the size of the main run must be maintained the same throughout the entire run.

When alterations are contemplated in any building the gas company should be notified as soon as the permit is taken out, so that arrangements can be made for properly taking care of the piping and gas meters.

Where alterations are made in a building, any change necessitated in the location of the meters or services must be made at the expense of the customer or owner of the building. In case of doubt as to proper location of the meters or services consult gas company.

If the rules governing the sizes of pipe to be installed are not in any instance clearly understood, or if unusual conditions are met with, not covered by the rules, the company should be consulted.

Estimate of cost of changing location of meters or services will be furnished by company on request.

All piping should be inspected as soon as possible after work is completed, and before lathing the building. It should again be inspected after completion of the building, and before fixtures are hung. When such inspections have been made by the gas company's inspectors, and the material used and labor performed conforms to the standards established in the rules herein, the gas company will, on request, issue a certificate of the form shown.

Application for Inspection

No............

St. Louis, Mo.................., 191....

THE LACLEDE GAS LIGHT COMPANY is hereby requested to examine the gas piping and fittings and workmanship done by................................
....gas fitters, at
No...................... ...St., and to report to the undersigned whether the same is gas tight, and done in accordance with the "Gas Fitters' Rules,'" published by the Gas Company.

Cert. No.......... ....

Certificate of Inspection

THE LACLEDE GAS LIGHT COMPANY

No............

St. Louis, Mo.............., 191....

This is to certify, that at the request of............ the gas piping in the building, No................... has been inspected by this Company, and found to be tight and in accordance with our rules.

The Laclede Gas Light Company,

Per......................

Chief Inspector.

Inspector.....................

RULES GOVERNING SIZE OF PIPE

In all houses and flats containing five rooms and under, the main run to the kitchen for fuel must not be less than ¾ in. in diameter.

Houses and flats having more than five rooms and less than twelve rooms, the minimum size of the main run to the kitchen for fuel must be 1 in.

In residences having more than twelve rooms, the minimum size run to the kitchen for fuel must be 1¼ in.

Cellar lines should be hung from the ceilings.

In each case leave one full size opening in the kitchen for gas range, etc.

In figuring up the number of openings to be supplied use the following relations:

Openings		Outlets
¾-in.	½-in.	⅜-in.
..	1	3
1	3	7

For large buildings, or where unusual conditions are met with, consult the gas company.

All fuel openings must rise from below. Cellar lights may be taken off of either fuel or illuminating pipes, and need not be considered in figuring size of pipes to be run in flats and residences.

For one grate and one opening in kitchen not less than ¾-in. pipe must be used. Where water heater is to be installed 1-in. pipe must be used to the first opening.

Three grates and one range may be taken off of 1-in. pipe.

When more than three grates and kitchen opening are taken off of pipe the minimum size must be 1¼-in. pipe.

Always leave a ½-in. opening in bathroom and a ¾-in. opening in laundry. They need not be considered when counting the number of openings to determine the size of pipe.

No more than one grate opening will be allowed off of ½-in. pipe.

All water heaters should be provided with vent pipe connected to open flue.

All instantaneous automatic water heaters, such as are ordinarily set in basement, must be provided with separate runs and connected to riser. Size of run to be as shown in following table:

Instantaneous Automatic Water Heaters

Cu. ft. per hour.	Run not over.	Diam. of Pipe
150 to 300..........	75 ft.	1¼ in.
300 to 400..........	75 ft.	1½ in.
400 to 1000..........	75 ft.	2 in.
1000 to 1500..........	75 ft.	2½ in.

For all water heaters of this type the size of the horizontal run most in no case be less than the size of the opening in the heater, and preferably should be one size larger.

Openings for kitchen appliances must extend 3 in. above floor level and be 2 in. clear of finished baseboard. Openings for fireplace appliances must not project more than 1 in. above the finished bottom of the fireplace, and must not be run closer than 6 in. from either of the finished sides or back of the fireplace.

In flat buildings or apartment houses, where appliances, such as laundry stoves, dryers, etc., are installed for the joint use of tenants, run pipe from each meter location to laundry, and provide a header with a lock cock for each tenant. Fasten securely to each cock a metal tag with the number of flat plainly marked thereon.

In installations of this character a warning tag should be posted in a conspicuous place in the laundry, giving full instructions as to how the installation is to be handled, and warning tenants to always shut off the gas and insert the lock in the lock cock when leaving the laundry, especially where tenant is vacating the premises. Owners should see that this rule is rigidly enforced.

In large buildings, where foundation walls are of unusual thickness, a way must be provided for service pipe to pass through walls when same are being constructed. The preferable way would be to build a sleeve of iron or terra cotta pipe in the wall at the point where the service pipe is to enter the building.

Application should be made to the superintendent of distribution at the gas company's main office to locate the point in the wall where the sleeve should be built

Risers in stores must not end under deck or bulkhead of show windows, as meters will not be set there.

Meter locations should be provided so that both meter and connections are of easy access, in order that the index may be read. The stop cock should be so placed that gas may readily be turned on and off.

In apartment buildings it is desirable to set meters in the basement or in a room provided for the purpose. If to be set on the different floors locations should be provided so that they may be accessible without entering the apartments. The company reserves the right to determine in all cases the location of the meters. When locations are provided that are not acceptable to the company, the necessary changes in piping will have to be made at the owner's expense before the meters are set.

In apartment buildings all risers must be properly tagged with aluminum tags firmly fastened to riser, each tag so stamped as to indicate the location in apartments supplied.

The piping and fittings for the conveyance of gas within the walls of a building, after it has passed the meter and meter connections, may be put in by any competent gas fitter.

In houses or buildings having no cellar, or where the conditions in the cellar are such as to make it an improper location in which to set meters, a meter location must be found in one of the rooms on the first floor, but in no case will a meter be set in a room used as a sleeping apartment.

Meters should not be set in an unventilated closet or in any location where they are liable to sustain damage, as for instance, behind a door or in a coal bin.

GAS ENGINES

Separate gas service and run for gas supply will be required where, in the judgment of the gas company, conditions demand such installations.

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Size of Engine.	Size of Pipe.
1 H. P..................	¾ in.
2 H. P..................	1 in.
5 H. P..................	1¼ in.
10 H. P..................	1½ in.

For gas engines using more than 250 cu. ft. per hour and less than 500 cu. ft. per hour, use no pipe less than 2 in. in diameter, where the length of the run is less than 60 ft.

For gas engines using more than 500 cu. ft. per hour and less than 750 cu. ft. per hour, use no pipe less than 2½ in. in diameter, where the length of the run is less than 60 ft.

For gas engines larger than the above consult the gas company.

It will be necessary to furnish a governing gas holder or some form of antifluctuator of sufficient size and suitable design to avoid all chance of causing a fluctuation or variation in the gas pressures near where the gas engine is installed.

It is advisable before proceeding with the installation of a gas engine or piping for same that consultation first be had with the gas company.

IMPORTANT

Drops in double parlors and large rooms in office buildings must not be less than ½ in.

Drops must not project more than 1½ in. or less than ⅝ in. below ceiling.

The running line for stores must be full size to end of last opening. All drops to be ½ in., except in show windows, where ⅜ in. may be used.

Risers for bracket lights should never be put in place until after the studding for partition is firmly secured, and must be rigidly supported and fastened by straps to wooden cleats.

All openings for wall brackets must be made with drop ells, and the wall outlet must project not more than ⅞ in. or less than ⅝ in., and be well fastened with straps. Fastening with nails will in no case be allowed.

When outlets are not in close proximity to studding a notched wooden crosspiece must be securely fastened to studding to secure same.

All bracket outlets must raise from below and not drop from above, where practicable.

The drop must be securely fastened, and when located between the joist a notched wooden crosspiece must be securely fastened to the joist to secure same.

Fastening with nails will in no case be allowed. Must be tin or iron straps.

Pipes must be so run and covered as to be readily accessible. Do not run them at bottom of floor beams which are to be lathed and plastered. They must be securely attached to the top of the beams, which should be cut out as little as possible. Where pipes are parallel to beams they must be supported by strips nailed between two beams. These strips must not be over 4 ft. apart. All cutting of beams should be done as near as possible to the ends or supports of the beams. Pipes must not be laid beneath tiled or parquet floors, under marble platforms or under hearthstones, where it can be avoided. Floor boards over pipes should be fastened down by screws so that they can be readily removed.

Cinder, concrete or any corrosive material will not be permitted around pipes.

When the walls are of masonry they should be plugged and the straps fastened to the plugs.

Always use fittings in making turns; do not bend pipe. Do not use unions in concealed work—use right-and-left couplings. Long runs of approximately horizontal pipe must be firmly supported at short intervals to prevent sagging. All horizontal outlet pipes must be taken from the sides or tops of running lines, never from below.

When pipes pass through masonry walls they must be encased, the gas pipe resting on the bottom of the casing pipe, with a clearance of half an inch on top.

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The piping must be entirely free from traps and grade to riser.

In no case will drips be allowed.

Split pipes or fittings will not be accepted, even though skillfully cemented.

All openings in building service must be equal to the size of the riser, which in no case must be less than 1 in.

The riser in any building must not be less than 22 in. from the floor for two to ten openings; 2 ft. 6 in. for ten to thirty openings; 4 ft. for thirty and over. Where meters are to be set on wall no riser must be higher than 9 ft. from floor.

Building services must be brought to point in building as designated by gas company, and within 18 in. of wall or partition. In all cases where building service is used provide header with an opening for each riser. Where risers are in groups they must not be less than 10 in. apart, and service openings must not be less than 14 in. apart.

In all cases where extensions are made care must be taken to break pipe where the rule for size can be maintained, and in no case must extension be made from small pipes.

Underground work by gas fitters between main and meter will not be allowed or accepted.

Where line is extended underground, as for instance, to supply a garage, galvanized pipe must be used and pipe must be run in a straight line. Care must be taken that underground piping shall not be surrounded by any corrosive substance, such as cinders, and should be drained to an accessible location. No underground pipes shall be laid having a diameter of less than 1 in.

Underground gas piping should be laid in separate trench from other conduit.

To avoid complications, gas fitters should consult the company before locating risers in corner buildings.

Hotel, boarding house, restaurant and industrial installations should be considered special and gas company should be consulted in connection therewith.

The tables given are sufficient to cover almost any case that may arise, but it is advisable for architects, builders and others installing piping systems to confer with the gas company on all installations in large buildings.

All tests will be made with an air pressure of 6 lbs. to the square inch on a spring gage, or 12 in. of mercury on a mercury gage.

Fixtures should be made to withstand an air pressure of 3 lbs. to the square inch on a spring gage, or 6 in. of mercury on a mercury gage. They should be tested in place with a pressure of 8 in. of water.

Pipe will not be tested until securely fastened in position and all outlets are provided with iron caps.

All drops to be bent or offset.

Double bracket strips will be counted as one opening if not more than 10 ft. of pipe is used in the horizontal run to such bracket strips. The two openings off of such bracket strips will be counted as one outlet.

A tee shall be installed at the bottom of every riser, located about 2 in. below the joist and left so as to be accessible for cleaning pipes.

The cap shall be omitted from bottom of riser and all tests of piping shall be made from that point. But all outlets in the entire system of piping, with this exception, must be properly closed by the fitter, as the gas company will not supply caps or plugs for this purpose.

The riser must be brought to within 6 ft. of the location of the meter.

This company's fitters are prohibited from doing any fitting work not ordered from the company's office. Inspectors are not expected to count the openings on building plans, but to inspect only the piping installed.

In inspecting piping, the company's inspectors are to notify the master plumber in charge of the building in connection with any changes required in piping. This company's inspectors will state cause for rejecting piping by addressing a written communication to the master plumber. If defects are not remedied in

[redacted]

four days after company has notified master plumber, then the company will take up the matter with the owner.

Master plumbers agree to inform this company, when ready to have piping tested, on postal cards to be furnished by the company.

OLD BUILDINGS

The foregoing rules for new buildings are applicable for old buildings wherever practicable, but it will be permissible to connect fuel appliances to an opening on a pipe which comes from above, providing the size of piping is sufficiently large to supply the appliance.

There should always be as a minimum a ¾-in. outlet left in the kitchen.

CONNECTING APPLIANCES

Fitters are particularly requested to see that all gas-burning appliances are connected solid wherever practicable with iron pipe.

RULES SUBJECT TO CHANGE

This company reserves the right to alter, amend or revoke these rules as may from time to time appear to be for the best interests of its patrons.

All gas fitters' rules heretofore issued by this company are hereby revoked.

Copies of these rules will be furnished on request at the office of the company.

Wilmington (Del.) Gas Light Co.

Consumers of gas often complain to the gas company regarding the quality of light or the flow of the gas, blaming the gas company for poor service when the entire fault lies in the manner in which their houses are piped.

It is for this reason that we have compiled the following specifications, which if followed will insure you satisfactory service and permit you to enjoy the good gas we supply. We feel that we are better qualified to know what piping specifications are proper for the interest of the people, and therefore recommend that they be closely followed and observed by all builders, thereby avoiding any future complications.

SPECIFICATIONS FOR PIPING

Section 1

The following table shows the correct sizes of house pipes for different lengths of pipes and the greatest number of burners allowed:

Diam. pipe, inches	Greatest length allowed, feet	Greatest No. of burners
3/8	10	2
1/2	30	6
3/4	60	20
1	80	35
1 1/4	120	60
1 1/2	160	100
2	200	200
2 1/2	300	300
3 1/2	450	450
4 1/2	600	700

In applying the above table the number of burners to outlets in various locations shall be estimated as follows: Parlor ceiling outlet, 4 burners; dining room ceiling outlet, 4 burners; bedroom ceiling outlet, 3 burners; kitchen ceiling outlet, 1 burner; bracket and newel outlet, 1 burner; office ceiling outlets, 2 burners.

Pipes smaller than 3/8 in. shall not be used except in stems of gas fixtures.

Gas pipes in churches, halls and other large buildings shall be in proportion to the number of lights as given by the table.

The pipe used shall be the best quality, with galvanized iron fittings and joints, and joint shall be made with white or red lead, which shall be applied to the male threads only; gas fitters or other cements will not be permitted except in hanging of gas fixtures; in making turns fittings must be used, no bent pipes; in making connections when required, long screws, or right and left couplings must be used; no second hand pipe shall be used, except that when a building is undergoing reconstruction or repairs, such gas pipes and fittings as are taken out and found in good condition and of the proper size may be reused.

7. All pipes shall be properly supported and stayed with pipe-hooks or straps and screws. All pipes shall be properly graded, and if practicable towards the meter, a bracket outlet shall be taken from the side or top of a main, and run as a riser, when possible to do so.

8. All split pipe and defective fittings shall be removed.

9. Pipes must be so run and covered as to be readily accessible, and must not be run at the bottom of floor beams or joists, which are to be lathed and plastered; they must be securely fastened to the top of the beams or joists, which should be cut out as little as possible. When pipes are run parallel to joists, they must be supported by strips nailed between the same, and these strips must not be more than five (5) feet apart. All cutting of floor beams or joists should be done as near as possible to the ends, or supports of the same; pipes must not be laid beneath tiles or parquet floors, or under marble platforms, or under hearth stones, when it can be avoided. Floor boards over main lines must be fastened down with screws, so that the same can be readily removed. All main risers shall extend full size to the first outlet.

10. When two or more tenants occupy one building, and each has a separate system of piping, supplied by a separate riser, each system of piping is considered in these regulations by itself, as though it had been in a separate building.

11. All ceiling outlets must project not more than two (2) inches, or less than five-eighths (5/8) inches from the finished surface, and must be firmly secured, and properly plumb. Side wall outlets must project not

more than seven-eighths (⅞) inches, or less than five-eighths (⅝) inches from the finished surface, and must be securely fastened.

12. The burr left on the inside of gas piping by the cutting-off tool must in every case be cleaned out, since such burrs not only materially reduce the effective area of the gas pipe, but they make lodging places for iron rust, scale, etc., making it extremely difficult to clear the gas piping when it has become stopped up.

13. No house riser shall be less than ¾ in. The house riser is considered to extend from the cellar to the ceiling of the first floor. Above the ceiling the pipe must be extended of the same size as the riser, until the first branch line is taken off.

14. No house pipe shall be less than ⅜ in. An extension to existing piping may be made of ⅜ in. pipe to supply not more than one outlet, provided said pipe is not over 6 ft. long.

Section 2

1. The company reserves the right to determine the location of its meter, which must be placed where they will be easily accessible; not exposed to extreme heat (as near steam pipes or furnaces), dampness, frost, sudden changes of temperature, or liability to damage by having things thrown on them.

2. No meters will be set in coal holes nor under the decks of show windows in stores.

3. All risers must be extended to within two (2) feet of the location provided for the meters, and all building services must be extended to the point where the company's service pipe enters the basement.

4. Where two or more risers are run together they must be spread not less than 15 in. apart where the meters are to set.

5. All risers and openings in building services must be located not less than 30 in. nor more than 8 ft. from the floor.

6. All risers must be run in inside walls, where they will not be exposed to frost, and not less than two (2)

feet from an outside wall. Vestibule wall will not be considered inside walls.

7. Outside gas fitters and all other persons are prohibited from connecting or disconnecting the company's meters, turning gas on premises where the gas has been turned off, or in any manner altering or interfering with the company's service pipes. The company maintains its own force of fitters for such work, and it will promptly, upon receipt of notice, attend to any work required in connection with its meters or service pipes.

8. Meters in apartment houses and flats must all be located in a convenient place in the basement, and not in the respective apartment. No meters will be set in such building unless all risers are located as per rules stated.

9. In running risers for fuel and illumination purposes where a number of meters are to be set in a row, as in the case of apartment buildings, 15 in. should be left between the opening of services and risers. The service to be on the left and riser on the right.

10. Where locations are provided contrary to the above rules the necessary changes will have to be made at the owner's expense before meter will be set.

11. The gas company will make no riser extension free of charge. All risers must be extended within two (2) feet of the location of the meter.

12. All meters will be set as close to the service, where it enters the building, as practical, and any extensions thereof in excess of two (2) feet will be charged to the respective tenant or owner of building.

13. No meter will be set except in the basement. Where there is no basement it will be set in the corner of the room or within two (2) feet of where the service enters the building.

Fuel Lines or Range Connections

All fuel lines must be run independent of the lighting system, and extend from the point where the gas meter will be located to the point in the kitchen where the gas range is to be installed. The following rules should be observed when installing fuel systems:

No fuel line installed shall be of smaller pipe than ¾ in.

Assume as a basis for figuring pipe that a—

Four-hole range uses 80 ft. of gas per hour,

Six-hole range uses 100 ft. of gas per hour,

Each gas fire or log uses 60 ft. of gas per hour,

Circulating tank gas heater uses 60 ft. of gas per hour.

If in connection with gas range add 30 ft. to consumption of range.

Figure each length of pipe between openings separately, commencing at the meter.

Use the table given on the opposite page, and adapt the size of pipe given in the table of capacity to pass the required amount for given length.

If exact capacity required is not given in the table use the next larger size of pipe.

Do not run over 40 ft. of ¾ in.
Do not run over 40 ft. of 1 in.
Do not run over 100 ft. of 1¼ in.
Do not run over 150 ft. of 1½ in.
Do not run over 200 ft. of 2 in.

Openings in side walls for fuel appliances should be 12 in. from the floor and project 1½ in. clear from the finished wall.

Capacity in Feet Per Hour

Length in feet.... Size of pipe, inches	10	20	30	40	50	60	80	100	150	200
¾	120	80	60	50	45	...	...	...	...	...
1	250	170	140	120	110	100	80	...	...	...
1¼	450	320	240	200	180	160	150	140	...	...
1½	800	600	480	360	320	270	240	210	180	...
2	1500	1100	800	700	625	560	520	480	400	320

An inspection of piping will be made by the gas company's inspector, by special request, free of charge.

The city ordinance covering gas piping, having been made several years ago, does not cover all regulations

[redacted]

required by us before meter will be installed. It is very essential that the consumer conform with the regulations contained in this booklet, as well as that required by the city ordinance, as this data is not compiled to conflict with the city requirements in any way.

Under no circumstances will a gas meter be installed where these requirements are not strictly adhered to.

Important

When piping new or old residences it is well to install a gas opening in the baseboard of the bathroom and one or two of the bedrooms. This will provide a heating stove connection that is always found desirable during cold weather for additional heat, or for furnishing heat in the spring or fall of the year when the weather is too mild to operate the furnace fire. When making this heating stove connection from the center fixture or bracket it not only presents an unsightly appearance, but the flow of gas is usually insufficient on account of the small pipe in the fixture. We carry in stock a special baseboard Conceal-o plate for heating stoves and portable lamps. These plates are neat in appearance and the cost is small.

Opening Left for Service

Provision should be made, especially where the walls are very thick, for the entrance of a gas service pipe through the foundation walls to all new buildings. The most preferable arrangement would be to build a sleeve of iron or terra cotta pipe in the wall at the point where the service is designed to enter. In order that the sleeve should be right as to size and location, the gas office should be communicated with, so that some one may be sent to examine the plans, furnish a suitable sleeve and superintend its placing. In this way architects and builders will be saved the annoyance of having walls cut into, and will also confer a favor on the company. Architects are asked to embody in all future specifications a clause obligating the contractor to arrange with the company for the placing of a proper sleeve, as above explained.

Jacksonville (Fla.) Gas Co.

The following rules have been adopted by the Jacksonville Gas Co. for the guidance of gas fitters.

House Piping for Lights for Residences Only

1. The following table shows the proportionate size and length of pipe for piping residences for lights:

Size of Pipe Diam., in.	Greatest Length Allowed, ft.	Greatest Number of Openings.
3/8	15	1
1/2	30	3
3/4	60	10
1	70	15
1 1/4	100	30
1 1/2	150	60
2	200	100
2 1/2	250	200
3	300	300

If the above length of pipe is exceeded use the next larger size of pipe.

Do not run pipe smaller than 3/8 in.

House Piping for Lights for Stores Only

1. The following table shows the proportionate size and length of pipe for piping store buildings for lights:

Size of Pipe Diam., in.	Greatest Length Allowed, ft.	Greatest Number of Openings.
1/2	20	1
3/4	30	3
1	60	6
1 1/4	100	10
1 1/2	150	15
2	200	20
2 1/2	250	35
3	300	50

Under no circumstances should smaller pipe than 1/2 in. be used except for drops.

[redacted]

General

1. The riser in any building must in no case be less than ¾-in. pipe. Extensions from same to meter must be so run that meter will be conveniently located for reading index, and such extension and place for meter so located as to insure protection from excessive heat. Gas company reserves right to locate meters. All openings from riser must be securely capped when work is finished and tested.

2. All drops and openings must be securely fastened with pipe hooks or clamps and lines kept free from traps. In no case will drops be allowed, except where absolutely necessary. All pipe and fittings must be put together with pipe cement. Every drop must be tried to insure that thread on it is straight and drop secured, so that fixtures attached to it will hang plumb. All drops must project 1½ in. from bottom of joist. Split-pipe or fittings will not be accepted even though skillfully repaired.

3. No unions will be accepted where piping is to be concealed. The use of bushings should be avoided as much as possible.

4. Openings for gas range should not be less than ¾-in. pipe and placed at least 12 in. above the floor, projecting 2 in. from the face of the wall. For kitchens in other than residences openings for ranges must be not less than 1¼ in. pipe, with no other openings off same line.

5. All tests must be made under 6 lb. air pressure or 10 in. mercury, said pressure to be retained 20 minutes. Under no circumstances should water be used in testing.

6. All piping must be examined by the inspector of gas company, both before and after being concealed, and due notice must be given by the fitter to gas company when piping is ready for inspection. No charge will be made for the first two inspections, but 50 cents will be charged for each subsequent inspection.

7. Gas company will positively refuse to connect

building with street main or to supply gas for same, unless gas piping in building has been inspected by Inspector of gas company and certificates issued. Architects are requested to allow no bill for gas fitting, unless accompanied by certificate of inspection from gas company.

Note—These rules apply to house piping for lights only. When heaters or other appliannces are to be installed, use proper size pipe according to capacity of appliances as shown in Information Table. Consider that each appliance shall be used to its maximum, and all appliances at one and the same time.

Information Table

A 4-hole range uses 90 cu. ft. per hour, full capacity. A 6-hole range uses 120 cu. ft. per hour, full capacity. Gas log or heater, 25 to 50 cu. ft. per hour. Circulating water heater, depending on size, 30 to 60 cu. ft. per hour. Automatic water heater, depending on size, 100 to 500 cu. ft. per hour.

Arc lamp, 25 cu. ft. per hour.

One mantle burner, 6 cu. ft. per hour.

Capacity of Pipe, Cubic Feet Per Hour

Pipe	Length — Feet									
Diam.. in.	10	20	30	40	50	60	80	100	150	200
½...	60	40								
¾...	120	80	60	50	45					
1 ...	250	170	140	120	110	100	80			
1¼...	450	320	240	200	180	160	170	140		
1½...	800	600	480	360	320	270	240	210	180	
2 ...	1500	1100	800	700	625	560	520	480	400	320

Consolidated Gas Co. of New York, N. Y.

The following rules are to be strictly observed in connection with all work of the meter department of the Consolidated Gas Co. of New York, and any unwarranted deviation from them will make the person responsible liable to dismissal.

GENERAL INSTRUCTIONS

1. Employes must familiarize themselves with the rules of this department. Entrance into the service of the company implies acceptance of its rules and regulations.

2. Compliance with the rules is essential for the safety of the public and employes, and for the protection of property.

3. The service demands the courteous, intelligent and faithful discharge of duty.

4. In order to give satisfactory results, the interests of the company and its employes, should be mutual; and those employes who are most active in looking after the welfare of the company will find that it will eventually result to their benefit.

5. Employes must at all times be courteous and gentlemanly in their dealings with consumers, and should strive in every way to give satisfaction.

6. Strict propriety of conduct and courteous treatment of consumers go a great way to allay irritation. Acquire this habit, and receive praise instead of condemnation.

7. Whatever the nature of your work, do it thoroughly, take an interest in it, and report in detail the exact conditions you find. This is the way to advance yourself.

8. Employes of every grade will be considered in line for promotion, dependent upon the faithful discharge of duty and their qualifications and capacity for assuming increased responsibilities.

9. All changes of address of employes must be reported immediately to man in charge of shop.

10. Keep your tickets clean and free from creases.

11. Employes will count their wages in proximity of the paymaster. No claims for any shortage will be rectified, unless attention is directed to same at time of payment.

12. The service of those employes habitually late, will be dispensed with.

13. The use of intoxicants during working hours is prohibited.

14. While on duty, employes will be expected to have the book of instructions with them.

15. Employes are to immediately obtain a time sheet upon entering the shop in the morning.

16. Ignorance of rules will not be accepted as an excuse for neglect or omission of duty. If in doubt as to the meaning of any rule, apply to your immediate superior for information.

17. Any employe disapproving of these regulations, or not disposed to aid in their enforcement, should leave the company's service.

18. Disobedience of orders, violation of rules or neglect of duty, will be considered a sufficient cause for dismissal.

19. Any employe noticing disobedience or neglect of any rule involving a matter of safety to the public or his fellow employe, is required to report it to the proper authority for the good of the service.

20. Employes will receipt for badges, tools, keys, books of rules, buttons, etc., and must never allow them to go out of their custody. When leaving the service of the company they will return them and all other property in their charge before being paid.

21. Uniforms may be bought where employe chooses if the color and style are satisfactory. The company supplies the buttons. All men must have a uniform coat and buttons with cap, which must be worn while on duty. Employe's badge must be securely sewed on his cap.

22. Special tickets must be executed, and, if for any reason, it is impossible to do so, the shop must be notified immediately.

23. Special tickets or general office tickets must be signed by consumer to signify that the work has been done to their satisfaction.

24. All outlets must be properly closed before gas is turned into any line. Employes are liable personally to criminal prosecution for any accident or damage

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which may result from the careless execution of their work.

25. Governors must not be removed from meters, nor their regulation changed, except when it is so ordered from the shop or upon the written request of the consumer.

26. Do not change the wording on the face of any ticket. If incorrect, note the mistake on the reverse side or attach a memorandum ticket.

27. Location sheets must show the route the fitter is working and on what floor the work is being done, and must also be time-stamped.

28. Helpers' names must be written at the top of fitters' location slip.

29. Always carry enough material to keep busy until the delivery wagon arrives.

30. D. N. R. means "Did Not Reach." When this report is found on a ticket you must reach it.

31. Additional reports are not to be written on the reverse or completed ticket, but must be written on a "continued report" ticket.

32. When employe finds consumer out, whom he wishes to see, he should ascertain, if possible, if there is any particular time or place where consumer can be found, and note the same on his report.

33. In case the person he wishes to see cannot be found, employes should request janitor to notify party that he (employe) has called.

34. Employes must state time of all calls and the name of the party interviewed on all tickets.

35. If, for any reason, an order cannot be executed, the employe must explain the reason to the consumer, so that consumer will know that he is not slighted or neglected, and if at night and the order is considered important, you must telephone to the shop for instructions.

36. Never make a promise to a consumer unless you know that it will be fulfilled.

37. Attention is called to the fact that the company

pays a reward of $10 to any employe who proves conclusively that gas is being stolen.

38. The company also pays a reward of $100 for information leading to the conviction of any person tampering with, or stealing money from prepayment meters.

39. Employes causing any damage to consumer's property, or meeting with any accident, while in the discharge of duty, will at once turn in a full written report giving all the details and names and addresses of any witnesses that may have been present when the accident accurred.

40. Employes should bear in mind that the office of the company is the proper place for consumers and the general public to obtain such information from the company as they may desire; and when asked for information, they are, in a courteous manner, to refer the parties making such requests to the office.

41. Employes will not enter into altercation with anyone, no matter what provocation may have been given, but will report the facts to their immediate superior.

42. Under no circumstances shall any employe assault a consumer. Any violation of this rule will be cause for immediate dismissal from the service.

43. Employes are positively prohibited from assigning their wages to anyone for any reason whatsoever.

44. Designating the different floors. The floor next below the level of the sidewalk shall be designated as the basement floor, the floor on or next above the level of the sidewalk shall be designated as the first floor and so on.

45. So far as possible, fitters should try joints and fittings by smelling, and when a flame is used, all points touched by same must be blown and every precaution taken to prevent leaving a small leak ignited.

46. When it is necessary for a fitter to work on a live service he must shut off the main stop cock, if there is one in the building, or in street, or, if he shuts off the gas by plugging the service, he must use wet waste or expansion plugs.

[redacted]

47. Electric lamps, rubber gloves and rubber boots are provided for the use of employes when necessary.

48. When changing meters, setting meters or resetting meters, employes must "gas" or "blow out" through the house pipes. No meter to be "gassed" or "blown off" through the outlet connection.

49. In case it is necessary to remove the covering from service pipes, report such removals upon your return to the shop, in order that the same may be replaced by the street department.

50. When bringing in meters, employes must securely cap up service and house pipes.

51. Fitters on "meter sets," "unlocks," "range sets," "exchanges" and "stove repair tickets" must endeavor to see that party lights appliance properly and state on ticket.................."Lighted appliance properly in my presence."

52. In writing up your tickets only put finished reports on face of orders; calls, or other information on the reverse side of ticket.

53. If compelled to be absent, send in your work and time sheet at once.

54. Charge tickets for material must be carefully filled out.

55. When you are in the shop at quitting time, stamp your time sheet before leaving.

56. Rubber stamps must not be used by consumer in signing applications for gas, nor by employes when witnessing the same, or when receipting for money paid on the district.

57. On the completion of a job the employe shall write his report on the ticket so that mistakes and delays may not occur on his return to the shop.

58. Fitters are expected to carry a full kit of tools, also lead, cock grease, stove cement, reamers and disinfectant, so as to be able to give complete attention to complaint tickets on the first call.

59. Do not break locks or pull staples from doors to gain access. Always return borrowed keys.

60. Report in writing all complaints of consumers

when on the district, giving strict attention to complaints of gas smells, or gas leaks, defective appliances, etc.

61. In range explosion cases where any damage has been done to the range, or the range is in need of repair, it should be immediately removed to the shop.

62. Meters or ranges should not be connected if the premises are not in a safe condition, even should the consumer insist.

63. Disconnect service when all meters have been removed from a building, and if it is necessary to cut off the service in the street, report that.

64. Employes will turn in an order to cover all services, up to 3 in. in diameter, that are in exposed locations, giving size of service and about the number of feet to be covered; in order that the street department may send the proper quantity of material without the department being compelled to inspect the job.

65. The special long plug must be used on heads of services and on drips.

66. If a remeasurement is necessary, attach another charge ticket and state why you remeasured. Do not scribble all over the original one. Do not destroy original.

67. Do not put a sketch on office tickets. Charge tickets are provided for this purpose.

68. Do not write on reverse side of location slips. Use two if necessary.

69. Classify your work on location slips, using following abbreviations:

Set—For setting a meter.

Stove Set—Connecting a range or any gas appliance.

Job—All jobs exclusive of meter setting, or stove sets.

U—For unlocks.

L—For locks.

P.L. or N.G.—For poor lights, and no gas.

S. W.—See whats.

C. M.—For changing a meter.

Leaks—Always write out in full.
B-O—For burner order.
B-A—For bringing in a meter.
B-R—For bringing in a range.
S. R.—For stove repairs.
S. I.—For scattering indexes.
Meas.—For measurements of all kinds.
Y.—For why's—ascertain—or see if registering.
V. L.—For verifying leaks.
App.—For get applications.
V. I.—For verify index.
P. P.—For prepayment.

LEAKS

1. Leaks are the most important part of the work, and must have prompt attention. Be sure to find the leak if possible and, in case it is unusually difficult to find, notify the shop at once and assistance will be sent you.

2. Whenever an employe finds a leak that requires

7. In locating leaks no flame is to be used when the smell of gas is at all pronounced.

8. If a leak cannot be immediately stopped the gas must be shut off.

9. If gas is shut off on account of leaks, employes must notify all consumers or the party in charge of premises of the reason.

10. When an employe finds it necessary to notify a tenant, janitor or owner to have a leak repaired such notice shall be given to an adult, and on his report the name of the adult so notified shall be stated, together with the relation such adult has to the premises in question.

11. If an adult cannot be reached on the first call order must be turned in as unfinished.

12. When executing a leak order, if consumer is out, he must see some adult and explain the object of his visit, stating on the ticket the name of the person seen and the time called.

13. Electric lamps are kept in the shops and must be used on the district where an open flame is dangerous.

14. In testing for leaks by meter employes must prove with a small light that the test hand registers.

15. In the event of a leak at the outlet of the meter the employe shall estimate, as nearly as possible, the leakage per hour, and report the same on the ticket.

16. In reporting leaks at meters, the part of meter which is defective shall be plainly stated.

17. Employes verifying leak orders must examine the repaired leak, see that there are no other leaks, state name of party seen, and that they are satisfied. This report is to be written on face of ticket.

18. All leak tickets must be time-stamped before leaving shop.

19. The employe repairing leak must fill in the form printed on the back of leak ticket.

20. Report immediately to the foreman full details of anything you may hear regarding any sickness or damage, however slight, resulting from a leak.

21. In reporting a leak on other company's meters do

not fail to report size, number of meter, and where located.

22. Leaks at fixtures—In cases where the fitter finds that fixtures leaks have not been repaired and no steps are likely to be taken to repair the same, he will remove the fixture and cap up the opening, providing the consumer does not object.

COMPLAINTS

1. Employes are to bear in mind that their object should be to fully remedy complaints, so far as possible, on the first call.

2. Whenever it is necessary for an owner or his representative to make repairs or alterations to the house pipes, the employe must so state on his ticket.

3. Employes when exchanging or bringing away a meter must make sure there is no back pressure of gas due to the gas lines being reinforced by meters setting on other services.

4. When making a report setting forth the necessity

his work, the more important orders must be given preference.

10. Employes shall cork or cap meters at time of disconnecting.

11. Employes changing meters must write up the paster on new meter, verify part supplied, and name of consumer, putting on the number of the old meter. No meters shall be turned on or exchanged where you cannot gain access to part supplied.

12. Cocks when found partly shut off must be left as found when exchanging meters.

13. "Resets" must be checked according to the meter number, and, in the case of "chronic" work, the meters and their locations should be checked up with office records.

14. Meters are not reset simply because they have lead connections, but should be reset when the lead connections are kinked or leaking.

15. Fitters on wagons, when bringing in meters from buildings undergoing alterations, will note the number of meters in the building belonging to other companies, specify the number belonging to each company, and report same on arrival at the shop.

16. No gas—Every proper effort must be made to give the consumer gas.

17. When answering a complaint of "No Gas," should the employe find the whole building to be without gas, he will, after giving gas to the building, see the original complainant to make sure that his gas is all right, as such complaint may have originated from a local trouble.

18. Employes attending to complaints of lights "jumping," should be careful to locate the real cause of the trouble and not assume that it is in the meter.

19. Before disconnecting a meter or service, employes must make certain that no gas is being used.

20. "When gas is cut off to clear service, employe must notify janitor, and tenant, to turn off all gas cocks on premises; and when service is reconnected he must see that no outlets are open or gas escaping when gas

is turned on again. Do not delegate anyone else to do this for you, but do it yourself personally, or a charge of criminal negligence may result from failure to carry out this rule in detail."

21. In clearing house pipes or services, employes shall see that no back pressure from pump gets to the meters and that no leaks are caused thereby.

22. In attending to complaints, when an employe finds that the complaint made by the consumer differs from that recorded on the ticket, he must not state that it is necessary to send another man, but he must himself attend to the trouble if it can be done without serious interference with his other work.

23. In the case of "chronic" complaints, employes shall report their causes, stating in their report whatever it is necessary to have done in order to remedy the trouble.

24. Meters in which condensation accumulates must be reported at the shop.

25. When an employe spills drip water he must use some disinfectant to deodorize, and notify someone in

[redacted]

30. Drips of ample size should be used, and when in exposed places should not be less than 1½ in. in diameter and of extra heavy pipe.

31. Do not tell consumers that the governor is no good if you find the gas O. K. at the meter outlet. If the trouble is in the governor and you cannot remedy it, notify the shop what make of governor is in use, and they will notify the Governor company.

32. Governors—In case it is necessary to put them out of action in order to give proper supply it is preferable to do this by placing a wad of paper under the cover, and the consumer must be notified that the company will take the matter up with the Governor company, and the name and address of the Governor company must be stated on the report.

33. Automatic Water Heaters—In such instances as it is found necessary to shut off the gas when executing an order, the valve on the gas line to the heater must be closed as must also the valve on the hot water pipe from the heater. In case the fitter is not familiar with the operation of the heater, he should leave the gas supply to the appliance shut off and notify the consumer and the shop at once.

SETTING METERS

1. Employes engaged in setting meters should see that the shelf and the meter are plainly marked as to the floor and the apartment that the meter supplies.

2. They should also be careful to observe that the house pipes are tight, and they must leave no leaks in the work.

3. If, after testing, pipes prove to be tight, the employe shall write on the "Set" ticket the words, "Set and Tested, O. K."

4. In setting meters, provide drips to take care of any condensation that would otherwise drain to meter.

5. When setting meters, the meter-cock should be so placed that it is easy of access and can be turned on or off without difficulty.

[redacted]

6. Employes must be careful to leave no strain and provide ample swing.

7. All upstairs meters to be set 6 ft. 3 in. from the floor to the bottom of meter when possible to do so.

8. A meter that has been dropped or having received a sudden jar in the handling of it must be returned to the shop.

9. The setting of a meter which has received severe handling renders the guilty employe liable to dismissal.

10. Meters must not be connected to trapped services or risers, or to risers with elbows on bottom of stand pipe.

11. Meters indicating leaks must be locked or disconnected at once, and so reported on ticket and consumer notified.

12. After setting meter employe must see that the meter registers on small light.

13. No meters to be set on new or altered work unless the top of set ticket is marked "O. K." by the district foreman.

14. No rising service must be connected or gas turned on until it is tested with water gauge by building inspector or district foreman.

15. When an employe has an order to set a black meter and finds a prepayment meter already set, or has an order to set a prepayment and finds a black set he will not make the change unless his order calls for a black meter to set in place of prepayment, but shall report the condition on his return to the shop.

16. Employe shall ascertain if burners are in good condition, and report it on ticket.

17. Setting of meters on floors should be avoided.

18. Addresses on orders must be corrected when necessary.

19. Meters for stores must be set under address of store entrance, and for apartments under address of apartment entrance.

20. Particular attention is directed to the necessity of filling out of label attached to upper right hand cor-

ner of meter, setting forth order number, name of party supplied, location, fitter's name, and date on which meter was set.

21. Meters should not be set in bedrooms.

22. When a prepayment meter is set, it should be ascertained whether a black meter has been supplying the apartment; and if so, such black meter should be brought to the shop and riser capped.

23. If a P. P. meter does not pass sufficient gas to test with, and consumer declines to insert a quarter in money box so that gas may be supplied, the meter must be locked and the shop notified.

24. Employes shall bear in mind that meters set in cold, damp and drafty locations are very liable to collect condensation.

25. When testing housepipes with the meter, the test should be made with the proving hand moving upward.

26. There shall be a heavy brass straight-away cock or valve placed on the service pipe, inside the front foundation wall, in all new and altered buildings, to control all meters.

STOVES, ETC.

1. Having connected gas appliances, the gas being turned on, fitter must see that they are regulated. If apartment should be vacant they must unlock meter, regulate appliance, and then relock meter.

2. When an employe connects a gas appliance with tubing, he must be careful to properly fasten both ends. If the consumer refuses to have this done, he must so state on his ticket, giving name of party interviewed.

3. When connecting appliances with tubing employes must place cock not less than 16 in. from cock on gas bracket.

4. Having set a rental appliance, employe must see that the location of the appliance is properly marked on the face of the order, opposite "Part Supplied."

5. Wall protectors must be put up back of ranges where needed.

6. Employes must not connect any flue to gas appli-

ances unless the owner and tenant of the building signs release.

7. Cookers are to be connected with iron pipe.

8. The special flue tee must be used on all flue connections.

9. No flues shall be connected where there is a back draught. When this condition is found in old installations, the flue must be removed.

10. Before removing appliances, employes must securely wire all movable parts and see that the handles of all cocks are turned in.

11. Employe, calling to remove a range, and finding that the consumer objects to its removal, shall leave range on premises and report to shop.

12. On ranges brought in, the reason for so doing must be stated on tag, attached to range.

13. Employes shall turn in to the shop a memorandum of the names and addresses of all consumers who are not familiar with the use of the gas range, in order that a "demonstrator" may be sent to give proper instruction regarding it.

14. After setting a gas range, take particular pains to be sure that all oven and burner cocks are adjusted and shut off securely.

WATER HEATERS

1. On account of varying conditions, such as water pressure, water temperature, gas supply, etc., employes are not to state to consumers how long it will take to heat the contents of a boiler.

2. Consumers having a water heater and range supplied from a 3-8 drop, must be informed that both appliances cannot be used to advantage at the same time.

3. If the conditions are such that you are unable to make the water connections, you are not to notify the consumer to get a "plumber," but report to shop.

4. When possible the cold water supply must be taken from the bottom of the boiler and the hot water pipe connected to the top of the boiler at the "spud." Great care must be taken in connecting a water heater to

a horizontal boiler, especially the type of boiler with four side outlets, so that the water heater will be efficient.

HIGH BILL AND BURNER WORK

1. "High Bill" men must not engage in controversies with consumers, but shall make it their object to ascertain the cause of increased consumption. Decrease the size of burners where necessary; prove that the meter on the ticket supplies the party, and, if possible, satisfy the consumer. Carefully fill out the back of high bill order, stating name of party interviewed and time of inspection. Verify the index and if possible figure out the daily consumption since last index was taken, and compare same with daily consumption of the month or months in dispute.

2. In ascertaining the probable quantity of gas used per day it would be desirable to use the following example as a guide in making out report:

3.

Location of Burners.	Total Number of Burners.	Burners claimed to be in use.	Consumption per hour.	Hrs. used.	Total.
Parlor	5	2	6	5	60
Dining-room	3	2	6	1	12
Bed-room	2	1	3	1	3

4. Be careful to mention every burner in premises and the consumption of same; also ascertain to what extent stoves and appliances are used and their probable consumption.

5. If the estimated total arrived at in this way corresponds, or nearly so, with the daily average as registered on meter, the figure should be shown to the complainant, and in this way try to convince consumer of the correctness of the bill.

6. In case of high bill complaints from consumers using prepayment meters, employes should be careful to see that burners are properly checked.

7. In case an error has been made in indexing the meter or rendering the bill, great care must be taken

[redacted]

to make certain beyond doubt that such is the case before making a statement to this effect to the consumer.

8. Employes engaged on "High Bill" work are expected to be familiar with the consumption of all stoves and heating appliances; but if the consumption of any heating apparatus or appliance is not known, it can easily be ascertained by observing the proving hand on meter dial when the appliance is being used.

9. It is also expected that "High Bill" men would know whether or not a stove is properly adjusted and giving the best results under most economical conditions. When an appliance is found to be defective, it should be reported to shop, stating at same time, whether this was the cause of complaint.

10. If a consumer cannot be convinced as to the correctness of a bill, it might be suggested to change the meter, "to satisfy"; but this should be avoided as far as possible.

11. If the consumer refuses to have burners checked or small burners put on, employes must fill in the printed form on back of the burner ticket, answer the questions printed on the front page, change the burners to the consumer's satisfaction, and state name of party interviewed.

12. When the consumer requests that larger size burners be substituted than those in use, employe must caution consumer that it will lead to increased consumption and larger bills and report such change on ticket.

13. It is the duty of the burner-man if, in his opinion, burners are not in proper condition, to demonstrate, if possible, why they are not right and to show by putting on the proper kind how the defects may be remedied, even though consumers state that they are satisfied with their burners. In short, he should do all in his power to avoid future cause for complaint.

14. Employes when putting on burners will use the same kind as those already in use, unless it is necessary to change all of them; that is, in the same room do not put on tips of different styles.

15. The following schedule may be used as a general guide when putting on burners, either on a high bill or burner order.

In tenement houses, where there are three or four families on a floor:

Kitchen	about	5	cu.	ft.	per	hour
Dining-room	"	5	"	"	"	"
Parlor	"	5	"	"	"	"
Bedroom	"	3	"	"	"	"
Private hall	"	3	"	"	"	"
Public hall, first floor.......	"	3	"	"	"	"
Public hall, above first floor..	"	2	"	"	"	"

Apartment houses, two families to a floor; private dwellings, etc.:

Kitchen	about	6	cu.	ft.	per	hour
Dining-room	"	6	"	"	"	"
Parlor	"	6	"	"	"	"
Bedroom	"	4	"	"	"	"
Bath room	"	3	"	"	"	"
Private hall	"	3	"	"	"	"
Public hall, first floor.......	"	4	"	"	"	"
Public hall, above first floor..	"	3	"	"	"	"
Stores	"	6	"	"	"	"

INDEXING

1. An employe making an intentional false report regarding an index will be dismissed instantly.
2. For each meter that an employe fails to index he will draw a ticket.
3. Indexers when making out "skipped" index tickets must mark same in index book to show the office that a ticket was issued.
4. State actual dial figures in reporting indexes.
5. All meters to be indexed, whether locked or unlocked.
6. Where buildings are vacant, and a bill is up, the "skip ticket" should be marked "vacant," and the name and address of agent should be given.

7. In cases of "skips," if index is taken, report should be made on the face of the ticket; but if index is not taken, report should be made on the back of the ticket, the name, date and cause of failure to index being stated.

8. Under no circumstances will indexer change meter number in index book.

9. If a meter number does not agree with number given in book, indexer will make a note opposite index and also draw a memorandum ticket calling attention to discrepacy. Memorandum ticket to be left in book.

10. Under no circumstances attempt to tell the consumers what the amount of their bill will be. You are only permitted to give them the present reading.

11. Watch for and report all false connections.

12. Should you find the company's meter disconnected, take the statement as usual, and report the fact to the shop.

13. Make report of all meters where conditions are as follows:

Meters found hanging by the connections and not properly supported by a shelf.

Connections that are bent or crushed so as to prevent the proper flow of gas.

All trapped connections.

All leaks in the service pipes, meters or connections, with location.

Broken glass in meter dials.

Meters that are badly rusted or badly dented or that show any signs of having been tampered with.

Meters set in a position making it difficult to see the dial and meter number.

Meters where the stop-cock is so placed as to prevent its being turned on or off.

Meters set in such position that access to them is dangerous.

All vacant places where meter is unlocked.

14. Indexers must use the code found pasted on the front cover of book, noting the code letter in the column containing the meter number, and make out the

necessary tickets. They must have as few "skips" as possible, and carefully note the increase or decrease of consumption, giving any necessary information, thereby making it unnecessary for the office to issue any tickets. They are expected to keep their books clean, and in good condition.

15. On all "Why" tickets the fitters must state if the meter registers on small light.

APPLICATIONS

1. Applications should be signed with the first and the last name of applicant fully written out.

2. If the signature be not plain, employe should write it plainly below and sign his own name as a witness.

3. In getting applications signed, the exact location of consumer should be designated, and if it is a store state the nature of the business and what gas is to be used for.

4. Applications must be signed by an adult and all necessary details stated.

5. If the applicant is unable to write, employe should sign for him or her and require applicant to affix his or her mark, viz:

His
John x Brown
Mark

and employe shall sign his own name as a witness.

6. When you have an order to get application for successor—index the meter even though you are unable to get the application.

LOCKING AND UNLOCKING

1. Under no circumstances shall a meter be unlocked when it is impossible to gain access to the apartment to be supplied.

2. "Unlock" orders must be attended to on the day they are received.

3. When a fitter has an "Unlock" order and finds the consumer has not yet moved in, he must so report on his ticket.

4. If, in executing an unlock order, an employe finds another company's meter is supplying the consumer, he will telephone to the office of that company stating on his ticket number of the telephone used, time called, and the name of company and employe to whom telephone message was delivered.

5. The printed questions on the back of "unlock" orders must be answered.

6. No meters to be unlocked unless fixtures are up.

7. Always carry a few caps and plugs when working on "unlocks."

8. Before unlocking meters, employes must first enter the premises to try the gas. If none is found, they must see that all outlets are properly closed; locate meter; unlock; turn on gas; watch dial to see if "proving hand" moves; have burner lit, and see that meter registers; take index; verify size and number of meter, floor and name of consumer, and notify consumer when leaving.

9. All pipes must be tested for leaks at the time gas is turned on, and should they be found defective, gas must be shut off and meter locked and consumer notified.

10. In reporting on "unlocks" and "locks" use the following terms: "I unlocked and tested O. K.," which means that you removed lock, turned on cock and tested.

11. "I found unlocked and tested O. K." means that you found no lock on, and the cock shut off, and that you turned same on and tested.

12. "I found unlocked" means that you found no lock on, and the cock open and gas on.

13. When having called to unlock a meter, an employe finds such meter unlocked and so reports on the order, he must prove that the meter covered by his report does supply the party named in the order.

14. In all cases after the unlocking of a meter, the consumer must be instructed in the use of gas appliances that may be found on the premises.

15. If you have one unlock order, and you find it necessary to unlock two meters to supply all parts of

premises, do so and attach a memorandum to the original order for the additional meter you unlocked.

16. Do not lock or unlock prepayment meters on orders calling for regular meters and vice versa.

17. Employe in locking a meter must prove the meter he locked supplied the premises and consumer as called for on the ticket.

18. When a fitter has a "lock" order and he finds a successor using gas, and for this reason refrains from locking the meter, he must prove that the meter on which he reports is the right one, and must get an application signed or report the number of deposit receipt.

19. "I locked meter" means that you turned off cock and locked same.

20. "I found locked" means that you found cock turned off and locked.

21. Having a lock order and finding that the old consumer is not moving, it is not necessaryy to get application signed, but have consumer sign statement that he is not moving.

House Piping Practice in Large Cities

A paper was read by H. R. Sterrett before the Philadelphia section of the Illuminating Engineering Society and published in their proceedings for June 10, 1915, which gives the piping practice in a large city and it very appropriately finds a place under the head of fitting rules. It is as follows:

Broadly speaking, any distribution system may be divided into four component parts: mains, services, meters and house piping, each of which contributes equally to the satisfactory supply of gas. Of these divisions the first three are under the gas company's control, and hence, are usually properly installed and maintained.

A brief description of a typical low pressure distribution system might now be apropos.

Typical Distribution System

From the works where the gas is made there is a net work of trunk or principal mains, which act as feeders for the thousands of branch pipes which supply gas to all parts of the city. In a large plant gas as manufactured is forced through pusher mains usually of 20 or 30 in. pipe (50.8 or 76.2 cm.) pipe, under a pressure of from 10 to 70 in. (0.25 to 1.78 m.) water column, the latter being a little less than 3 lbs. (1.36 kg.) per square inch (6.45 sq. cm.), to the various holders or reserve tanks.

The pusher mains are so interconnected that if, for any reason, something unforeseen should happen to either of the manufacturing plants, the other could instantly take up the additional load without endangering the continuity of supply. During the periods of low demand the holders are filled, and when the peak load comes on the gas supply is ample. The gas is discharged from the holder through governing valves into the distribution system, which is under a pressure averaging about 3 in. of water column. The distribution mains, which range from 6 to 48 in. in diameter, are so cross connected and interconnected that any break in the system affects but a few consumers. Continuously recording pressure gauges are set in different parts of the city so that any change in the gas pressure, due to increased or diminished consumption, perhaps caused by a shifting population, can be adjusted by partly closing or opening the holder valve. In this way the general pressure conditions are kept constant within certain limits.

Piping Specifications

The remaining division of the distribution system, house piping, is usually installed by plumbers or gas fitters, and does not come under the direct control of the gas company. It is, therefore, necessary that this work be properly inspected.

The importance of a specification which will thoroughly cover the installation of all interior gas piping cannot be too greatly emphasized. In order that such a specification be of any real value, it is very necessary that proper laws be enacted to insure to the gas company the enforcement of the various rules embodied in the specification.

In one large city, before any gas piping may be installed in a building it is necessary to obtain a permit from the bureau of buildings, which also inspects the work when completed and issues an approval card before a meter may be set. In another city all piping must be installed in accordance with specifications issued by the gas company, whose inspectors supervise the work; while in still another city all gas fitters must be licensed and file a plan of the proposed piping with the building department for its approval, the gas company supervising the installation.

In one city where about 375,000 meters are in use the city government by ordinance requires the gas company to exercise a supervision over the character of material used and work done in installing gas piping and fixtures. In accordance with the obligation thus created, the company has adopted a specification for fuel and illuminating piping and fixtures. This specification includes the kind of material, methods, locations, etc., to be used and avoided in making installations, a schedule of pipe sizes and lengths for various consumptions, instruction how to properly draft a piping plan, and an explanation of just what is required in the way of inspections by the gas company's representatives.

The piping schedule is based on Prof. Pole's well-known formula for the flow of gas through pipes,

$$Q = C \sqrt{\frac{d^5(P_1 - P_2)}{LW}}$$

where Q = cubic feet per hour; d = diameter pipe in inches; P_1 = initial pressure, inches water; P_2 = ter-

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minal pressure, inches water; L = length in yards; W = specific gravity of gas (air = 1); C = constant.

A computer designed by Wm. Cox is based on this formula, and saves much time which otherwise would be spent in making calculations. With the computer, either the discharge, the required size pipe, or the difference in pressure can be determined, provided the other two are known.

If the sizes specified in the schedule are checked with the formula they will be found somewhat in excess of the figures derived from the latter, it being the desire of the gas company to make provision for the future installation of additional appliances without necessitating an increase in the size of piping.

The smallest diameter pipe, and therefore the smallest outlet permitted, is ⅜ in. (9.52 mm.), and this, it is assumed, will usually supply 10 cu. ft. (0.28 cu. m.) per hour at the average pressure. The capacity of a larger outlet as compared with a ⅜-in. outlet, varies directly as the areas. In designing a system of piping, after the sizes of the various outlets and the best direction to run the pipes have been determined, it remains to decide the proper size piping to install. This is accomplished by starting at that part of the system farthest from the meter and working toward the latter, determining the proper sizes by consulting the piping schedule. When the first branch line is reached the sizes are again determined by starting at the far end of the branch and proceeding to the junction, where the quantities of gas for the two pipes are added and the same process repeated until finally the meter is reached.

Pressure Considerations

When no outlets are open the pressure in a system of house piping is uniform, except the small difference due to elevation, each 10 ft. (2.54 m.) being equal to about 1/10 in. (2.5 mm.) water column. Just as soon as a burner is lighted, gas begins to flow through the piping and, as a result of frictional losses, the pressure by the time the gas reaches the burner is reduced. Since it is necessary to have a certain volume of gas at a burner, and since the volume depends on the pressure as well as on the size of piping, a certain pressure loss through a system of piping must be used as a basic, so that in the piping schedule mentioned before a loss of 2/10-in. water pressure between the meter and the farthest outlet is considered as maximum. Then since there is from 25/10 to 35/10-in. (63.5 to 90 mm.) pressure on the mains and services, the pressure at an appliance connected to the extreme outlet would be from 20/10 or 30/10 in., there being about a 3/10-in. drop through the meter.

Due to the fact that there is a certain unavoidable range in pressure over an area as great as that included by the limits of a large city, gas appliances are usually equipped with the necessary means of adjusting the burner to take care of the different pressures.

In one large city where the gas company is responsible to the city government for all material and workmanship in the installation of house piping three inspections of interior piping are made, the inspectors being employes of the gas company, impartial and working for the combined interest of the consumer and the company. When an installation is ready for the first inspection, which is made while the piping is still exposed, a plan of the system or extension, plotted on a regular form, is forwarded to the gas company. The inspector compares the actual installation with the plan, and tests the piping for leaks, a pressure of 3 lbs. (1.36 kg.) per square inch (6.45 sq. cm.) as indicated by a 6-in. (15.24 cm.) mercury column, being applied for 10 minutes.

If the rules have been complied with, and the system is tight, a certificate of first inspection is issued and the piping may be covered. If any changes are necessary, they must be made before the certificate is granted. After all carpenter and other building work that might disturb the piping has been finished, and after the last coat of white plaster is on, the gas fitter

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applies for the second inspection, which is principally one of pressure and is made before any fixtures are hung. A pressure test identical with that of the first inspection is made, and if the piping is tight a certificate of second inspection is given.

After the fixtures are installed and the system is ready to receive gas, the third inspection is applied for. This, the last inspection, is principally one of fixtures; the entire system is put under a pressure of 6-in. water column, which must show no drop in 10 minutes. Fixtures are examined for poor workmanship, objectionable design, etc., and all gas fixture cocks are carefully measured with a special gauge made for the purpose of determining whether they comply with the fixture cock specification.

Installing the Piping System

There is very little to say about the actual physical house piping. It is simply a case of determining the proper location of and the approximate consumption of gas for each outlet, joining the various outlets to the riser, care being exercised so that the piping is of the correct size, properly supported, sloping in the right direction, etc.

In ordinary dwelling houses, which form the great majority of cases, a system of house piping usually consists of a riser or pipe running vertically from a point in the basement near the meter, and supplying gas at each floor to a branch pipe, to which are connected the various outlets on that floor. In larger dwellings two or more risers may be run, all being supplied by one meter; while in the case of apartment houses a separate riser and meter supplies each apartment. The meters are always installed in the basement, and in some cases where the number warrants a special meter room is built. In modern manufacturing buildings it is the custom to install a trunk or common riser, the meter or meters being set on each floor, according to the number of tenants occupying it.

In most cases horizontal gas piping is run parallel with and under the floor boards, which not only makes it more convenient if the piping should ever, for any reason, need to be uncovered, but also assures that it will be supported by the joists which may be notched out as near their points of support as is possible. Vertical pipes are usually run in hollow partition walls. Wherever possible it is preferable to have the gas piping exposed to view.

Piping may be laid level, but if not it should be sloped toward an outlet where it can be properly dripped, that is, where any condensation formed might be conveniently drained off.

After a system of piping has been properly installed it needs very little attention under normal conditions. In time a certain amount of scale may form, and if this collects at any point the area will be reduced and the pressure lowered, thus causing a complaint from the consumer that the supply has been insufficient. By shutting off the gas at the meter and forcing air through the pipes by means of a hand pump these obstructions can usually be removed. The decision as to where each outlet should be placed to afford the proper distribution of light should be made by an illuminating engineer.

Of course, there are innumerable little houses where the small rooms, usually square or oblong, do not allow fixtures other than central pendants or side wall brackets to be installed, and in these cases it is of little importance that the various outlets are located by one who, perhaps, knows little or nothing about lumens, foot-candles, glare, coefficients of reflection, etc. On the other hand, there are thousands of larger residences, apartment houses, commercial buildings and school houses where the size of the rooms does not limit the type or location of lighting fixtures. In structures such as these the location of the light sources should rest with one familiar with first principles.

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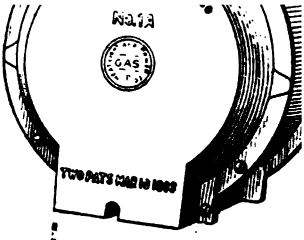
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