TRAIN SERVICE.

FORMING ONE OF THE TWELVE VOLUMES OF THE REVISED AND ENLARGED EDITION OF

THE SCIENCE OF RAILWAYS.

BY

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TRAIN SERVICE

TREATS OF THE UTILIZATION OF MEN AND EQUIPMENT; THE ORGANIZATION OF TRAINS; THE FORCES OPERATING THEM; THE CONDITIONS AND PECULIARITIES OF THE SERVICE; THE SIGNALS AND RULES AND REGULATIONS GOVERNING THE MOVEMENT OF TRAINS ON AMERICAN RAILWAYS, WITH AN ACCOUNT OF PRACTICES ON RAILROADS IN GREAT BRITAIN.

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INTRODUCTION.

While the physical life of a railway is too great to be comprehended in its entirety by any man, a general knowledge of the operations of railroads and the economic laws that govern them is essential to every railroad man, whether he be prominent in his line of duty or not. It is as necessary, in many respects, to Train Men as to Managers. Many men, eager to acquire this information, do not have the facilities because no one except the very highest officials of a railroad possesses them. This book, with the others that make up "THE SCIENCE OF RAILWAYS," is especially intended to aid those who seek to acquire knowledge of the operations of railroads in the many departments of the service, yet have no practical opportunity of doing do.

When we speak of a railroad we conjure up in our minds the right of way and track of steel winding away through the green fields and pastures of the country. As a matter of fact, these are only the foundations or mechanical features of the railroad, so to speak. The spirit or vital flame of the enterprise is the engines and cars that traverse the country, controlled and directed by the skilled and trusted men in charge thereof.

The Train Service of a railroad is its supreme feature. Roadways existed before locomotives were invented, but they had no general interest to mankind. The locomotive vitalized them. It is the trains that rush and roar through the land, loaded with the world's traffic, which make railroads interesting to the public and useful to mankind. The subject is a great one, the greatest, in fact, of all those connected with railroads.

CHAPTER I.

ECONOMIC ASPECTS OF THE SUBJECT.

The denizens of the different countries of Western Europe do not have the same habits nor the same likes and dislikes, and yet the men and women are everywhere practically the same. Their differences are the outgrowth of local causes, and wholly superficial. Thus the French descendants of a German family hate the mother country with all the intensity of the original Gaul. National lines will fade away when those who live on either side of them come to know each other familiarly. Steam and electricity make a common family possible. Social unity and trade progress are dependent upon intercommunication. The present rate of progress in this respect, compared to the past, is as the present rate of speed is to that of the stage coach and sailing vessel of an earlier age.

It is the province of railroads to overcome distance, to bring peoples together, to make markets accessible. The more cheaply, rapidly and safely trains are run, the greater the traffic, the greater the intercommunication. Every train is a factor in the evolution of mankind and has a direct effect on the relations of peoples and the growth of trade. Its movements thus become a matter of universal concern.

The fundamental conditions governing the service are that trains shall be ample, regular in their movements and adapted to the traffic they handle. That they shall be safe so far as careful foresight and experienced men can make them goes without saying.

The business of railroads is governed by the divergent interests of those who use them. Their government is founded on well known economic laws designed to accommodate a traffic regulated by such laws. It is self-adjustive and harmonizes perfectly with surrounding interests. Its methods are such as to protect and foster the community upon which railroads are dependent. They are based on natural laws and are the outgrowth of mutual concessions and a careful apportionment of interests. Statutory laws, on the other hand, such as those regulating rates, speed of trains and kindred details, are not thus self-responsive, and in so far as this is the case, bear oppressively while they seem, perhaps, for the moment to benefit mankind.

The physical life of a railway, as I have remarked in the introduction, is too great to be comprehended in its entirety by any man. But a good general knowledge of the operations of railroads and the economic laws that regulate them is essential to every student and to every railroad man, whether he be prominent in his vocation or not. Men connected with railroads, eager to acquire this information, do not, as a rule, possess the facilities. Only the very high officials of railroads come in direct contact with every phase of railway operations. This book is intended to facilitate the inquiries of those who do not possess such avenues of information. It treats of the organization, duties and responsibility of the train force, the employment of equipment, the movement of trains, the rules and regulations governing the service, the accidents incident to railway operations, signals and kindred subjects.

It is devoted particularly to the physical operations of trains and the rules and regulations that may profitably be used in that particular field. It is not exhaustive, and a full understanding of the subject requires that collateral branches of the service should be mastered. The boundaries of the different departments and bureaus of railways have, as railway men are aware, no well defined line of demarkation, but merge insensibly at many points into those about them. Thus the operating and traffic departments, for instance, include within their scope many of the self-same things. Hence it is necessary to understand generally, at least, all branches of railways in order to comprehend a particular one.

I have in the past written several books on train service. The first one was published in 1878. There, for the first time, was pointed out the incongruities of the service noticeable at that time.

The volume in question embraced a complete code of train rules and signals. It suggested for the first time the necessity of concerted and harmonious action between different railroads. Every important suggestion it contained, and the great bulk of the regulations it embodied, have since been carried out.

Of the forces which have accelerated the development of the world, the railway has been the greatest, but its progress has been so rapid, and its achievements so great, that a dispassionate study of the economic laws governing it has been well nigh impossible.

In the operation of trains, comparisons are, in the main, valueless between different railroads, because the conditions are never alike. They are, therefore, not attempted herein. The train service of American railroads may be said to be perfect according to the facilities that the traffic renders feasible. Nevertheless, owners and managers have been much criticised in this respect, but without cause. The service is at once ample and safe, and, at the same time, the cheapest and most extended in the world. Its triumphs, too, have been achieved in the face of apparently insurmountable obstacles; the obstacles that a new and widely extended country offer; a country without credit, wherein money was scarce, labor high priced, material costly, taxes excessive and public opinion oftentimes unjust and oppressive.

Information in regard to the trains of railways is always of interest and importance. Their producing capacity is determined by statistics compiled with that object in view. These exhibits portray the income and the outgo. Thus the value of a traffic is determined, while the service performed by engines and crews of trains, and their relative effectiveness, is, incidentally, ascertained. The last is of the utmost importance, as upon the skill and economy exercised depends the profitableness of a service. This applies to both freight and passenger trains. In describing one we, therefore, describe both.

CHAPTER II.

MORALE OF THE SERVICE.

The train and station force of a railroad is its creative force—the means by which it accomplishes its ends. Here is the place for those who contemplate making the railway business an occupation to begin work. At the station, or on the train, the traffic, upon which everything hinges, is handled. Having learned the business in this primary school, the application of general principles will come more easily to the student afterward, should he be promoted to higher duties.

In corporate life, promotion is necessarily slow. It must be so wherever large bodies of men are associated. The struggle for supremacy is unremitting and merciless. The fittest survive. The work is oftentimes hard and the hours long. Moreover, men laboring thus in obscurity are apt oftentimes to think themselves overlooked or forgotten, and, thinking thus, they lose heart and quit the service, or seek employment elsewhere. It is not such who achieve success upon railroads; preferment here demands perseverance, patience, courage, hard, unremitting labor of body and mind.

Not only does the train service of a railroad intertwine its functions with those of every department and bureau of the service, but it takes on new color with the introduction of each new device and with every added employe. These conditions, never alike for two successive days, render any attempt to portray it in permanent colors futile.

A description that might represent one road would be untrustworthy if applied to another, and a description that embraced every detail to-day would be imperfect to-morrow. The duties of those in charge of trains of the same class seem, to the casual observer, to be identical, yet the greatest diversity exists because of differences in the character of the business handled and the rights trains enjoy. Nothing would be gained by an attempt to describe or analyze these differences. Some of them are apparent upon reflection. Others, again, are too subtle to be conveyed by written or verbal description. Nevertheless, certain general conditions attach to the service of all railroads. These may be depicted and profitably studied.

The train force of railroads must be composed of temperate men (I do not say total abstinence men), otherwise their habits will lead them into excesses that will sooner or later end in disaster.

The fund of practical information of a local nature that trainmen must possess to make them valuable to their employer I cannot pretend to set down in words, but in general I may say that they must be familiar with the route over which they pass, the sidings, stations, grades, crossings and other physical features of the line; with the signals of the company; with the rules governing the movements of its trains, and finally with the disposition of auxiliary forces.

It is no exaggeration to say that trainmen are, in general and in particular, comprehensive, sagacious and worldly wise. They are required not only to obey specific rules, but to take cognizance of other necessary things not embraced therein. All these varied and complex requirements they meet.

Trainmen upon many lines are required to be familiar with methods of operating both single and double track, so that no risk may be run in transferring from one to the other.

In the discharge of their duties they must obey established rules without reference to their value in particular instances, for to transgress them in unimportant cases is to incur the habit of disobedience in important instances. Upon them rests the responsibility of seeing that every appliance necessary to protect a train is in order before it starts; brakes must be in perfect condition, signals in their places, and in the event of detention on the line prompt and adequate measures taken to protect the train. They must, it appears, be not only experts, but men of calm judgment and quick decision.

The train service is peculiar and is characteristic of railways. Other branches of the service must find their counterparts in commercial pursuits of various kinds, but not so the train service. It receives the unstinted admiration of us all; of travelers as well as others. Its service in the early days of railroads was in the main recruited from among the hardy, adventurous boys of cities and towns. Its hardships and dangers appalled all but the more daring. No favorite son, no heir apparent, was allowed to brave the dangers that attended service on freight trains or about the yards and stations. Other and less dangerous avenues to fortune were sought for the delicately nurtured. It was only those whose lines had fallen in hard places, who were restricted in the pursuits they might follow, and who were courageous beyond their associates, who voluntarily risked the chances. However, the dangers of the service, while real and appalling, were soon robbed of their terror by daily familiarity and the feeling, so common to soldiers and men in venturesome pursuits, that while others might be unfortunate they would escape.

All these risks, or at least many of them, are extinguished, or in process of extinguishment, by the introduction of automatic couplings and other devices intended to rob the train service of railroads of its more dangerous features. The introduction of automatic signals, brakes, switches, couplers, and kindred mechanical devices, will bring into the train service men who would otherwise have avoided it. This will benefit everyone. It is probable, also, that the introduction of improved devices, such as I have mentioned, will effect a marked change, if not a revolution, in other important particulars connected with the personnel of the service.

In every trainman we see a possible railway manager or president. The train and station service is the gateway to a knowledge of railway operation. It is also the natural recruiting ground for officers and sub-officials, and constitutes what the merchant marine was to the navy before the introduction of steam—a preparatory school.

Few appreciate the varied responsibilities that rest upon conductors and engineers, and in a lesser degree on other trainmen. They are so great as to affect in a marked manner the character of these officials. It is not too much to say that they sober and ennoble them. No matter how indifferent they may have been to the grave responsibilities of life before their appointment, once life and property are placed in their keeping their demeanor becomes that of men who appreciate the responsibility and strive to fit themselves to meet it fully.

Men whose lives often hang in the balance, or upon whose courage, vigilance, skill and presence of mind the lives and property of others depend, will, in the end, have little that is trivial or superficial in their natures. Those who are unable to appreciate the greatness of the responsibility and its requirements do not long continue in the train service, but quickly seek other and less difficult positions in life.

The difference between the freight and passenger train business is great, and quickly impresses itself upon those promoted to the latter service. The facility with which they adapt themselves to the new conditions generally evinces the fitness of the selection. The transition is, however, in every case expected and so finds the incumbent in a measure prepared. But notwithstanding this, the change is so marked that only those who possess great adaptability can adjust themselves to it without more or less friction. The simplification of the service that is going on all the time will in a measure lessen the obstacles to be overcome. It at the same time secures greater unity in the service. These advantages no one appreciates so highly as those immediately connected with the movement of trains.

The duties of trainmen in America differ materially from those of other countries, being at once more varied, more arduous and more responsible. This is especially true of the passenger service. Its members in America come in constant contact with the patrons of their employer, and hence must cultivate the art of getting along pleasantly with the traveling public. They study, and successfully, the art of satisfying the patron without sacrificing the carrier. Their mechanical duties may be learned by practice and observation, but ability to get on pleasantly with the public can only be acquired by the exercise of an enlightened understanding and a cheerful and kindly disposition, which latter, as has been aptly said, forms the basis of all true politeness.

The train force is highly drilled. It is at once expert, prompt, active and trustworthy. It thinks and acts quickly, as hesitation may precipitate disaster involving both life and property. No government will knowingly license a dull man as pilot; the risk would be too great, and at once an unkindness to the man and a wrong to the public. The same conditions apply to the train force of railroads. A dull man in its ranks is a constant menace. A man upon whose action interests so vital rest must possess quick perception, good judgment and a resolute will.

The vicissitudes attending the operations of trains cannot always be anticipated, so that occasions constantly arise where those in charge must act on the spur of the moment. They must, therefore, be men qualified to assume such responsibilities. The fitness of men to fill positions in the train service is in the main determined by long observation of their acts by official superiors. The surveillance is not offensive, however. The rudimentary needs of the service require that a man shall know how to read and write, have good hearing and good eyesight.* The

* The prevalence of a color blindness is well known, but according to Dr. Robert Barclay, a railway surgeon of experience, "profound deafness among railway employes is by no means rare. It is usually developed insidiously, and is unrecognized unless brought to notice through some aggravating circumstance."

custom of requiring men seeking positions in the train service to pass an examination seems to be a growing practice all over the world. Such examinations may not always be agreeable, but their usefulness is coming to be generally recognized. They may, indeed, be the means of protecting the life of the person examined and, without them, many defects would remain unknown until, perhaps, revealed by some grave disaster. While examinations are desirable, it is also true that they may be carried to absurd lengths. What is required, primarily, is that the employe should know the rules governing his particular duties, be able to read and write, have good hearing, perfect eyesight, reasonably stable health, and a courageous spirit.

It is important that the members of a train force should not be worked to the point of exhaustion. Due time for rest, sleep and recreation must be allowed. To deny this is to invite carelessness, inattention and indifference; to court disaster, in fact. Flesh and blood will not withstand undue strain. As a rule, trainmen are not overworked, and instances to the contrary are exceptional and, as a rule, unavoidable.

The legislation that has been enacted is not uniform as to the maximum number of hours that trainmen may work without rest. In Switzerland sixteen hours is prescribed; in the state of Ohio, twenty-four hours. In both cases, it is directed that employes shall be accorded eight hours of continuous rest. Many other enactments might be cited if it were desirable.

The practice requiring trainmen to wear uniforms is a growing one. It was objected to at first by employes in America on the ground of cost, conspicuity and the necessity of frequent changes of garments not alike in texture or warmth. However, upon trial, these objections proved not to be well founded and so only stayed without preventing the adoption of the practice. The innovation was on the whole a good one and in the interest of trainmen. Men in the service are governed with the strict discipline of military life. To receive an order is to obey it. The uniform helps to emphasize this. Every trainman must be the equal of the soldier in courage and disposition. His duties are on the whole more dangerous than those of a soldier and the many mishaps that attend his career enlist general sympathy. They also suggest that permanent provision so far as possible should be made for him when he can no longer work.

The practices that characterize the train service of different companies are not the same. Thus upon many lines the system more or less generally designated as "first in, first out" is observed. Upon other roads crews are assigned arbitrarily to particular trains. An objection to what is known as the "first in, first out" method is that it breaks up the habits of men and prevents their eating, drinking and sleeping in a methodical, orderly way like the rest of mankind. Moreover, it is urged against it that it injures the service in this that it treats all alike without reference to capacity, length of service or faithfulness. If there is no promotion ahead, if there is not something to strive for continually, men lose interest, say these critics. However, the practice does not have an injurious effect where it has been tried, and therefore, criticisms upon it are to be accepted qualifiedly. Those who favor the method claim that it equalizes the pay of trainmen and in general prevents favoritism. Operating officers favor it for the same reason. They find it lessens complaints and enables the management to secure desired safeguards and also make comparisons otherwise impossible. An advocate describing its working says that the number of engine crews assigned to a particular district, should be in excess of the number of engines. The first crew in should be the first crew out without reference to the engine to which it is assigned, engines being assigned to meet the needs of traffic irrespective of any rule regarding particular crews. The plan is to keep the engines in constant service, barring necessary repairs, and at all times to have them manned with crews that have had opportunity to secure rest. The number of engines and crews should be so regulated that the engines in actual service will be worked to their full capacity. Those not needed, to be laid up. The number of crews assigned should be such that they will have ample rest before going on the road, and also earn uniform pay. The system affords sufficient flexibility to cover any range of business. The arguments in favor of it are many. A man assigned permanently to a particular engine is interested more or less, it is claimed, in keeping his machine out of the shop, and hence in working it as lightly as possible. Men who pool their efforts, on the contrary, are willing to work the engines hard and haul heavy trains. A saving is thus effected. Engines are built for service and the sooner an engine is worn out in hard work, the more money it will have earned. Under the system of assigning crews to engines according to the plan "first in, first out," every engine is available. When a particular crew is assigned to a particular engine, the latter will often be taken out by the engineer when it ought to be sent to the repair shop, and hence will not perform full service. Under the practice of assigning crews to engines on the principle of "first in, first out," it is possible to get greater mileage out of engines than under the regular crew system; a given amount of work can be done with much fewer engines; engines will be made to haul heavier trains. Cost of repairs and service per mile will thus show better. Finally the advantages of the system are mutual as between the railroad and the enginemen. In arranging the work a sufficient number of crews should be assigned to insure every man an opportunity to get proper rest between trips. The number will have to be readjusted from time to time to meet fluctuations in business. This elasticity adapts the system perfectly to the varying needs of business. Engineers and firemen should be assigned together and kept together. In some instances where this has not been done, results have not been satisfactory. Those who favor the interchange of crews on engines claim that engines are thus kept constantly in service while in good condition, rendering it possible, if there is a surplus, to lay such surplus by and put it in good order against the day when it will be needed. Or, if there is no surplus, then the maximum service possible is secured by running every engine to its full capacity. The practice of sending out engine crews in the order of their arrival irrespective of the engines they work, is also enforced more or less by many railroad companies with conductors and brakemen. It is claimed that under this system wages are more nearly equalized than under any other, and consequently it is more popular than any other with those it affects.

Methods designed to improve the service of railways in general affect favorably the train service. The particular requirements of the latter are implicit obedience, constant watchfulness, energetic prosecution of work, economy of time. Judicious selection of the members of the train force is recommended, followed afterward by careful schooling and proper discipline, the last named tempered at all times by good judgment.

A belief that the interests of employer and employe are in the main identical each day grows in strength among railway men. Those connected with the train service are no exception to the rule. Railway managers seek to cement this feeling by careful consideration of the present and future interests of employes and by leading them to regard at all times the permanent prosperity of the company as a part of their being and as a matter in which they and theirs are vitally concerned.

While the practice of giving prizes and bounties for superior efficiency is not general, it is practiced more or less by every company in one way or another. Whatever shape it may take, its purpose is to build up the morale of the organization and to foster friendly relations between the employer and the employe. Aside from this, however, it is a proper recognition of superior services and worthy of all praise.

In the operation of railroads, while rewards may be proper, fines for dereliction of duty are not proper and should be avoided. Men should be encouraged with praise, but threats should be avoided; the worthy should be promoted, but the unworthy should not be degraded; unremitting vigilance should be suitably noticed, but mistakes not the result of carelessness or indifference should be overlooked; errors of judgment should be leniently dealt with while disloyalty should be punished with dismissal. A service thus governed must, in the end, be animated by a high respect for itself and a clear conception of its duty to its employer. I do not here speak of the train service particularly. Those who look after the track of railways and its physical appliances are similarly governed. Deficiencies here, as in the train service, are detrimental to the property and add to their injurious effects a loss of prestige.

There is nothing new in the practice of giving rewards for superior efficiency. It is as old as the details of business, or as the disposition of one man to actively interest another in his affairs. In the case of railroads, those, for instance, connected with the Machinery Department, who perform the greatest amount of work with the least amount of material, such as fuel or oil, are thus recognized on some of our roads. Awards or premiums are also granted men in other departments of the service for superior work and interest. Premiums have been found valuable, it is claimed, where the practice has been tried, in improving the train service. The basis of premiums is not the same in every case, but one I have particularly in mind, at this moment, takes cognizance of the number and weight of cars moved in the train, its delays, accidents, the complaints of the public, the mistakes made, the deportment, dress, condition and cleanliness of the cars, and so on. A sum of money, in addition to regular pay, is awarded the fortunate recipients of the bounty. The conductor of a passenger train, presenting the best personal appearance, who is least complained of and whose train conforms most closely to its schedule and meets with the fewest accidents, and fulfills other desirable requirements, gets a prize and stands high with his company. His brakemen and baggagemen are also favored, for we may be certain that they excel in their positions as he does in his. Like begets like. Similarly, the crews of freight trains are recognized and rewarded for superior efficiency. The records, in addition to furnishing the data upon which prizes are awarded, are also made, as I have intimated, the basis of promotion, a bad record being looked upon as a mark of inferiority, while a good one indicates the reverse. A company encouraging its train force in the way I have mentioned is benefited, say the advocates of the system, in increased number of cars hauled; in accelerated movement of trains; in fewer accidents; in lessened complaints; in decreased payments for overtime; in economical but efficient use of supplies; in quickened interest, and generally in a heightened desire to achieve results. The premiums are of little consequence from the employer's point of view, but of great importance to the employe, not only as an evidence of recognition, but because of their intrinsic value.

Where men are scattered over a wide extent of country, incentives such as I have mentioned cannot but be beneficial, but to secure the best results, the recognition must be gracious, prompt and just. It must be the spontaneous act of the employer and indicate a high appreciation of the value of faithful service.

The practice of giving bounties answers a further and desirable purpose, namely, that of dispelling the idea that everyone must be treated alike, without reference to skill and faithfulness. Herein railways, like other corporations, are prone to be weak.

Improvements in railway appliances demand, on the whole, increased intelligence upon the part of those who use them. This involves greater care in the selection of men and greater encouragement to them to perfect themselves in their duties. The engineer of to-day, it is apparent, must be far more skillful than the engineer of sixty years ago, because his appliances are far more numerous and complicated, and, therefore, require greater experience and skill to use them effectively. This is also true, in a measure, of others connected with the train service.

In order to build up the train force to the highest standard of which it is capable, those admitted to it should be selected with the foresight and care that characterize the selection of the employes of a bank. Two things are to be kept in view, namely, present and future usefulness; ability to do the work in hand, and capacity to grow. These particular features of the service were not considered with the care they should have been in the early days of railroads. Managers were too hurried. Moreover, the material was not at hand to select from. No department of railway service has received the consideration in this respect in the past that it will in the future. Men have necessarily been oftentimes chosen haphazard. Their antecedents have not been scrutinized, and after installation, no systematic effort has been put forth to lead them to study and otherwise fit themselves for their positions.

Applicants seeking to enter the service of railways should be passed upon by men who are experts in their way, and are, moreover, good judges of human nature; men highly interested in building up and ennobling the service. To be connected with the train service of a railway is in itself an evidence of high intelligence and fitness. Each year has shown improvement. Each year has developed higher aspirations and greater skill in the performance of duty. The train force presents, all in all, the most important feature of the operating department of a railroad. Mr. J. S. Gadsden, at one time President of the American Association of Railway Superintendents, referring to this phase of railway life in connection with other things appertaining to the service, has this to say: "The maintenance of proper discipline is as necessary to the proper operation of railroads as it is difficult of application and distasteful to the superintendent called on to exercise it. So long as the necessity exists for the employment of the 'personal equation,' as it is called, in the service of railroads, laws must be framed for its government, and punishment must follow their violation. The problem is to measure the degree of punishment suitable to the offense; to correct the violation of law without doing greater harm to the system. Personal government without fixed rules for guidance will tend either to unusual severity or to harmful lenience. To the superintendent, busied and interested in the daily solution of the ever-changing problems of the hour, the rude shocks to which he is ever liable by the errors or omissions of his men, leading to accidents or disasters, are trials of temper, and so disturbing in their effects upon the nervous system as to quite unfit him, oftentimes, for the exercise of the functions of judge. When contemplating the results of the violation of established laws, which violations often defeat all the provisions which wise foresight had taken for security of life and property, a person of the most equable temper is apt to lose self-control, and resort to measures which would be unjustifiable under the most aggravated instances of disobedience. Improvements in physical structures should and do enlist eager interest and commend themselves to judicious minds; but the ethics of railway management, the maturing and systematizing of a code of laws for classification and punishment of offenders, so aimed and adjusted as to correct the errors and mistakes of employes without unnecessary friction, is a subject of equal, if not paramount, interest and importance. The theory on which is based the code of discipline presented below is to clearly state the regulations, which are to be enforced by a penalty, and the nature and extent of the penalty; also to place such regulations before those expected to obey them; to follow up every violation promptly, inflicting a penalty for the violation, and not for the consequences of the violation, but only after a fair hearing of the case; and to surround the train rules with greater sanctity than others by treating their violation with greater severity. Further, by increment in the measure of punishment growing with the repetition of offenses, to draw attention to the fact that the offender is gradually but surely working out his dismissal from the service without any agency outside of himself. The code I have to suggest is this: The first fine imposed upon an employe in any calendar year should be one dollar, and each succeeding fine during the same year should be increased by one dollar. The fifth fine in any calendar year should be accompanied by suspension from duty for one week without pay. Any employe who has been fined five times in any calendar year should, for the sixth offense, be dismissed from the service. Any fine for violation or neglect of train rules should be accompanied by one week's suspension from duty without pay. An employe whose carelessness or neglect results in injury to property should, at the discretion of the superintendent, make good the injury; except that any amount deducted from pay under this rule should not, in any month, exceed one-fifth of his monthly pay, and such deductions for any one offense should not continue for a longer period than twelve months. All fines, deductions, suspensions and dismissals under this rule should be authorized by the superintendent and duly entered on the pay roll. Such entries should state the order or rule that has been violated or neglected. A record of penalties should be kept in the superintendent's office and checked by a monthly report from the paymaster of the penalties entered on the pay rolls. All fines, except to make good injuries to property, should be donated to the employes' mutual relief association. The code should not limit the power of heads of departments or other authorized persons to dismiss employes for incompetency or the good of the service."

I do not believe the enforcement of fines to be desirable. That is, however, merely an opinion. There are many others much better qualified to judge of such matters than I. Well managed companies have tried the experiment and found it to work successfully. There must, therefore, be something in it. How much its success has resulted from merit and how much from the tact and wisdom of officials in charge, I do not know, but in regard to the necessity of rules and the enforcement of the same we are all agreed. They are necessary to the employe, the employer and the public. In many cases the courts have saved carriers harmless from suits for damages because their rules, if carried out, would have prevented the accident.

CHAPTER III.

THE TRAIN FORCE.

Passing now from the general consideration of the train service, I propose briefly to refer to some of the members of the force.*

And first, the engineer—the key to the arch. This able, experienced and highly trusted employe is in Great Britain called a Driver. While it is not necessary that he should be a machinist, it is essential that he should understand the care and use of tools, especially those making up the outfit of his engine. He must understand, also, how to take a locomotive apart and how to put it together. Hence it is necessary that he should have conquered thoroughly the details of his business. He must also have perfectly familiarized himself with the working of his machine and its multifarious weaknesses. The acquisition of this knowledge, it is apparent, requires long, practical experience and study.

Each locomotive has its peculiarities. No two machines are alike. There may be no difference between them so far as the eye can discern, and

*Railway baggagemen are referred to and their work described in the book on baggage. The duties and responsibilities of the engineer and fireman referred to briefly in this chapter will be further and more particularly described in another part of the work.

the patterns from which they were built may have been identical, but their steam making power, their inherent force and their behavior generally will be different in many things. The engineer must fathom the secrets of his particular engine; must understand its weaknesses and its strength; how to utilize its forces and how to overcome its inherent defects. His skill in doing this, coupled with his ability to supervise the duties of the fireman, is in the main the measure of his capacity.

The necessity that those who run engines should be men wedded to their office and should pursue it steadily as a business, is too apparent to need argument. Amateurs, or those who desire to go on the road for a time only, have not the knowledge that an engineer should possess. He, above all men, must be practical and conservative and possessed of a comprehensive mind. He must not only be alive to his own duty, but alert to that of others. There must be nothing of the braggadocio about him, nothing pyrotechnical nor spectacular. He must be a conscientious man, taking the safe course, not because the rules tell him so, but because it is his nature.

Such is the engineer. That such a man will be temperate in what he eats and drinks goes without saying. He must withal have good health, and having this, his life is such as to preserve him to a vigorous old age. The hardships of his occupation, while great, are not such as to break him down. He quickly becomes accustomed to his environment and wedded to his responsibilities. As a set off against the things that harass and perplex him, there are many compensating advantages connected with his business which serve to refresh and encourage him.

It is said of Stephenson that he sought educated men for engineers, but that Brunel preferred those who were ignorant, on the theory that they should not know anything outside of their duties. It is hardly necessary to say that the methods of the former proved superior. Knowledge of the multitudinous affairs involved in the duties of the engineer require a good foundation on which to build. Education forms a foundation. Those who seek to climb higher must conquer still wider fields. Their minds must be alert, strong and supple. They must be able to observe, experiment, analyze and formulate. The possessors of such minds make good agents, engineers, conductors or officers.

Those who seek to fill any office acceptably must learn the steps precedent thereto. It is not necessary that an engineer should first be a fireman, but it is necessary that he should be familiar with the practical workings of a locomotive. The position of a fireman affords this and at the same time enables the person thus situated to utilize the time with advantage to himself and his employer.

The effectiveness of the locomotive is largely dependent upon the skill of the engineer. He, therefore, loses no opportunity to add to his experience and knowledge by studying the construction of his engine; its details; how it is put together; how taken apart; the relation of the parts to each other, and its general unity. Native talent supplemented by experience and study make a good engineer. Quite a number of books have been written on the locomotive. They contain much valuable information. One writer* says: "The locomotive engine which reaches nearest perfection is one which performs the greatest amount of work at the least cost for fuel, lubricants, wear and tear of machinery and track. The nearest approach to perfection in an engineer is the man who can work an engine so as to develop its best capabilities at the least cost. Capability of handling an engine can be acquired by a few months' practice; opening the throttle and moving the reverse lever require but scanty skill; there is no great accomplishment in being able to pack a gland, or tighten up a loose nut; but the magazine of practical knowledge, which enables an engineer to meet every emergency with calmness and promptitude, is obtained only by years of experience on the footboard, and by assiduous observation while there. To accomplish results, a thorough acquaintance with all details of the engine is essential, so that the entire machine may be operated as a harmonious unit, without jar or pound; the various methods of economizing heat must be intimately understood, and the laws which govern combustion should be

* Mr. Sinclair.

well known so far as they apply to the management of the fire. . . . Every advance in brake improvement increases the duties of the enginemen, and upon them will soon devolve the entire management and control of trains while in motion. The daily wage paid to an engineer is a trifling sum compared to the amount he can save or waste by good or bad management of his engine. Fuel wasted, lubricants thrown away, supplies destroyed and machinery abused, leading to extravagant running repairs, make up a long bill when enginemen are incompetent." The position of engineer grows more important with every advance in train appliances. The more complicated the machine, the more varied its requirements, the greater necessity there is for adaptability upon the part of the person handling it.

The position of engineer is the stepping stone to that of master mechanic. Everyone cannot become a master mechanic, but the position carries this honorable aspiration. Nor does promotion necessarily end there. No other place affords better opportunities for becoming familiar with the physical operations of a railroad. Every position, no matter how high, is thus open to the engineer of capacity and adaptability. Many of the greatest railway managers in the world have been practical engineers. Here, as elsewhere, knowledge is power.

The engineer must have the signals and rules and regulations at his fingers' ends. Their requirements as taught by his experience enforce prudence upon his part. He is, without knowing it, the embodiment of conservatism in his actions.

The practice of working engines continuously changed many early customs. Among other things, it suggested the employment of inspectors to examine engines at particular places, in addition to the inspection of the engineer in charge. The innovation added much to the usefulness of locomotives without increasing the risk of their breaking down. In early days, a locomotive, after a short run, was put into the house, and after being cleaned was allowed to rest, like the engineer and fireman, until the next day. This was a great waste, as experience has since taught.

Prevention is the essence of safety in the operation of trains. It is attained by constant watchfulness. The engineer becomes imbued with this spirit. Nothing on the road escapes his searching scrutiny. Before starting, he examines his machine to see that everything is as it should be. He watches it unceasingly afterward. Every bolt, nut, screw, link, key, rod, guide, spring, oil-box and detail is looked after with unflagging attention. He realizes that the safety of his engine is dependent upon its every part being in order. He trusts nothing to the accidents of chance. In regard to the specific duties of the engineer, the author already quoted says: "The engineer should reach his engine in good season, so that he will not be hurried in getting it ready for the road; he should see that the necessary supplies and tools are on the engine, that the locomotive is properly supplied with coal, that the tank is full of water and the sandbox full of sand; he should see that his engine is kept clean and in good order; he should make systematic inspections of his engine while it is standing over the pit between trips, should frequently examine the outside running gear, should also examine the boiler for leaks and see to the condition of the grates; he should be careful in oiling to pay attention to the oil cups, and see that the oil boxes are properly packed; he should consider the load to be hauled, the capacity of the engine, and the nature of the track; he should adjust the oil cups so that they will not feed faster than is needed; he should lose no opportunity to examine his engine for defects in machinery. When he leaves the roundhouse he should watch the workings of the various parts of the engine, try the brakes and pumps, and ascertain by the gauge cocks if the water level as shown by the glass water gauge is correct; he should compare his time with that of the conductor before starting; he should approach all stopping places cautiously; he should study his engine in order to obtain results at the least expense for fuel, oil and wear and tear of machinery; he should instruct his fireman in all matters relating to the duties of the latter; he should at all times keep a vigilant lookout for signals, switches and obstructions on the track, and should give the prescribed notice of his approach to crossings, stations, etc.; he should watch his train to see that it is intact. At the end of a trip, fire should be regulated so that a head of steam will be retained sufficient to take the engine into the house after the fire is drawn; he should call the attention of the proper official to any needed repairs to his engine on arriving at the end of his trip; he should use every precaution to guard against damage by fire from his engine; he should report promptly to the proper officer any injury to persons, live stock, or property by his engine.*

As the boy is father to the man and indicates unmistakably the character of the latter, so the fireman is father to the engineer. It follows, therefore, that in order to possess good engineers, a wise selection must be made of firemen.

The fireman is a factor of enormous importance from an economical standpoint in the train service. The fuel that under his manipulation is burned in the firebox of the engine, or blown through its smokestack unconsumed, amounts in the aggregate to a large percentage of the operating expenses. If he is skillful and conscientious in the performance of his duty, his company is fortunate. If he is not, it is unfortunate. Much has been said as to how his duties shall be performed. Manuals have been written for his benefit and experts on many railroads undertake

*I do not think I exaggerate the value of book knowledge too much when I say that everything worthy written on the subject of the duties of those connected with locomotives should be sought and read by the parties interested.

to further enlighten him. Perfection, while attained in many instances, is not universal, as the vast volumes of smoke emitted by locomotives, the result of poor firing, evince. Firemen are born, not made; a good fireman possesses the art instinctively. Practical experience is necessary to all, however, but experience must be carried on under the direction of one skilled in knowledge of the principles of combustion as applied to the locomotive. Formulas are laid down as the basis of the art of firing. They are not difficult to learn and are exceedingly interesting and valuable. An instructor* in this field thus explains the combustion of coal. He says it is "A chemical union of the atoms of the coal with the atoms of the oxygen of the air. To effect this union it is necessary that the atoms of the two named substances meet at a high temperature (called the temperature of ignition), which for coal and coal gas is that of bright red hot iron, or about eighteen hundred degrees. At this temperature the attractions of the atoms of coal and oxygen become so great that they clash together, and light and heat are the result of their collision. . . . The first thing that happens when coal is put on a fire is that the coal absorbs a great amount of heat, and the work the latter performs is to expel the gaseous matter of the coal, the constituents of which are two atoms of hydrogen and one atom of carbon, called carbureted hydrogen. Now, if the temperature is sufficiently high, as

* George H. Baker.

explained, the attractions existing between the oxygen and gas are so intensified that they clash together, and light and heat result, and they are burned, the products of their combustion being vapor of water and carbonic acid gas. At the igniting temperature the hydrogen separates itself from its fellow constituent, the carbon, and combines with the oxygen present, forming vapor of water. This is because the oxygen has a stronger attraction for the hydrogen than it has for the carbon, and not until the hydrogen meets and combines with its equivalent of oxygen does the carbon take its turn. The carbon vapor yields up one of its atoms to two atoms of oxygen and in that proportion combines with oxygen and is burned, forming carbonic acid. In this manner the gaseous portion of the coal is expelled and consumed, leaving the most of the carbon yet upon the grates in a solid, incandescent state. A proper supply of oxygen alone will enable it to perfectly burn and yield up its greatest heat." The same writer enters with considerable particularity into the practical duties of the locomotive fireman; they are to see that the grates and appurtenances of his engine are in proper order and that the full complement of tools is on hand before starting; that the flue sheets are cleaned of clinkers before his engine is fired up, and that the fire is evenly placed over the entire grate surface; that a bed of fire covers the forward portion of the grate next the flue sheets before the blower is used; that the blower be used as lightly as possible; that there is sufficient fuel on the fire before starting the locomotive to hold it and keep up steam while the engine is getting under way; that opening the fire door while the exhaust is strong should be avoided as much as possible; that coal is broken into pieces as near egg size as possible; that in firing the coal is scattered over the surface of the fire evenly, giving the sides and corners the preference.* Coal is not to be thrown in heaps on any part of the fire, but is to be put on lightly and frequently and the door closed between each shovelful when the engine is working. Grates are to be shaken lightly every thirty miles in the case of passenger trains and every twenty miles in the case of freight trains. If clinkers accumulate in the fire box, they are to be removed at the first opportunity. Steam pressure is to be kept within prescribed limits and not permitted to change rapidly either way. The blower should be used while the injector is working, so as to prevent change of temperature of the boiler. To prevent or stop the engine blowing off, the supply of water is to be increased or the damper dropped. If necessary

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* This last is known as the "spreading system." There is, however, another system of firing practiced known as "banking." When the latter is employed, the coal is piled up at the back part of the fire box, sloping down toward the front, where the layer of coal, being thin, is naturally in a high state of incandescence. When the heap of coal at the back of the fire box is thoroughly coked it is pushed forward, and a fresh supply of fuel put in its place to undergo the same process.

to open the door of the fire box while the engine is working, it is to be done slightly or swung open and shut. So far as practicable, the smoking or drumming of the engine while at stations, or when attached to or in the vicinity of a passenger train, is to be prevented. Ash pans and fires are not to be cleaned near a bridge, culvert, depot or building, or on a frog or switch, and the fire is to be extinguished with water before leaving it. Finally, that at the close of a run, when the fire has been removed, the dampers and fire doors are to be kept closed while the engine is being handled.

The cost of fuel is one of the largest items of expense, as I have intimated. It is probable that in time some substitute will be found for coal, but until then it should be utilized in the most effective manner possible, by scientific construction and skillful firing. Much study has been given to the subject and considerable pains taken to instruct firemen in their duties. Mr. Sinclair, in his admirable book, says: "To comprehend what causes fire to burn, we must understand something about the laws of nature as they are explained by chemistry. Practical men are generally very easily repelled by the strange names they meet with in reading anything where chemical terms are used. An engineer or fireman who is ambitious to learn the principles of his business ought to attack the hard words with courage and perseverance, when it will be found that the difficulties of understanding them vanish. A man may become a good fireman without knowing anything about these laws. This frequently happens. If he becomes skillful in making an engine steam freely, while using the least possible supply of fuel, he has learned by practice to put in the coal and to regulate the admission of air in a scientific manner. That is, he puts in the exact quantity of fuel to suit the amount of air that is passing the fire box, and in the shape that will cause it to produce the greatest amount of heat. When this degree of skill is attained by men ignorant of nature's laws, it is attained by groping in the dark. A man who has acquired his skill in this manner is not, however, perfectly master of the art of firing, for any change of furnace arrangement is likely to bewilder him, and he has to find out by repeated trying what method of firing suits best. He is also liable to waste fuel, or to cause delay by want of steam when anything unusual happens. A knowledge of the laws of combustion teaches a man to go straight to the correct method, and the information possessed enables him to deal intelligently with the numerous difficulties which are constantly arising owing to inferior fuel, obstructed draft due to various causes, and to viciously designed fire boxes and smoke boxes. The nature of fuel, the composition of the air that fans the fire, the character of the gases formed by the burning fuel, and the proper proportion of air to fuel for producing the greatest degree of heat, are the principal things to be learned in the study of laws relating to combustion. The elements which perform the most important functions in the act of combustion are oxygen and carbon. Carbon is the fuel, and oxygen is the supporter of combustion. Combustion results from a strong natural tendency that oxygen and carbon have for each other, but they cannot unite freely till they reach a certain high temperature, when they combine very rapidly with violent evolution of light and heat. When air, drawn violently through the grates by the suction of the exhaust, strikes the glowing fuel, the oxygen in the air separates from the nitrogen and combines with the carbon of the coal. In some cases elements combine in different proportions to form different kinds of products. If the supply of air is so liberal that there is abundance of oxygen for the burning fuel, the carbon will unite in the proportion of twelve parts by weight (one atom) with thirty-two parts by weight of oxygen (two atoms). This produces carbonic acid, an intensely hot gas, and, therefore, of great value in steam making. If, however, the supply of air is restricted and the oxygen scarce, the atom of carbon is contented to grasp one atom of oxygen, and the combination is made at the rate of twelve parts by weight of carbon to sixteen parts by weight of oxygen, producing carbonic oxide gas, which is not nearly so hot as carbonic acid gas. It makes a very important difference in the economical use of fuel which of these two gases is formed in the fire. When combustion is rapid the fuel must be saturated with the air that contains the oxygen, bathed in it, as it were, otherwise a large portion of the furnace gases will pass away uncombined with the element that gives them any heating value. There are several practical objections to the air blowing through the grates like a hurricane. The high speed of the gases lifts the smaller particles of the fuel and starts them toward the entrance of the flues, helping to begin the action of spark throwing. Where they find a thin or dead part of the fire, the gases pass in below the igniting temperature, or tend in spots to reduce the heat below the igniting point, and go away unconsumed, at the same time making a cold streak in the firebox, chilling the flues or other surface touched, and starting leaks and cracks. Then the great volume of air has, under ordinary circumstances, to be heated up to the temperature of the firebox and a considerable part of the heat produced from the coal has to be used up doing this before any of it can be utilized in steam making. When a large volume of gas is employed it must be passed through the furnace and tubes at a high velocity, the result being that there is not sufficient time for the heat to be imparted to the water; consequently the gases pass into the stack at a higher temperature than would be the case if the movement of the gases were slower. One can get a good personal illustration of this by passing his hand through the flame of a gas burner. Good firemen keep sufficient fire on the grates to suit the way the engine is working, and enough to prevent loss from air passing up so freely as to reduce the temperature of the firebox. They keep up the fire by throwing in a shovelful or two of coal at short intervals, and the result is that the greater portion of the hydrocarbon gases is burned, and very little smoke is seen issuing from the stack. When the engine is stopped at a station or any other place, the fireman has planned ahead to have a good fire. When the train starts he is on the lookout for signals and switches, and when the engineer hooks up the links and the pull of the exhaust is light, he replenishes the fire. Although he keeps up his fire at stations and stopping places, he prevents his engine pouring out a cloud of black smoke by not putting in a heavy charge of coal at one time. Thus he maintains a flame on top of the fire, which consumes the gases that would make smoke. If it is necessary to put in considerable coal at a station, he closes the dampers, opens the firedoor slightly and starts the blower. By such exercise of care he reduces the consumption of coal and, so far as possible, burns up the smoke." It is as true of firemen as it is of others that each year teaches some new thing, adds something to the knowledge we possess by which work is made more effective.

While the fireman has not become a scientist, he is better acquainted with effective means of generating steam at the lowest cost, than formerly. While he may not understand scientific formulas, he fires according to scientific principles. He puts on the fuel in quantities best suited to perfect combustion, being governed by the load to be hauled, the speed to be attained, peculiarities of engine, kind of coal, weather, character of road, and so on

The physique of the fireman, it is apparent, must be of the highest type in order to enable him to perform satisfactorily the hard work that devolves upon him. Although the fireman's duty, as his title indicates, is primarily to look after the fire, he incidentally attends to many other important things, such as replenishing the tender with water, ringing the bell, cleaning the ash pan, shaking the grates, filling the oil cans, attending to lights and keeping the engine clean.

Firemen, according to the customs of railways, are frequently called upon to act for the engineer and are, therefore, in many respects, his deputy. In case of accident befalling the engineer, the fireman must be able to supply his place temporarily. He is, therefore, something more than a fireman. To make a good engineer, he must possess intelligence, industry, sobriety, good habits and an observing mind. He must necessarily receive thorough prior training. This he gets as fireman

Familiarity with the performance of the engine by day and night, in all kinds of weather and on every kind of track, enables those in charge to tell, with accuracy, the speed a machine is making. Exactly how they are able to do this, they cannot tell. It is partly intuition, in which the sound of the revolving wheels, the sway of the locomotive and the fleeting objects by the wayside help to aid the judgment.

Only by long familiarity with the workings of a locomotive are men able to detect, instantly, when anything is wrong; to distinguish normal from abnormal conditions. "It requires an experienced ear to detect the false note amid the mingled sounds produced by an engine and train hammering over a track. The novice hears nothing but a medley of confused noises, strange and meaningless as the harmonies of the opera to a savage. But the trained ear of the engineer can distinguish a strange sound amid the tumult of exhaust, screaming steam and clashing steel, as readily as a musician can detect a false note in a chorus. Upon this ability to detect defects, which pave the way to disaster, depends much of an engineer's chances of success in his calling. This kind of skill is not obtained in a few weeks. It is the accumulation of months and years of patient labor." Long experience is also necessary to enable the engineer to handle a locomotive with ease and smoothness, and preserve uniformity in starting and stopping. Lack of skill in these respects is quickly noticed and commented upon by travelers.

The fireman learns little by little. In time he is able to pass his examination preparatory to becoming an engineer. These examinations have not been general, but each year are more and more favored by railroad companies. There is nothing about them to excite dread. They are confined to practical things and do not deal with the philosophy of the subject.

The duties of the fireman, like those of the engineer, are multifarious. Among those of a primary nature that may be recapitulated are the following: He must be at his post before starting on a trip in time to make such disposition of the fuel supply as circumstances and the rules require; to see that oil cans are filled and ready for use; that the fire is properly made; that the engine is clean; that supplies necessary for the trip are in their places; that flags, lanterns and other signals are on hand; that lamps are trimmed; that the ash pan is clean; that tools are on hand for handling fuel and attending to the fire; that the water tank and sand box are full; that there is no delay in taking water on the road; that the cinders and clinkers are removed from the grates and the ashes from the ash pan, if necessary, when stops are made at coaling stations; that the fire is equal to the work the engine has to perform, and, finally, that the fuel is applied in such a way as to secure the greatest possible volume of steam. Withal, he must keep a sharp lookout for signals and report promptly to the engineer anything he notices that the latter should know.

The conductor handles all the traffic of railroads, and in America collects more or less of their receipts. With the engineer he represents the central idea of railroads as carriers. He is the skillful and highly trusted representative of his company, and, from the nature of his duties, a semi-public servant. It is his office to see that the cars in his train are in good order and properly equipped for service. He represents his employer in all his dealings with passengers. He is responsible and it belongs to him to see that the train force is attentive and regardful of the conveniences, rights and, as far as possible, prejudices, of travelers. He is also the conservator of order and empowered to compel its observance on the part of everyone on his train.

Each year lessens the responsibilities of conductors in particular directions and adds to them in others.* The better systemization of the service and the introduction of new and approved appliances make the responsibilities of the conductor less onerous in many things than formerly, but, on the other hand, increased business and more complicated methods of ticketing passengers add to his duties in other directions. The old time canal boat captain and stage driver did very well for railroad conductors in the early

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* In speaking of conductors here I refer more particularly to those on American railways, or those operated on the American plan. The responsibilities and duties of conductors or "guards" in Great Britain and on the continent of Europe are more restricted.

days of these properties, but at the present time men of high attainment are required to perform the work.

A conductor must be a man of tact. The demands upon him in this direction are great and constant. He must also be a man of patience and forbearance. He must be discriminating, and, to be so, must be wise. Thus, to illustrate, his rules will require him to collect a ticket, or, in the absence of a ticket, a fare from every passenger, but there will be exceptions to the rule, although the company makes none. His dilemma here is only one of the many perplexing incidents of his daily life.

The management of his train demands the constant attention of the conductor. If passengers are carried, they add tenfold to his responsibilities. On American roads he scans, so far as he can, each person entering the train. Afterward he seeks to locate and identify them in their order, so as not to disturb those from whom he has already collected tickets. To the casual observer the conductor wanders back and forth through his train often without aim. In reality this is not true. Among other perplexing things the conductor is called upon constantly to interest himself in the petty affairs of the nervous and inquisitive among his passengers. The rattle of a loose brake rod is sufficient to throw the former into spasms and precipitate a hundred questions from the latter. However, the harassment of conductors in this direction grows less and less each year, as people become more and more accustomed to railroad travel. In early days the conductor was a target for innumerable questions at every stop, as he went back and forth in his train.

Under the American system the conductor is oftentimes sorely beset in his fiduciary capacity. His honesty, no matter how unimpeachable, may at any moment be questioned. This because there cannot in the nature of things be any adequate check placed upon his acts. This is the unutterably sore spot in his life. If trustworthy, he is still liable to misrepresentation. If unfaithful, to detection. That he often suffers unjustly, there can be no doubt. A remedy for this unfortunate situation, however desirable, has been found exceedingly difficult.

The difference in the degree of excellence that conductors attain in their ability to satisfy the requirements of passengers and others, without sacrificing the company's interests or prestige, is remarkable. With one conductor an accident will be made to appear natural and excusable; with another it will seem to be avoidable and inexcusable.

The trustworthiness of the brakemen on our passenger trains is as stable as that of a bank teller. This without ostentation. Every traveler has in his own experience had occasion to observe acts upon the part of these employes of railroads that only those inherently honest are capable of. Yet a "tip" in such cases is ever gratefully accepted, for the brakeman is not proud to the extent of refusing favors of this kind.

The brakeman is the lieutenant of the conductor, and so accustomed is he to the movements of the train that the slightest break or disarrangement of its machinery instantly attracts his attention.

Like the rest of us, he is a man of averages. He finds it impossible to please everybody. He, therefore, endeavors to please the greatest number and to placate the balance. He cannot keep the car heated to the temperature some would like, so he endeavors to strike a happy mean—something that will prevent the full blooded from fainting and the thin blooded from freezing. But, if importuned, he will open a window, or close it, whether or no, if the request is not too glaringly inconsistent with the comfort of others. His amiability is great under every circumstance, and the desire to please a part of his daily life.

He is much harassed in his duties by freaks and cranks. To them the car is ever too hot or too cold, ever too dirty from neglect, or too damp from much washing. He, however, bears with his tormentors patiently, finding compensation in his wages and the commendation of his superiors. His intercourse with passengers, it is noticeable, is almost wholly with the extremists. Not that he cultivates such company. Far from it. He is not eccentric himself and does not like eccentric people. But in his peregrinations they, above all others, lie in wait for him. He cannot escape. He can only dally.

The disposition of the brakeman is accommodating. As he stands beside the steps of his car, assisting passengers to enter or alight, he is full of benignity—a man of information and precedents. His position is apparently a sinecure, prosy and monotonous. This is its normal state. There are times when his patience and courage are tried to the utmost by vicious passengers, and while he ever seeks to avoid conflict, he is without fear, and, if necessary, will singly attack a mob without thought as to the result. He fears neither pistols, bludgeons nor knives, but seizes the unruly passenger as he would a bag of feathers, and hurrying him to the platform, hurls him from the train.

The system more or less in vogue in America of making the brakeman, to a certain extent, the guardian of the rear of the train in case of detention, causes him to be an important factor at such times. Consequently, it is of the utmost importance that he should have good judgment, be energetic, conscientious and quick in the discharge of his duties.

CHAPTER IV.

EFFECTIVE USE OF CARS.

Upon the active employment of their equipment and the expeditious handling of their traffic depend largely the profits of carriers. The earnings of a freight car may be quickly frittered away by delays at yards, stations and sidings.

To be profitable, the progress of traffic must be easy and continuous. Moreover, whatever adds to the usefulness of a car lessens the outlay for construction by reducing the number of cars.

It also lessens, relatively, the cost of maintenance per unit of service.

It enables a company, moreover, to do business that would be impossible otherwise, for the reason that in the end traffic cannot be handled which does not pay cost of carriage and the wear and tear it engenders.

It is of the highest importance, therefore, that the equipment of a company should be fully utilized; should, so far as possible, be kept constantly earning something. Cars that lie idle and exposed on sidings, or in the yards of shippers, bring in nothing, while cost of maintenance goes on without cessation.

Utilization of cars is only to be secured by the exercise of vigilance, by systematically looking after each car.

One effective method of accelerating the movement of cars is to make a charge against shippers for cars allowed to lie idle awaiting to be loaded or unloaded. A means of enforcing this at points where a number of lines converge is found in the appointment of a common agent to act for all the interested companies. This concentration secures unity of action among carriers, without which, because of their suspicion of each other and for other reasons, a charge at such points cannot be effectively enforced. At other places local agents act.

Carriers are upheld by the courts in the enforcement of reasonable regulations governing the time and manner of loading and unloading cars by private parties. They are also permitted to make a reasonable charge in those cases where they are forced to become involuntary warehousemen, i. e., where goods are not removed within the prescribed time. Shippers are reconciled to these regulations, because they expedite business and benefit all.

American railways have many admirable rules designed to enforce effective use of cars. The subject is a growing one. The general trend is to have prompt returns of the whereabouts and use of cars made to a particular person—in many cases the Car Accountant. This official (whoever he may be) is able to make daily or even hourly reports to the operating officers, whose duty it is to distribute the cars for use or otherwise see that they are effectively employed. Among the many statements rendered to the official in question is a return of cars going to and coming from connecting lines. It is from this that his record of interline cars is largely made up.

In the interchange of cars between carriers the charge for their use is, generally speaking, determined by the class of the car. Cost and earnings capacity are, or should be, determining factors. Thus, a flat car costing three hundred dollars is not charged at the same rate as a merchandise car costing twice as much; and, similarly, in regard to earnings capacity. Thus, cars peculiar in construction, such as oil tank cars which can only be loaded one way, should not be charged as high as others that may be loaded both ways. As to what the basis shall be for the charge, there exists more or less diversity of opinion. One basis is that of mileage, namely, assessing a certain rate per mile for each class of cars, according to the distance run on the line using it. It is claimed by many that a per diem rate (based on the value of the car) is the correct basis, and that such method (if the rate is intelligently determined) would prevent a company from holding the cars of another company longer than necessary. "The apportionment or adjustment for use of freight cars should be equitable and universal. Passenger equipment in America is generally rated according to the value of each class of cars and of their earnings capacity, and a scale for their use has been agreed upon. Compensation for use of freight cars should be based on the several classes, taking into account the size, nature and earnings capacity of the car." *

While the equipment of a railway is, so far as possible, kept earning something for its owner, it must also be systematically inspected. This duty is rigorously attended to in the case of passenger cars, but it is not always looked after with equal care in the case of freight equipment. While it might be too much to say that loss of life has been occasioned by neglect in this latter respect, there can be no doubt it has caused the loss of more or less property. Many wrecks attributed to defects in the track are due to defects of equipment. There is every reason to believe that the derailment of cars in many cases attributed to the breaking of rails is due to the same cause. Many accidents attributed to other causes are really to be traced to overloaded cars, sprung axles, defective wheels, weak arch bracket truck bars, arch bars of unequal length, the placing of light cars between heavy ones, and so on. I mention the matter here because it emphasizes the necessity of cars of every description being inspected systematically and at frequent intervals.

To insure proper knowledge of cars used in interline traffic, they are or should be inspected at junction points. This is necessary to ascertain the fitness of the vehicles for service, and also to

* F. M. Luce.

determine their condition with a view to liabilities for damages and repairs that may arise later on. There will be transfer points at which it will not be practicable to have this joint inspection, but with these exceptions the custom is a good one and should be generally followed.

CHAPTER V.

EFFECTIVE TRAIN SERVICE.

Train statistics, I may say concisely in advance, should take into account the speed and gross tonnage hauled and also the percentage of the power of the locomotive that is utilized. However, much valuable information in regard to the details of train service is derived from observation and inquiry by the officials and employes of a company.

Statistics designed to determine the service of engines and train crews, and the relative income and outlay connected therewith, are not wholly satisfactory to practical railway men. Much thought has been given the subject, however, and each year adds something to our knowledge. Many different forms have been devised for collecting needed data, but none of them is entirely satisfactory. They generally afford, or should afford, specific information in regard to the number of cars in train; the initials of cars; the numbers of loaded cars; the numbers of empty cars; where cars were taken into train; where left; ultimate destination; number of miles cars were hauled by train; weight of cars, and finally, contents of loaded cars in tons.

While the information thus afforded has various valuable uses, an important purpose is to compare the fuel, oil, waste, etc., used by locomotives, also other expenses of operating such machines, on the basis of service performed. To do this properly, engines must be rated in tons in accordance with tests made. How these tests shall be determined is a matter for the superintendent of motive power to determine. One method is on a heavy grade; first, under favorable conditions of rail and weather, and second, under unfavorable conditions of rail and weather.

As much more fuel is consumed in running fast than slow, it is important to know the rate of speed. To do this, allowance must be made for delays. The forms referred to provide for this.

Comparison of work done by engines on the basis of tonnage, rather than cars hauled as formerly, has been found to result in greatly increasing the efficiency of engines by adding materially to the load hauled.

This is important, as it decreases the cost per ton per mile while adding not only to the utility of locomotives, but to other property as well.

Details of passenger traffic differ from those of freight, but the principle of comparison based on the capacity of engines, the work done and the speed made is the same in many particulars. So far as applicable, similar data should, therefore, be collected on which to make comparisons.

The blanks already referred to also answer the purpose of determining the movement of cars, gross traffic, direction, etc. However, their main object is to furnish the car accountant (or officer to whom they are sent), and through him the operating officers, information in regard to the service performed by engines. From the returns is also gathered information as to who owns the cars (with a view to reporting use of same to owners, and paying therefor in the event they belong to some other company), the number of empty and loaded cars, direction in which they are moving, and finally, the mileage made by empty and loaded cars. The information, it will thus be seen, is of value to the carrier, in regard to particular trains and in reference to the traffic as a whole.

The information afforded as to weight of cars hauled (that is, "dead" and "live" weight respectively) has a practical purpose. From it the work performed by engines and crews of trains is, in the main, determined. Thus, the number of cars in an empty train may be greater than that of a train with loaded cars, yet the service performed (the tonnage hauled) by the locomotive and crew of the first named train may be much less than the other. Without the weight of cars, including contents hauled, statistical data in regard to train service must, in the nature of things, be largely speculative.*

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* "It was at one time the general custom of American railways to rate the hauling capacity of locomotives by the num-

Nothing definite can be determined in regard to the comparative merits of exhibits of fuel and other supplies used, and mileage made, without knowing exactly the amount of work the locomotive has performed. With data in regard to this and collateral information, the statistician is able to furnish information that will enable those in charge of the operating department to determine, measurably, the efficiency of those in charge of trains.

In addition to the information that I have pointed out, the train returns give the number of the train; its direction; when it left point of departure; when it arrived at destination; date; name of conductor; number and kind of cars; where taken; where left; number of engine; where it was attached to train; where detached; mileage made by the engine; and, finally, the name of the

ber of cars per train. Under this system no account was taken of the weight or character of the contents of the cars; a locomotive hauling thirty loaded cars containing woodenware and other bulky but light freight weighing 700 tons would receive greater credit than a locomotive hauling twenty cars loaded with pig iron, or other compact, heavy freight, weighing, say 800 tons. Such a method, it will be readily perceived, would not be equitable, and would, moreover, result in failure to utilize the maximum power of the locomotives. In order to enforce the full utilization of locomotives, it is necessary that a careful supervision be kept of their operation. To do this, the actual performance of each run must be made. In addition to the usual train returns, the car accountant, or officer in charge, should be furnished with a statement of the number of trains run and the points between which they are run; also the name of the conductors in charge. This information will enable the car accountant to know that he has received a report for every train."—*F. M. Luce.*

engineer. In the event a train is delayed en route the fact should be reported, and a place is provided in the return for giving the number of hours and minutes of detention, where it occurred, and the cause. Without information in regard to delays, the actual running time of the train and the miles per hour could not, of course, be determined. This is of the utmost importance, as statistics that do not take into account the speed of trains lack an essential particular.

While a train return is not satisfactory that does not show the tonnage hauled in each train, and the speed made, so no exhibit would be satisfactory that did not show what percentage of the power of the engine was utilized. To give this the prominence it merits is to at once interest the engineer. Thus, if one engineer only utilizes eighty per cent. of the power of his engine, while another utilizes ninety per cent. on the same line, the first engineer will strive to make a better showing and will call upon agents and conductors to put more cars into his train.

It is thus seen that the prime basis of train statistics is the gross tonnage hauled, including live and dead weight, speed and percentage of the power of the locomotive that is utilized, the latter being more important than all else. The work accomplished will not be identical for different divisions of a road, and results will vary on the same line according to the weather and condition of track, but the average over a considerable number of days will be practically the same for particular trains. And in reference to differences that will be noticeable between different lines and for different trains on the same line, the information in the hands of officials in regard to the nature of the traffic and the character of the service will enable them to determine with approximate accuracy the comparative efficiency shown.

CHAPTER VI.

HYGIENE.

With the great advances we have made in knowledge of sanitary laws and the value of their observance, the cars and station buildings have been brought by every railway company more and more within their purview, until the hygienic department of our railroads has become an important adjunct.

The subject merits the thoughtful attention of managers and the promulgation and enforcement of rules and regulations that will secure the object to be desired. The health and usefulness of employes will be greatly added to and indefinitely prolonged by such a course. The comfort of the traveling public will find an echo in the receipts of carriers.

The ends to be attained are cleanliness and comfort, proper ventilation, equitable temperature, prevention of water pollution and disinfection of articles and places likely to breed or disseminate disease.

In furtherance of this, cars, stations, offices, shops, buildings, toilet rooms and outhouses must be kept clean, and all accumulations of decaying matter systematically and quickly removed or rendered harmless.

Water closets, privies, drains and sewers must be kept clean and disinfected.

Passenger cars must be heated, ventilated, cleansed and disinfected under well considered rules.

Drinking water must be guarded from contamination.

Clothing, linen and upholstery must be cleaned, aired and, when necessary, disinfected.

Passengers afflicted with contagious diseases must be properly quarantined and such other steps taken to prevent the spread of disease as may be necessary.

The subject is a scientific one and far-reaching withal. I point out its importance here merely.

It receives more and more the earnest thought of railway managers. Many companies think the matter of sufficient importance to justify a bureau whose sole duty it is to look after the matter. The subject is a growing one. Each day sees some advance in our methods and appliances.

Thus, the primitive way of ventilating cars by opening windows is, little by little, giving place to scientific contrivances; the dangerous and otherwise objectionable car stove gives way to steam or hot water; the oil lamp to gas or electricity, and so on. The service is in a transition state. However, this will doubtless always be its condition. The striving for something better will never end as long as men have brains and can make money by utilizing them. The appliances of to-day, which seem very fine to us, will be supplanted by something better to-morrow. The aim of owner and manager, here as elsewhere, is perfection, so far as revenues render this possible.

CHAPTER VII.

REGULATION OF TRAINS.

The machinery by which trains are managed is a subject of more or less speculation, even to railroad men. The secrets of the time table or schedule by which they are moved are profound, and to many impenetrable.

How officials handle trains, how watch them as they wind in and out, how adjust so nicely the time of their arrival at meeting points, how keep them all in motion, regulate their speed, and give to each the exact consideration its importance merits, are questions only a few fully understand. We know that somewhere there is a mysterious chart, on which at intervals the superintendent works; that upon this he fixes the time trains shall start, when they shall reach their destinations, their character, speed, stopping places and meeting points. Some of us have had surreptitious glimpses of this wonderful chart through partly closed doors, but our view has been obstructed and our faculties of observation clouded by the presence of the austere superintendent, who paces the room with measured stride, or bends over his work, pencil in hand, with absent air and corrugated brow, like one who struggled with a problem dire and difficult.

We have noted with awe the hieroglyphics, pregnant with meaning, covering the broad, white surface of the mysterious chart; the stations printed in big, fat letters of varying size, and evidently deriving a good deal of importance from that fact; the broad lines of different color that traverse its face; the faint, irregular lines running here and there, seemingly without object, beginning and ending in space, feeble, inconsequential and indefinite, like disconnected dreams or half completed thoughts. While we surmise that these faint lines forecast trains (organized, harmonious and forceful action), and that each line represents a completed idea, we do not know how these ideas, clothed in this symbolical language, are to be arranged and grouped in the printed schedule.

Sometimes twine or thread of different colors is used in making up the table of trains, instead of pencil marks. In such cases one color may stand for a passenger train, another color for a freight train, and so on. If the track is used by trains belonging to different companies, still other colors may be used. In preparing the chart, a large sheet of drawing paper is stretched on a smooth surface and mounted. The chart is ruled with horizontal lines, each line representing a station or siding, the name of the station or siding being printed at the end of the line. Heavy, perpendicular lines represent the hours, the number of the hours being printed at the top of the line. Thus, twelve at midnight will be marked at the top of the first perpendicular line, the twenty-four hours following in their order. Between the hour lines ten-minute intervals will be indicated by lighter lines, and between these again five-minute, two-minute or one-minute intervals, as may be desired. A passenger train, we will say, with a running time of thirty miles an hour, leaves one terminus of the road (New York, for example) at 9 a. m. A red thread represents it. This thread is attached to a pin which is inserted in the horizontal line for New York at the 9 a. m. mark. If the train runs without stopping for fifteen miles, another pin is inserted in the line representing the station at which the first stop is made at 9:30 a. m. If the train stops at this station ten minutes, another pin is inserted in the same station line at the crossing of the line representing 9:40 a. m. The thread is stretched along the station line to this and again fastened, then stretched to the next stopping place, and so on. All trains are indicated in a similar manner. Thus, the time chart when finished looks like a piece of fancy lace work.

While anyone may, without much labor, become acquainted with the charts the superintendent uses in arranging his table of trains, no one can, without long association with his duties and responsibilities, understand the nice distinctions that govern him in his work. The schedule, however, presents many features that never change, or at least seldom. Thus, certain passenger trains are like the staple articles the grocer keeps, whether profitable or not. The most trivial change in their organization or time precipitates upon the management the indignation and sharp criticism of the community. Its discomfiture finds expression in petitions, sarcastic newspaper articles, mass meetings, waiting committees and such other devices as seem most likely to stir up the officials.

Aside from this stable feature, the amount and nature of the traffic, its source and direction are governing factors in constructing the time table. All such considerations have to be reviewed over and over again, as new schedules are constructed. It is probable that the movement of freight involves by far the greatest attention upon the part of those having charge of the traffic of railroads, but the passenger business on many lines necessitates the most constant and intelligent thought. The number of passenger trains run is seldom reduced, but new trains are often added, as the business of the bulk of our railroads is steadily growing in this direction. The standard passenger trains move to and fro year after year, almost with the monotony of a pendulum, until they in time come to have a fixed name and character along the route, and people speak of them as they do of the sun and moon or other unalterable thing.

Many freight trains also are classed as staple. They comprise those necessary to do the current business of the road. Like passenger trains, they may, at certain seasons of the year, present a beggarly appearance, but as they are necessary to the convenience of the community, they escape the reductions that overtake other unproductive trains.

Many things that I might mention have to be considered in making a time table. Thus, close connections at junctions with other roads is required by travelers. This phase of the subject tries the patience and ingenuity of officials to the utmost in many instances. All of us feel grateful for being able to make quick connections at the junctions on our route, but few of us stop to realize that this happy circumstance is oftentimes the result of much contention among the officials of the lines interested, of many long and angry communications, great bitterness of feeling, closed finally by concessions and counter concessions. Oftentimes the connection with other lines is made at the end of the road. In this case, as in others of a like nature, it is of the greatest importance that trains shall reach the connecting point at the right minute. When trains shall start upon their journey, however, is largely a local question, to be considered in connection with other local questions.

The economical management of railways requires that the schedule shall provide only for the minimum number of regular trains. Others may be added as business requires. The appendix contains a diagram of the chart used in making a time card for a single track road.* The

* Appendix A.

diagonal lines represent regular trains; the dotted lines a special train, i. e., one not provided for on the time table. The stations opposite where the lines intersect each other represent the meeting points of trains. The diagram should show the time trains stop at stations when the stop exceeds five minutes. The heavy vertical lines divide the time into hours; the lighter vertical lines subdivide the hours into periods of five minutes each. The zigzag line on the diagram represents a way freight, the time being slow and the number of stops frequent, seven hours being occupied in running ninety-five miles.

Trains not provided for by the time card are oftentimes run as sections of regular trains. They have the same rights. When not practicable to run extra trains in this way, their movements are outlined on the diagram, and they are operated under special orders, telegraphic or otherwise.

Trains provided for by the schedule are called regular trains; each has its number; those going in one direction bear odd numbers, those moving in a contrary direction bear even numbers. To know the number of a train is to know its direction. The American Railway Association suggests in reference to the designation of through trains: "That on lines where trains, either in part or in whole, run over different systems, such trains be designated with the same numbers, as far as practicable, from the initial to the terminal station on the same route (however extended) and that such record be kept by some one designated by the management of such lines, and a detailed statement made monthly, showing the time of such trains leaving initial and arriving at terminal points, time lost, time gained en route, cause of lost time, and such returns submitted to the lines interested."

The relative importance of trains is often indicated by the number given them, as first, second, third, and so on. The schedule fixes the grade of each train, and the rules and regulations forming a part of the time table define its rights. Thus, to illustrate, they provide that passenger trains north-bound will only wait five minutes at meeting points in the event trains of the same grade going south are delayed. After that they must proceed on their way, keeping five minutes behind their schedule time, until the belated trains are met. In the event a north-bound passenger train is delayed, a corresponding train going south is compelled to wait thirty minutes at the meeting point before proceeding. After that it must resume its course, keeping, however, thirty minutes behind its time until it meets the delayed train. The preferences given indicate, relatively, the importance of the traffic.

Trains of an inferior grade are required to keep out of the way of those of a superior grade. Thus if, at a meeting point, two trains of dissimilar grade, the train of superior rank is late, the train of inferior grade must wait indefinitely. The length of time a train must be behind time before it loses its rights as a regular train varies on different roads from eight to twenty-four hours. After a certain time it is not recognized at all and can only proceed under special orders, or in company with some other train.

If a train is operated under special instructions (i. e., pursues its way from point to point as ordered, without reference to the time indicated in the schedule), it is called a "special."* The special trains in motion upon a line are sometimes greatly in excess of the regular trains.

When the business of a road necessitates a temporary increase in the number of its trains, or when delay or accident overtakes those in motion, the telegraph is brought into use to accelerate their movements in America. This phase of the subject I refer to elsewhere.

The clerical work involved in the preparation of the time table is considerable and requires the utmost exactness. The work is not difficult when understood, but understanding requires experience. The practices of railways in different countries are very much alike so far as the preparation of their schedules is concerned. An English writer† of note thus describes how a time table is made in Great Britain: "The time tables of the London & Northwestern are printed at Newton-le-Willows. To that town, within a few days of the train alterations having been decided upon by the officers' conference, there

* At one time such trains were called "Wild."

† Colonel Findlay.

repairs a clerk from each of the ten districts, and with these ten clerks comes an official from the office of the superintendent to supervise their labors and assist them with his experience. Taking the minutes of the officers' conference as their guide, the clerks proceed to revise the time table, each working out the time for his own section of the line, but all comparing notes as they proceed so as to insure harmony. As they progress the results of their labors are placed in the hands of the printers, on the spot, and the proof sheets are afterward revised and corrected by the clerks who have prepared them. No one who has ever glanced with an intelligent eye at the time table of a great railway will be surprised to learn that this operation is one of the most complicated nature, involving great labor and considerable skill. This will be apparent if it be borne in mind that, supposing, for instance, a train running from London to Scotland is altered in its timing ever so slightly, it involves the necessity of altering all the trains running on branch lines in connection with it, and many other trains which are affected by it. A train service is, in fact, like a house of cards; if the bottom card be interfered with, the whole edifice is disarranged, and has to be built up afresh." What Colonel Findlay says of the railroads of his country applies with equal truth to those of all other countries.

CHAPTER VIII.

EXPEDITING THE MOVEMENT OF TRAINS.

The skill required to move trains quickly and safely upon a single track is infinitely greater than upon two or more tracks; indeed, the skill required may be said to be in inverse ratio to the number of tracks. Upon a double track meeting places need not be provided, but where there is only one track this is of the greatest consequence and involves, oftentimes, delay of business and other annoyances of a serious nature. Moreover, sidings of sufficient length to enable passenger trains to pass may not be adequate for freight trains. Hence, calculations must be made to arrange the passing places of such trains at points where the accommodations are adequate. Difficulties of this kind in the early history of railroads were very frequent and annoying.

If there are three tracks, provision for trains passing each other (when going in the same direction) required in the case of double track lines is practically obviated. Thus, if a train is to pass another, the forward train pursues its way on the third track, while the fast train following passes it on the main line. It sometimes happens, however, that the third track is required for use simultaneously by slow trains moving in opposite directions. In such cases, of course, one of the opposing trains must be side-tracked.

With four tracks the manipulation of trains becomes still more simple. It, however, affords abundant scope for the exercise of experience and good judgment. In such cases, trains of the same class follow each other, and only inferior trains are required to give way. Four tracks reduce the danger to the minimum, while facility of movement and economy of operation are increased to the maximum.

With double tracks it would seem as if life and property were secure. Disaster, however, constantly menaces trains following each other, even at moderate rates of speed. "Anyone who has examined our reports of train accidents will have observed that about one-fifth of all those reported are rear collisions."* This statement will surprise those who have not examined the subject, but there can be no doubt of its truthfulness. The danger of rear collisions is constant, and one of the many harassing questions that trainmen have to deal with. The block system and automatic signaling are the most effective means yet devised to prevent trains following each other too closely. In time the danger will be minimized, if not entirely avoided.

The satisfactory movement of trains requires that they shall start at the time specified in the

* "Railroad Gazette."

schedule.* If this is impracticable, the schedule should be changed, so that patrons may have so much more leeway. Those who start trains sometimes reason that lost time will be made up before the destination is reached, and so concern themselves less about the matter than they otherwise would. While this may be true, and thus no one greatly inconvenienced in the case of through trains, it is not so in regard to suburban business. The time cannot be made up in many cases, and thus to the inconvenience of being compelled to reach the depot earlier than necessary, there is added the delay at the end of the journey. This is a very serious matter to suburbanites who are compelled, in any event, to spend so much of their time going back and forth. This fact is generally appreciated by railway officials, and, as a rule, the suburban service is carefully looked after.

It is not an impossible task to secure uniform promptness in the movement of trains, if skill and foresight are exercised in preparing the schedule and in carrying it out. Regularity in the movement of passenger trains may be said to be an absolute essential of the service. However, accurate movement of all trains is important. Promptness in this respect is not only a virtue in itself, but valuable to the carrier, as he thereby utilizes to the fullest extent his outlay for wages and equipment.

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* "Seventeen trains starting between the hours of six and seven-thirty o'clock on the *Blank Railway* were from three to eight minutes late in leaving."—*Railroad Paper*.

A valuable agency in America for facilitating the movement of trains is the telegraph. It is especially useful when trains are delayed or their movements interfered with. The practice of directing trains by telegraph is a distinct feature of the American service. It is effective and economical, and has been found safe and superior to all other methods. Each year adds to its utility and emphasizes its value. Under its operation a single track may become as useful as a double track under a less facile system. When, for any reason, there is delay, the train arriving at the scheduled point is not required to wait, but is ordered by telegraph to proceed on its way. The telegraph is also effectively used in directing the movements of special trains.

There are three methods of telegraphic dispatching in vogue, known respectively as the "single order," "duplicate order" and "triplicate order" systems. Under the duplicate order system, as its name implies, the order given a train is a copy of the one given to the opposing train. This being so, the order may be sent to the trains affected simultaneously. Under the triplicate order system the order given a train, in addition to being sent to the trains at stations each side of the meeting point, is also sent to the actual meeting point. Upon the arrival of the trains at the meeting point the operator delivers the orders and does not clear his signal until the trains have met. He depends upon his personal observation for proof that both trains have arrived. Under the single order system the orders to different trains read differently and so mistakes are liable to be made; thus the meeting place may be differently stated in the orders to the different trains. Under the duplicate and triplicate order systems this could not occur, because the dispatcher transmits the orders simultaneously in the same words.

The duplicate and triplicate order systems minimize the telegraphic service and greatly expedite the movement of trains. Moreover, by reason of the orders to different trains being alike, the strain on the dispatcher is less than under the other system.

In moving trains by telegraph the order must conform to certain requirements. Thus, it must be explicit. It must not be encumbered with extraneous matter, but relate solely to the subject in hand. It must be brief, clearly stated and simple. It must be expressed in formulas that everyone understands. It must be confined to one transaction. The recipient of an order construes it literally and in no case as authorizing him to do something not specifically stated. Nor can it be construed to apply to other trains than those specifically mentioned.

Details are all important. Messages must be legibly written; they must be numbered consecutively to permit of their identification; each order must be written on a separate paper; the engineer must be furnished with a place for posting his orders, so that they may be before his eyes while he is attending to his duties; duplicate dispatches must be made simultaneously by some mechanical process, so as to prevent possibility of variance.

Each step taken in the issuance of an order is noted on the original by the dispatcher. The document thus records on its face its salient features, such as name of person issuing it, names of the operators concerned, time each step was taken, to whom the order was addressed, and so on.

It is desirable that stations should be provided with a device by which the operator can stop a train for which he holds an order without leaving his table. This is usually done, but such conveniences are unknown where the business is carried on along economical lines, as it is in many cases.

Special care is required to avoid delivering orders to one person intended for another. To facilitate this, receptacles are provided, so arranged as to prevent the orders becoming confused. Every person receiving a train order is required by the operator to receipt therefor.

The following steps are taken in transmitting orders: The order is written as received; it is then repeated back by the operator to the dispatcher; the latter responds, indicating whether it is correct or not; the receiving operator acknowledges this response; afterward the order is compared (if it is not copied in manifold) by the person to whom it is addressed, with the copy retained by the operator; the person receiving it then signs his name; this signature is telegraphed to the dispatcher; the latter replies by directing that the order be delivered. This authorization is indorsed on the order and it is then delivered to the person to whom it is addressed.

The telegraph is an auxiliary merely, not the principal agency for moving trains, and care is taken to avoid using it any more than necessary. The time table is the medium for moving trains; but circumstances constantly occur to render the former inadequate; accidents happen, unforeseen delays occur, the road is blocked, special trains require to be moved; many things "in fact" occur to render it necessary to supplement the time table with the telegraph.

It is desirable on economical and other grounds, that trains should, so far as possible, have a place assigned them in the schedule and that the number of special trains should be reduced to the minimum. Moving trains from station to station on telegraphic orders (except in the case of delays and extra trains) is a cumbersome method at best and results in more or less confusion and loss of time. Trains thus moved cannot be allowed to follow each other too closely, nor can the margin of time for opposing trains to meet and pass be too greatly circumscribed. Time is lost in other ways. Thus, while the telegraphic movement of trains is valuable in emergencies, it is not so economical as the operation of trains by printed schedules.

While telegraphic movement of trains has been of great utility to our railroads and has added to the convenience and comfort of the public and the profit of owners, it has a drawback in the fact that it is attended with more danger than the slower and more methodical movement of trains by printed schedules. The risk has, however, never been such as to excite attention nor to offset the great advantages to the public that the system affords.

In Great Britain, where the block system is in general use, train dispatching is practically unknown. The telegraph is utilized, but in a different way. A writer on the subject says:* "By means of the telegraph, trains are started from stations and conducted safely from point to point throughout their journey; the signalmen who regulate their passage are placed in an unbroken chain of communication one with the other; the nature of the train and its destination, and the fact of its punctual running or otherwise, are flashed ahead from signal cabin to signal cabin as it speeds on its journey, while the faithful telegraph warns the signalman if his signals are not acting freely or if his lamps are not burning brightly. By telegraph the marshalling of goods wagons, the loading of trains and the movements of empty wagons are intelligently controlled, and the whole business of the railway is carried on with a promptitude and despatch that could not otherwise be attained. To insure the

* Colonel George Findlay.

principal station masters and inspectors being kept well posted as to the working of the line and the movement of the trains, a most elaborate system is in force for telegraphing the progress of the trains from point to point. For instance, the telegraph clerk at Stafford will telegraph the time of departure of all trains from Stafford, to Crewe, to Chester, to Wolverhampton, to Tamworth, to Warrington and to any other stations at which the information is useful, and this is continually going on all over the line, and from almost every station and signal cabin."

In the United States train dispatching from a central office by means of the telegraph is, as I have intimated, esteemed a necessary adjunct in the management of trains upon the majority of roads. It has reached a state of development that renders considerable experience necessary to understand it properly. The art is, however, in a state of evolution.

Perfection has not been reached and, it is more than probable, never will be. The requirements of the situation are too great and varied. Every day's added experience suggests some new thing whereby the service is bettered.

The telegraph enables the official in charge to view the road as in a mirror. The moving trains present to him the appearance of a vast panorama, in which he holds the magic wand. This officer is known as the train dispatcher.*

* The duties of the train dispatcher and superintendent are always closely allied; in many cases both offices are filled by

He is governed, as I have already pointed out, by well understood formulas, that do not admit of being varied. He must have, it is apparent, the absolute confidence and obedience of the force. Upon his efficiency depends the good repute of the company; the safety of life and property, and the expeditious discharge of business.

The work of the train dispatcher is so exacting that upon many lines he has no other duties. His office is purposely isolated. In many cases he is a telegraph operator. He is familiar in every respect with the road over which he operates—its distances, gradients, stations, sidings and business generally. He also knows accurately the capacity of every engine, and is generally a man of good judgment and habits. He is assisted by operators especially adapted to their work, who possess generally the same characteristics as their chief.

The duties of the train dispatcher are greatly lessened by the double tracking of a road. However, he is the creature of emergencies; the doctor to be called in when the trains are sick; when the digestive or respiratory organs of the road become clogged. He watches the trains that creep along the line very much as a spider watches the flies that buzz about his web. The moment anything wrong occurs he seizes them and guides

the same incumbent. For a description of the superintendent and his duties, the reader is referred to the volume, "Railway Organization."

them on their way. They obey implicitly what he says. The telegraph is his amanuensis. He is imperturbable when at work. Nothing ever disturbs the equanimity of his temper. His head is clear, his mind comprehensive and his action prompt. Familiar with details, he takes advantage of every circumstance. The rules are at his fingers' ends, and the experience, talents and characteristics of the men are as an open book to him

It is an especial duty of the train dispatcher to provide convenient passing places for trains operated by telegraph. Trains are in this way kept in motion that would otherwise lie inactive for hours at a time. The accommodation thus afforded travelers and shippers, no one but those versed in railway matters can fully appreciate.

It is exceedingly difficult for a number of trains advancing upon a single track to move with the regularity necessary to enable them to pass each other on time at the places designated in the schedule. Many things conspire to bring about such a state of affairs; the condition of the track, the load hauled, the efficiency of engines, skill of drivers, character of grades, direction of the wind, nature of the weather, activity of the station force, and finally, the efficiency of conductors and their assistants. The train that moves forward without difficulty at the rate of twenty miles an hour to-day may be barely able to make ten miles an hour to-morrow. All these irregularities are recognized and in a measure surmounted by the skill of the train dispatcher. He advances the trains from point to point without reference to the schedule, the meeting place depending in every case upon the exigencies of the moment.

When regular trains are moved by telegraph, they do not necessarily lose their rights under the schedule, except so far as they may be particularly affected. The moment an order is fulfilled, or ceases to operate, the train it concerns resumes the fixed rights it possesses under the schedule; if a regular train, it conforms to that instrument; if a special train, it awaits further instructions from the dispatcher before proceeding, or in the absence of that, seeks the protection of a regular train.

Special orders are rarely issued affecting passenger trains, except when they are behind time, in which case the telegraph is brought into requisition to expedite their movements.

When there are a number of delayed trains in motion, they are moved by the dispatcher without much reference to the time table. Like the pieces on a chessboard, they move in harmony with his will and are ultimately brought safely to their destinations. He constructs in his mind's eye a schedule for each occasion and executes it with clearness, expedition and safety. Of course there are degrees of excellence among dispatchers as among other people. The mind of one will be clear and quick to apprehend and execute; the mind of another slow, heavy witted and fatty.

The position requires a good memory and the exercise of a nice judgment.

The capacity of a single track road with convenient sidings may be multiplied indefinitely by the skillful use of the telegraph. The statement appended below of the performance of trains for fourteen consecutive days upon such a line one hundred and eight miles in length happily illustrates this. No accident or mishap attended the movement of the trains. The result indicates the possibilities of a single track line handled by an efficient dispatcher and a well disciplined force.*

The more the movement of trains by telegraph is practiced, the simpler it becomes. This is the secret of its popularity and growth. Through its aid American managers are able to make meager resources accomplish results otherwise unattainable. The system is worthy of study and practice in every country.

The staff system is a favorite means of protecting trains on single track roads in Great Britain. It may thus be described: The road is divided into sections. On starting out, the engineer is

* Total number passenger trains west bound......	56	
" " " " east "	56	
" " freight " west "	308	
" " " " east "	301	
		721
Freight cars in west-bound trains..................	7,701	
Freight cars in east-bound trains..................	7,272	
		14,973
Average number of cars per train..................		24.59
" " " trains per day of twenty-four hours		51.50

The load hauled was in every case up to the full capacity of the engines.

given a staff marked with the boundaries of the section it covers. This indicates that he has the right of way on the section in question, and that the track is clear. A second train cannot be started before the staff is returned. On arriving at the end of the section, the engineer hands the staff to a designated person and receives another in due course for the next section, and so on to the end of his run. The staff he leaves is used by the next train going in an opposite direction. Tablets or tickets supplement the staff when two or more trains are to follow one another in the same direction. All except the last train are given a tablet or ticket. The last train carries the staff. Some companies use tablets exclusively.

Drawbacks to the staff system are the time required to return the staff to the starting point and the consequent delay of following trains; the delivery of the staff by an engineer without being sure that he has the whole of his train; the difficulty of delivering the staff to the engineer without slacking speed; the liability of dropping or losing the staff en route, etc. The value of the staff system has been greatly enhanced by the use of electricity; thus, a number of staffs are provided at the place of distribution. They are placed in receptacles controlled by electrical and mechanical devices, so that only one staff can be withdrawn at a time, and until the staff thus withdrawn is deposited in its receptacle at the other end of the block, another staff cannot be reached or used. By this means the necessity of awaiting the return of the staff is avoided. In the end of the staff a key is placed for unlocking the switches on the block to which it belongs, the lock being so arranged that the key cannot be withdrawn until the switch is reset for the main track and locked. A device similar to that used in America for taking up mail bags without stopping is sometimes used for taking a staff or tablet without slacking speed.

An important problem in the operation of trains is the switching or marshalling of cars. This work, as is known, is performed at junctions and other centers where the business is handled. The work requires systemization, as, in order to secure economical movement of traffic, it is necessary that through trains shall be interrupted as little as possible in their progress. This necessitates the handling of the traffic at intermediate places by way trains, that collect the through business and take it to the junctions and other places where it is classified and made up into through trains. The usual methods of switching and making up trains are well known. Switching and marshalling of trains by gravitation is, however, not so well known, and I do not think I can close this chapter more appropriately than by describing the same in the words of Colonel Findlay, of the London and Northwestern Railway. The sidings for outward traffic consist of:

(1) Six upper reception lines at the summit of the incline holding two hundred and ninety-four wagons; (2) the sorting sidings, twenty-four in number and holding one thousand and sixty-five wagons, into which the wagons, when separated, first run, each siding receiving the wagons for a particular train; (3) two groups of marshalling sidings (called "gridirons"), through which the wagons of each train are filtered so as to make them take their proper order in the train, and (4) four lower reception lines which receive the trains in their complete state and where the engines are attached to take them away. On the arrival of a set of wagons in the upper reception lines, the rear brakes are put on, the engine is detached, and then on each wagon is chalked the number of the sorting siding it has to enter. One man carefully inspects the brake of each wagon and calls out the chalked number to a second man, standing below him, who has to regulate the speed of the descending wagons. This second man passes the number on by hand signal to the shunter lower down, who has charge of the switches, and who, by moving a lever, turns the wagon into its proper siding." In order to recover wagons or cars that run away or get beyond the control of those moving them, an apparatus is provided, called a chain drag. It "consists of a heavy iron chain cable placed in a wrought-iron tank between the rails and below their level; a steel hook attached to the cable is fixed in a loose socket at the height of a wagon axle and is

worked by a lever which also works a signal. When a train is intended to pass, the hook is lowered by the lever; but if it is desired to stop a wagon, the hook is raised by the lever and catches the axle of the wagon, and the heavy cable attached to the hook being drawn out of its tank, by its weight, when dragged over the ballast, soon stops the runaway."

CHAPTER IX.

PARTICULARS OF TRAIN SERVICE.

In discussing the operations of trains I wish to refer, briefly, here, to the motive power and mechanical appliances. To attempt to discuss the subject in its entirety in this place is neither practicable nor desirable.*

In doing its work the locomotive has much to overcome besides its own inertia and the load it hauls. To particularize some of these obstacles, it must overcome the resistance of the air, the friction of the working parts of the locomotive and train, including axles and wheels, the back pressure of the steam on its pistons, etc. In ascending a grade, the engine, moreover, must lift the train, including its own weight, a height equal to the ascent.

The resistance of the atmosphere is a very important factor, especially with high speed trains. It amounts in some instances, it is claimed, to one-half the total resistance. Much of this resistance is due to the locomotive. This was demonstrated in the case of two engines, for which the resistance (when tested separately) was found to be 19.8 pounds per ton at a speed

*The locomotive is described very fully in the book "Railway Equipment."

of thirty-seven miles an hour. When coupled together, the resistance fell to 14.3 pounds per ton, the first engine serving as a shield to the second. It is thought, therefore, that by placing a suitable contrivance on the front of the locomotive, a saving amounting to something like eight to ten per cent. of effective power may be secured, and by shielding the spaces between the cars, a further and material reduction of atmospheric pressure may be effected. The vestibuled train accomplishes, in a measure, this object. "The resistance of the atmosphere to the passage of a train is proportionate to the square of the velocity of the train. It has been found that the increase in ocean-going steamers from eleven to twelve and a half knots involved an additional expenditure of forty-seven and a half per cent. for steam."*

Air resistance nas been the subject of considerable study, especially in Europe. The result of the experiments made indicates that a force of from four to six pounds per ton is required to move a car slowly after it has been started. As the speed is increased, the resistance, it is claimed, increases with the square of the velocity; thus, it is four times as great at a speed of fifty miles per hour as at a speed of twenty-five miles per hour. On the other hand, up to a certain point, the power of the locomotive is increased as speed increases.

From experiments made by the state railways of France, it was found that the maximum power

* J. S. Jeans.

of a locomotive of a certain class was fully developed at a speed of twenty-one and three-quarter miles per hour; after that the power decreased as speed increased.

The curves of a railroad offer resistance to the movement of trains proportionate to their extent. European authorities estimate, in the case of cars with long and rigid wheel bases, that the resistance is increased about one per cent. for each degree of curvature. When the bogie truck is used, the resistance is, of course, very much less.

The power of a locomotive to haul a load increases with the size of its boiler (the cylinders being proportionate thereto) and the weight on its driving wheels; so that, except for injury to the track and machinery occasioned by the weight of the machine, there would be, practically, no limit to the load that might be hauled. To overcome the destructive agency occasioned by increasing the weight, all the various parts of the locomotive must be correspondingly strengthened. This, it is apparent, places a limit on the weight of locomotives and, consequently, on their power. The speed with which a locomotive can haul a train will also be limited, as already pointed out, because the resisting force increases greater, relatively, than the speed.

The hauling power of a machine is increased by adding to the number of its driving wheels, provided the weight resting thereon is increased correspondingly. This is why, in the case of switching engines, the whole weight of the machine is placed on the drivers.

In calculating the force of the locomotive, Forney, in his catechism, says that "the proportion of the adhesion to the weight on the driving wheels is, on dry sanded rails about equal to one-third, on perfectly dry rails (without sand) one-fourth, under ordinary conditions (without sand or on wet sanded rails) one-fifth, on wet or frosty rails one-sixth."

The locomotive is the symbol of railway life; the train its fruition. Evolution in both has been great. Form and utility have adjusted themselves to practical needs. At first the car was a duplicate merely of the old-fashioned stage coach, as I have pointed out in another place. The locomotive was constructed upon the same lines as the stationary engine. There has been less departure from original car models in Great Britain than in America. In the former country passengers still enter at the side, as in olden times, while we have consolidated a number of coaches into one and enter the whole from platforms at the ends of the combined vehicle.

The development of the locomotive has been like the growth of a tree. The machinery required to construct its intricate parts has been invented as required. Ability to utilize a discovery has, in every case, been dependent upon a further invention. Happily, the two have gone hand in hand. Thus, inventions have progressed until their extent surpasses ability to describe.

In early days an enterprising company offered a prize for a locomotive weighing not to exceed three and one-half tons, and capable of hauling fifteen tons at a maximum speed of fifteen miles per hour. To-day, locomotives are constructed weighing one hundred tons, more or less, and capable of hauling loads proportionate thereto.

A more recent phase in the evolution of the locomotive is the utilization of the compound principle, by which the steam acts upon two or more cylinders and pistons in succession instead of one. It is claimed by its advocates that a large percentage of fuel is saved by this means because of the greater degree of steam expansion utilized. This method of economizing force, they point out, has long been utilized with marine and other engines. Those, however, who do not favor the adaptation of the compound principle in the case of locomotives, claim that it is not suitable for variable classes of service; is difficult to keep in condition; is not regular in performance; costs excessively for lubricants, and finally, gets out of order more easily than the old-fashioned locomotive.

The attainment of rates of speed hitherto unknown, and not now thought probable, is a possible feature of the train service in the near future. Attendant conditions, however, mean much besides the construction of a suitable locomotive. They mean that the roadbed must be constructed of good material and well maintained; that bridges shall be of commensurate strength; that grade crossings shall be carefully guarded, or abolished; that curves and gradients be reduced to the minimum; that rails be of proper weight and good metal; that the equipment be strongly constructed; that brakes be efficacious; that switches be proof from accidental misplacement; that drawbridges be made secure beyond peradventure; that methods of signaling be of an approved character, and finally, that employes be capable, vigilant, trustworthy and well governed.

"The real danger in increasing the speed does not lie in incidental risks. It is not denied that a modern locomotive might be built which could run up to ninety or possibly one hundred miles an hour, if the lines were straight. It is the curves of the existing lines which render any such speeds impossible, unless the weight of the engines and trains were also increased far beyond what the bridges and permanent way would bear. At the first sharp curve the one-hundred-mile express would fly off the rails. The necessary relation of these curves to speed is accurately known, and it is that, and not the want of power or novel dangers from wind pressure or boiler explosions, which sets the limit to modern train speed. As the force tending to throw off the line a train running at the speed of one hundred and fifty miles an hour would be about six and a half times greater than that which a steam express train resists at a curve when running at sixty miles an hour, it is plain that the present lines could not be used for the 'lightning express,' even though the electro-motor were substituted for the steam engine. The line must not only be stronger, but straighter than would be possible by any modification of their present form."*

Speed of trains is an element of great economic importance, especially in a country where trade centers are widely scattered, as in America. Carriers may thus expand or contract these distances at pleasure. Speed is also an element of particular importance in connection with the suburban service of railroads. Traffic of this kind may be thus stimulated or depressed at the pleasure of the superintendent.

The speed of trains varies greatly in different countries. It has averaged higher in England than in America. The speed of their freight trains has been double that of similar trains in America. The average speed of passenger trains has been about a third greater. One reason is, their vehicles are lighter and the roads better built. This last difference is, however, not inherent. At the start the American companies were poor and their traffic light. Roads had to be cheaply built, or not at all. Pinching economy was also a necessity. None of these things is conducive to fast trains. However, every defect that characterized our railway system in its infancy, and their name was legion, has been overcome or is in process of being overcome.

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* *The Spectator.* NOTE.—*The Spectator,* it should be remembered, has reference to the railroads of Great Britain in what it says.

As time passes, growth of business will necessitate increased speed. The world will be too busy and the facilities of carriers too limited for a moment to be wasted in getting from place to place. The carrier will perform in thirty minutes what has before taken an hour. He will thus double his receipts. His patrons, too, will be equally favored. The commerce of the world will in this way be doubled, and so the process will go on indefinitely. How this change will be brought about, so far as the operation of railroads is concerned, is a mere detail.

As I have had occasion to say elsewhere, trains earn money only when in motion. The less the interruption of business, therefore, the greater the profit. To lessen the speed of a train unnecessarily, or to detain it at a switch, station or water tank, is to add to the cost of operating and to reduce the earnings capacity of a property. The time will come in the operation of railways when nothing but the loading and unloading of traffic will be allowed to impede its progress. And in this connection it is interesting to note that the more nearly trains are moved at uniform rates of speed, according to their class, the greater the results attained by the carrier. How to secure such uniformity through disciplinary, mechanical and other practical measures occupies the thought of everyone interested in bringing about such a result. One thing of especial value to railroads, that would be secured by such uniformity of speed as the time table contemplates, is avoidance of the unnecessary wear and tear of track and other property which undue speed engenders. The enormous importance of this every well informed railroad man appreciates.

While an absolutely perfect train service is probably not attainable, any more than perfection in other things, yet those familiar with railroad affairs are able to note a decided progress each year in this respect. Obstacles that at one time seemed insurmountable have, one by one, been overcome. With increased experience, the impossible has become possible. All the petty things that impede the progress of trains have been swept aside. The more serious ones have been modified. All ultimately will be overcome, except what phraseologists will term "the acts of God."

CHAPTER X.

SAFETY APPLIANCES AND THEIR PRACTICAL USES.

The community, including the bulk of railway men, agree in designating certain appurtenances of railroads as safety appliances, overlooking in that connection others much more important. The reason is, the former were introduced coincidentally with or to meet public clamor, while the latter were not.

A noticeable thing in connection with the safety appliances of railroads is that they in general facilitate the movement of trains as well as protect them. While the public does not, perhaps, place an exaggerated estimate on the importance of what it designates as safety devices, it ignores the efforts that have been made in other directions having the same object in view. When a train is hurled from a high embankment or plunges through a bridge, the occurrence excites horror, but in the majority of cases the mystery which envelops the cause of the accident dulls the edge of criticism. This does not, however, lessen the seriousness of the occurrence in the eyes of railway managers. They do not make the distinction in reference to accidents that the public does. Being responsible for the operation of the road as a whole, they think of it as a whole and act with that view, remembering always the importance of avoiding accidents of every description. Thus, they consider it in reference to the maintenance of the track; to its supervision; to the drainage needed to protect the road from floods, or becoming surcharged with water; to the strength of the rails; to the security with which they are fastened; to the soundness of ties and the care with which they are looked after; to the adequacy of the ballast; to the appurtenances to grade crossings, frogs and switches; to the signals; to the maintenance of bridges and culverts; to properly guarding same, and finally, to the care with which the equipment is constructed, inspected and maintained.

These things, and many others I might mention, are fundamental, and a disregard of them is fraught with danger to life and property. Yet we do not associate them with the so-called safety devices of railroads. Thus, it appears our appreciation of the latter is partial only. Everything connected with the track, as well as with trains, is constructed and operated with a view to the prevention of accidents. Foresight in this respect is fundamental. So much is said about the block system, mechanical coupling of cars, automatic brakes and similar specialties that we forget that they are only incidents, details in the great panorama.

Many books and essays have been written on railway accidents, mainly to recount their horrors, but partly, as the authors hint, to point out to the public, and to legislators and railway man agers, how they may be avoided. In regard to collisions, one and all agree that the block system prevents two trains from being on the same track at the same moment, and therefore prevents collisions. Arguing from this, they lay it down as essential that every company should have a block system. The financial aspect of the subject troubles them not at all.

Essays on railway accidents are always accompanied by tabulated statements of accidents which have arisen from various causes. Their general effect is to lead the reader to believe the subject is not receiving the attention from railway managers which it should. Statistics of this kind, it is to be remarked, are always convincing and nearly always misleading. They are so in this case. It is perfectly well known to every railway manager in the world that absence of prevention is not so much a matter of oversight or neglect as of inability to supply the thing needed.

All writers are not equally unreasonable, but generally they assume that every railroad should be supplied with the block system and with overhead bridges. This, notwithstanding the fact that many companies are only able to pay for the most primitive and economical train and station service.

Railway accidents are unavoidable, and will continue to be so as long as man is fallible and his devices fall short of absolute perfection.

They are the penalty we pay for abandoning primitive methods of travel; for emancipation from humdrum conditions. Each day's experience, however, makes them more rare, but that they can ever be wholly avoided is improbable.

Railway accidents have, from the first, been the lurid theme of impassioned writers and speakers. It is a favorite metaphor of demagogues, that thousands are thus annually doomed to death because of the grasping avarice of railway corporations. This is, of course, not true, even in part. It is so clearly to the interest of railways to supply every needed safeguard within their means that this interest will always cause them to do so without extraneous pressure. When a man is run over on the street, or meets with other disaster in the turmoil of business, we recognize it as unavoidable, and pass on. More or less philosophy of this kind must be exercised in contemplating railway accidents. Such safeguards as are reasonable, and within the ability of the carrier to provide, he provides. He would quickly lose prestige with his patrons if he did not. The matter is one to be regulated by good sense and the financial ability of the carrier.

Marked interest is evinced by railways in every kind of safety appliance, and, stimulated by this, inventors have been and are making continual progress in such matters.

The owners and managers of railways are not more selfish than others, and are interested, the same as the rest of us, in safety applicances on humanitarian grounds. Self-interest influences them in this direction, as I have already pointed out. If they sometimes appear dilatory or indifferent, it is because their means are circumscribed or devices are not known to be suitable. In the multiplicity of these latter, it is difficult even for experts to separate those that are valuable from those that are worthless. The clamor of inventors and promoters serves only to heighten the doubt and confusion.

One of the greatest safety devices ever perfected is the interlocking switch. It is also one of the most useful contrivances for accelerating business ever invented in connection with railways. Although its operation is familiar to many railway men, there are still a great many more whose ideas in regard to it are very vague. A description of it, therefore, will not only be proper, but valuable. The interlocking switch is worked, as is well known, from a central tower. It is found especially valuable in crowded yards and at railroad crossings and draw-bridges. Through this contrivance the track upon which a train is proceeding is closed to all other trains. Thus, where two or more railways cross each other, if the towerman opens the switch to a train on one road, he at the same time and by the same movement reverses the switches on the other road, so that the trains of the latter will be derailed or diverted in the event they attempt to cross. The interlocking system is operated by levers, to which the switches and signals are connected by rods or wires. The levers controlling all the switches at a junction or station are concentrated in a building from which the signalman has a full view of the tracks. A spring catch rod renders it impossible for him to move any particular switch or signal until all other switches and signals having any relation to the one he intends to move are locked. The interlocking principle may be applied to any system of levers (so that one lever may be interlocked with any other lever), regardless of the work to be performed. Thus, switch levers may be interlocked with other switch levers, as well as with signal levers. Aside from its use at railroad crossings, the interlocking switch is an effective safety device at draw-bridges. Thus, the draw in opening, by a mechanical arrangement, disconnects the tracks approaching the bridge, so that an engine or train that does not stop (i. e., disregards the signal) is diverted or derailed. The fact that the interlocking device prevents a train from running into an open draw, or into another train at a crossing, renders it unnecessary (as a precautionary measure(for trains to stop when approaching draw-bridges and railroad crossings. Much time is saved in this way. Interlocking is also available for use in connection with highway crossings; in such case the gates are operated by a wheel from the tower and, when closed, are locked by a lever made to interlock with the signal.

H. W. Sperry, an expert in such matters, in describing the system, says that interlocking is a term used to describe appliances for operating switches and signals from a central point. The levers of the apparatus are interlocked with each other. Of this system it is said that if a man were to go blindfolded into a signal tower with an interlocking apparatus he might, so far as accordance between switches and signals is concerned, be allowed with safety to pull over any lever at random. He might delay traffic because he might not know which signal to lower for a particular train, but he could not lower such a signal or produce such a combination of position of switches and signals as would, if the signals were obeyed, produce a collision. The results of the interlocking principle may be illustrated by the example of a piano or organ constructed in such a way that no notes could be played on it which are not in harmony with each other. The utility and safety of the interlocking system have caused it to be popular in America. In many states of the Union interlocking is prescribed by law for the protection of grade railroad crossings and draw-bridges. Some states require the crossings of electric railways to be interlocked.

There is some difference of opinion as to the use of derails in connection with the interlocking system, for the reason that every derail is a facing switch, and therefore to be avoided if possible. Again, accidents have been occasioned by the levermen changing signals and opening the derail after the train has accepted the clear signal, and therefore too late for it to stop, resulting in throwing it off the track. To avoid this, electric locking of derails has been introduced, so that after a signal has once been cleared, it is made impossible to change the derail until after the train has passed over the crossing. Until reliance can be placed upon enginemen to act strictly in accordance with the signal displayed, and in no case to overrun a stop signal, derails will be a necessity and, with electric locking, can be relied upon. Essential features in connection with an interlocking plant are these, viz.: a system of tracks that with a minimum of switches will provide for the maximum traffic; a well constructed interlocking apparatus, the cost of maintenance to be the measure of its efficiency; a systematic arrangement of signals, so that their indications may be easily understood, the signals to be always on the right or over the track they govern; electrical control of high speed routes; ample means of communication for the information of the levermen.

Such is the interlocking system, one of the most interesting and valuable of the myriad of devices designed to facilitate railroad business and at the same time throw a needed safeguard around life and property.

The split switch is another safety device intended to expedite business and at the same time mechanically protect trains where through men's neglect or omission they might otherwise be in danger. The split switch, as trainmen know, is a device by which an open switch in front of a train is closed by the action of the wheels of the locomotive. The device by which this is accomplished is so simple, and yet so effective, that we can only wonder railroads should have been operated fifty years before it was invented.

The automatic brake is another device, so arranged that if disabled to the extent that the train can no longer be controlled through it, the brake is applied automatically and the train stopped; or, to state it differently, the brake stops the train when the brake is no longer to be depended upon to perform such action at the pleasure of the engineer. Thus the engineer is always assured of his ability to control the movements of his train. "Of all safety appliances, the air brake is the most important. It has greatly reduced the distance in which a train can be stopped compared with the distance in which it could be stopped by hand brakes. Thus, a train of fifty cars running at forty miles an hour cannot be stopped on a dry and level track in less than three thousand feet by hand brakes fully manned; but under the same conditions and on the same track the same train can be stopped in six hundred feet, or less, with the air brake. It also enables the train to be stopped instantly from any car without the loss of time necessary to communicate with the engineer. But what is of still greater importance in the automatic feature is that it makes the air brake quick acting by storing the air under each car, and it is the quick action of the brake that makes it possible to use it on any train."*

A description of the air brake and a manual of its workings will be found in another part of this work. Also, an account of the brakeshoe. Together, they contain some ninety pages and forty illustrations. A description will also be found of the application of electricity to railroads, embracing some one hundred and forty pages and eighty illustrations.

The air whistle used on the rear of trains when backing up, to warn pedestrians and others, is esteemed a valuable safety device. It is an attachment of the air brake proper.†

The block system, another safety appliance, is a contrivance to prevent accidents and facilitate business. If the theory upon which it is based could be effectively carried out, two trains would never be upon the same section of track at the same time. Thus, if two trains were going south, the first must have passed from the section before the other could enter it. But the block system, so long as it merely signals danger, will not prevent accidents, because its working depends upon man's watchfulness and intelligence. Accidents,

*Arthur W. Soper.

†It consists of a stop cock attached to the air brake hose. The stop cock has a whistle in it and when the valve is opened the air escapes through the whistle. Rapidly opening and closing the valve in the stop cock causes a short, sharp whistle. By moving the valve wide open a further and larger port is opened and thus the brakes on the whole train are applied from the rear of the train whenever it becomes necessary.

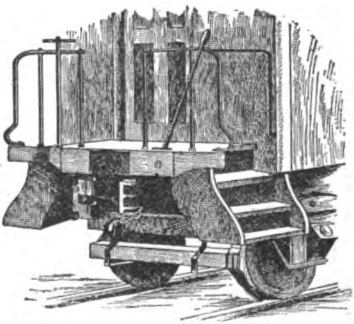
under such circumstances, will always be of more or less frequent occurrence. Thus, a section will be reported clear by the signalman when it is not, or the engineer will not observe the danger signal. The track may be occupied by train, or by an engine or a detached car. Signalmen are not more infallible than ordinary mortals. Indeed, where low priced men are employed, as is necessarily the case in many instances, they are exceedingly fallible. Opportunities for omissions and mistakes are particularly numerous and aggravating in connection with the movement of trains. The system, so-called, therefore, while affording considerable security, is far from perfect. This is well known to railroad men.

Devices now in a more or less forward state, designed to operate the block system automatically, indicate that railway trains will sooner or later be much better protected in this way than under old systems. The expense these systems entail will stand in the way of many companies adopting them, however.

The workings of the automatic systems, although more or less crude, are yet extremely interesting. Thus, under one plan, when a train enters a section the signals protecting it indicate danger, and remain so until the train leaves the section, but should a car break loose from a moving train, the signals would not denote the fact. Apparently the section would be clear. The device to this extent, it is apparent, is deficient. Under another automatic system, the signals remain at danger if a car or truck is detached on a section; this because the electrical device governing the signals (at danger) is connected by the passing of a current through the wheels and axles of the vehicles on the section, so that one axle and set of wheels are as valuable for the purpose as a whole train, keeping the signals at danger until removed. It is claimed for both these systems that, in the event the apparatus is out of order, the effect is to place the signals at danger. The devices, however crude, are great advances over primitive methods. But until they and all others of like tenor are supplemented by a mechanical contrivance that will divert trains automatically from a section that is occupied, we shall be far from what we need to fully protect us. Devices of this nature must not in any way depend for their efficiency upon the care or watchfulness of employes. They must be self-acting throughout. The expense of the block system is too great to be warranted on railroads generally, but there is some portion of nearly every line where the needs of business justify its introduction.

The automatic car coupler is another safety device of great value. Its introduction was first suggested on that account, but it also cheapens and simplifies the service and thereby facilitates business. No device has been the subject of so many experiments or harassing perplexities as this. The old link and pin method of coupling cars in America was literally the occasion of hundreds of thousands of accidents to railway men. The Car of Juggernaut never claimed one-tenth as many victims. The automatic coupler sensibly changed this. It was at first thought to be impracticable except in the case of passenger trains, but it is equally adaptable to freight service. An order of the Interstate Commerce Commission had much to do in hastening its general introduction in the United States. The pattern is uniform throughout, so that cars may be interchanged between railroads at will. Uniformity in height of drawbar from the rail is one of its requirements.

It is probable that no safety appliance ever adopted approaches the automatic coupler in value so far as the employes of railroads are concerned. Referring to this subject, Arthur W. Soper, an authority on such matters, says: "The meeting of the master car builders at Minneapolis will ever be remembered as accomplishing one of the greatest works in the history of our railroads in deciding upon a uniform drawbar. For many years this subject has been before them. There never was a session at which it was not discussed, and it had finally reduced itself down to where there were six links and pins and six vertical hoops recommended by this association, none of which would couple with the other; and there the matter rested for years, until this decisive step was taken that threw them all out and settled upon a single type requiring that every drawbar should couple with the other. In the history of our railroads no question has been solved more important than this. All these years there has hardly been a railroad shop that has not produced its many inventive geniuses who were devoting much time and money to their own particular safety couplers, and not alone was it confined to railroad employes. So much interest centered in the question that men of almost every occupation enlisted in it, until there were more than three thousand such appliances connected with car coupling in the patent office of this country, many of them in operation on the railroads, and hardly any of them that would couple with one another. Taking the many years past there is no doubt but that more time has been spent by officers of railroads in the examination of the different devices, and more thought given to the subject, than to any other, and it must be a relief to all their minds to know that the question is finally settled."



Miller Platform with automatic coupler.

The vestibuled car is a comparatively modern invention. It is found to be a much safer vehicle than the old form, although this was scarcely a consideration in its adoption. It was designed to facilitate passage from one car to another, and thereby add to the comfort of the traveler, but aside from this, it is found to be an economical device. It lessens the air resistance that the engine must overcome, steadies and strengthens the train when in motion, and in the event of collision, the resistance of all the cars is offered instead of a single car, as was at one time the case.

The "Miller" platform and automatic coupler (by which the ends of connecting passenger cars are brought closely together in the train on the line with the sills of the vehicles) are both extremely useful inventions. The latter prevents accidents to trainmen in coupling and uncoupling cars, while the former prevents passengers from falling between the vehicles while in motion. It also reduces the liability of vehicles being telescoped.

The insertion of blocks of wood or other material in the space between the rails at frogs is another safety device of great value to railway men. It is designed to prevent the foot of the switchman being caught and held in the face of an advancing train. Many men have been killed or crippled in this way.

Among the minor safety implements connected with trains may be mentioned the axes, saws and other tools with which passenger cars are stocked, for use in case of derailment or other accident. Provision for the extinguishing of fires has the same object in view.

While improvements in various directions have been taking place, progress has also been made in strengthening the passenger car. It is generally believed by railroad managers that the maximum security that can be attained in this direction is not too great. If the resources of a company are cramped, comfort must be sacrificed to safety in the construction of passenger cars. The car must be strong. It need not be elegant. Much thought is given the subject; humanity and business interests alike suggest it. The American freight car has also been greatly strengthened since the early days of railroads. Its carrying capacity has been doubled and quadrupled during the same period.

In considering the subject of railway accidents it must not be overlooked that passengers are, so far as practicable, protected by carriers from their own ignorance and carelessness. The erection of fences between the tracks at stations, designed to prevent passengers from getting in front of moving trains, has this purpose in view. It is probable that this last named practice will become general in time. In the absence of fences, closed gates on the platforms of cars, compelling passengers to alight on the right side of the train, have been found useful. The European railroads very generally erect fences and overhead bridges at stations so as to prevent passengers having access to the track. In the absence of these, through trains are required to stop or slow up at a station if other trains are loading or unloading passengers thereat. The station facilities I have referred to recommend themselves to managers as facilitating the movement of traffic. The expense, however, involved is too great to warrant their immediate and general introduction in America. They will come little by little as business and income warrant.

The compartment car is a safety device in this that it compels people to enter from the station platform and to alight thereon.

Safety appliances, to reach the highest point of value, must not depend for their efficacy upon the care of employes. It is probable the time will come in railway practice when trains will be protected by automatic devices on every line where the traffic warrants it. Roads will be cut up into sections and under the operation of a block system so perfected that it acts automatically trains will be secure. However, the system must be such that it will be physically impossible for a train to enter a section while occupied by another train. Both head and rear collisions will thus happily be avoided. The problem does not offer insurmountable difficulties. When railways can afford such a system, man's ingenuity will, it is probable, find a way.

A melancholy feature of railway operations is the accidents to employes. They are partly the result of imperfect appliances and partly the result of indifference (oftentimes contemptuous) upon the part of employes. Everyone connected with the movement of trains is familiar with the risks incurred. While often unavoidable, they can be minimized by the exercise of care. This care is oftentimes not exercised. Long familiarity with a danger finally leads men to disregard it. However, progress is being made in every direction. This is evinced in the fact that accidents are not so numerous as they were at one time. Trains are handled more scientifically and employes exercise greater care. Among other things, the switching yards of railroads are safer than they were formerly, have better appliances, are better arranged and better lighted.

Information in regard to train accidents is imperfect. We do not know how many accidents occur from neglect to protect trains standing upon the main track from rear collisions, nor how many accidents are the result of carelessness, of incompetency, of inexperience, of excusable mistakes, of defective appliances and imperfect rules and regulations. Statistics of this nature are very incomplete and will always be so, because of the obstacles that must be overcome in order to secure fullness and accuracy.

Of all the accidents that occur in connection with the operation of railroads, the collision of trains is the most dramatic. The block system is intended to lessen such accidents, if not prevent them entirely. But the block system is too costly for general use. Upon many American roads, therefore, the protection of the rear of trains is, of necessity, left to the brakeman. That he, as a rule, fulfills his duty with intelligence and faithfulness there can be no doubt, but the trustworthiness of many employes has never been tried, and whether they will perform their work faithfully or not when the emergency arises is always an open question. That the difficulties of the situation tempt them to slight their work, there can be no doubt; thus, the weather may be bad, the hour unpropitious, the distance great, or the time they must wait such as to tempt them to take undue chances. Everything conspires to render the brakeman unwilling to go back any further than he is compelled in protecting his train. The efficiency of the service is, therefore, always in doubt. The brakeman's responsibility is fortunately shared with the conductor and the engineer, but this is not enough. The situation demands some automatic method of protecting the train that does not require torpedoes, nor flags, nor flagmen. This protection it will ultimately get.

One difficulty of the service is the necessity, oftentimes, of employing untried men. Any great and sudden increase in the traffic of a railroad necessitates this. There is less danger of collision on a road whereon fifty trains a day run regularly than on a line where the service is suddenly increased from twenty to thirty trains a day. The service not only requires experienced men, but men thoroughly familiar with the line over which they run.

Railroad accidents, as a whole, arise from causes beyond the reasonable control of managers. Their attempts to improve the service in this respect are constant and intelligent, and in many cases far beyond the financial strength of the companies they represent. This fact is well known to everyone familiar with the affairs of railroads.

A comparison of the methods followed by railroads of different countries shows that they borrow freely of each other. Each is benefited in this way by the practices of the others. Thus, the English roads have much greater experience than those in America in the conduct of a heavy traffic in a densely populated country. This experience American companies can utilize in many ways, as the problems of such a traffic press upon them more and more.

It is a favorite maxim of trainmen that an ounce of prevention is worth a pound of cure. Running freight trains too fast is a frequent cause of train accidents upon cheaply built roads. When conditions are not propitious such trains should be run at a very moderate rate of speed. The rules generally contemplate this, but the needs of traffic or the vicissitudes of the service lead to their being disregarded in many instances.

Whenever changes in a service are frequent or laxity of discipline prevails, accidents are frequent. Those familiar with the details of train service have occasion to notice that things forbidden under the rules are oftentimes matters of everyday occurrence. So long as no accident follows, the infringement is allowed to pass unnoticed. In explanation of this, it is claimed, and truly, that the business done on many lines could not be performed if the rules were literally enforced. But the result of this conflict between theory and practice is to weaken discipline; to make men disregard essentials as well as non-essentials. The result finally is disastrous. Necessary rules must be intelligently, uniformly and consistently administered. The occasional discharge of an offender, because a practice which he and his associates have indulged in has at last resulted in disaster, carries little or no weight. The person discharged has no difficulty in securing employment with some other company, where the offense is winked at as before. Moreover, reliance on fear of dismissal as a means of discipline is unworthy an enlightened management. On the other hand, the absolute discipline of military rule is not practicable in the railway service, nor would it be to the benefit of carriers in managing trains or in dealing with the community.

The dealings of railroads with employes, as well as with patrons, are based generally on what is practicable; on business methods. The temper, ambition and affection of men, and the economic laws governing affairs, are never lost sight of.

Men who have to do with the movement of trains should be carefully chosen, must be made to feel that results are intelligently scanned, that the rules are reasonable and necessary and that faithful compliance with them will result to their advantage.

In judicial notice of railway accidents, the inclination of judges and juries is, in general, to place a charitable construction on the acts of employes. They remember that it is human to err; that perfection is a divine attribute. There is, however, a growing disposition to hold railways to a more strict account for acts whereby persons are injured or killed. This has gone so far, in some cases, as to lead to the imprisonment of employes. It may go still further. It is to be regarded as evidencing a determination to compel train men to meet the requirements of every emergency. This disposition is to be deplored, but it is a progressive step and one that, while fraught with more or less present hardship, will redound finally to the good of the service. The equities of particular cases should, however, never be disregarded by public prosecutors.

Want of care and observance of necessary precautions upon the part of the public is a noticeable feature in the operations of trains. To these are attributable a large percentage of the accidents that occur. In America the laws in this respect are exceedingly remiss, and such as we have are not faithfully enforced. Thus, men get on and off the cars while in motion, trespass upon the track of railroads, contrary to the statutes, and when accident overtakes them the public do not condemn the individual but the carrier. If the latter ventures to arrest a person for getting on or off a moving train, or who is found trespassing upon railroad property, the magistrate releases him with a gentle reprimand. When the courts send men to jail or fine them for disregarding the just rights of railroads in this respect, offenses will cease, but not until then.

But few people are killed or injured at the grade crossings in Germany, although such crossings are as numerous as in America. The reason is that the laws made to protect the public in such cases are enforced. Anyone there who should attempt to cross a track when the signalman has warned him back would be fined or imprisoned; in America the carrier would be censured, it is more than probable, and the trespasser acquitted.

Because of the newness of the country and the poverty of carriers the American railroads were far behind those of Europe in providing station precautions. Fewer people are killed and injured by the railroads, relatively, in England than elsewhere. There, however, carriers have gone to the other extreme in adopting precautionary measures, with the result that great sums have been sunk in safety appliances which should have been used to provide facilities for handling traffic. Vast amounts have thus been expended for tunnels, overhead bridges and in the introduction of the block system upon lines having little or no business, that might better have been left unexpended, because the outlay has circumscribed needed expenditures in other directions.

The comfort and necessities of a people as a whole are all-important. Every dollar added unnecessarily to the cost of constructing and operating railroads is so much taken from the common fund. A happy mean should be observed. In the matter of safeguards it is to be found in the calm, dispassionate co-operation of the state and the carrier in providing such precautions as general needs justify. Carriers, if left to themselves, will do this from self-interest and will not abuse the trust, nor will they sacrifice material interests in vain efforts to attain theoretical ends.

A man may travel in America fifty millions of miles without being killed, or twelve million miles without being injured. This risk, small as it is, is greater than in England or Germany, but it is much less than the risk incurred on the streets of a city.

While the precautions that railways adopt to prevent accidents at stations and elsewhere are each year more complete, the most effective preventive of all is the growing knowledge, intelligence and experience of the community.

The easy approach to the tracks of railways in America and the indisposition of the courts to enforce the regulations of carriers, as sanctioned by the statutes, greatly increase the number of casualties. Generally, it may be said that absence of necessary safety appliances on American railroads has not arisen from lack of appreciation, but from lack of means. When roads only render a bare return upon the investment, owners cannot be expected to provide precautions against ordinary casualties from their private means.

In the operation of railroads, complete freedom from danger, it may be truthfully said, can only be secured by expenditures entirely beyond the means of the wealthiest corporation.

Statistics show, curiously enough, that the mishaps to trespassers greatly exceed those to all others upon the property of American railroads.*

Causes of accidents at grade crossings are thus summarized by a writer on the subject: multiplicity of tracks; speed at which trains are run; number of trains; character of the approach to the railroad (i. e., whether the highway approaches the track on a level, or ascends or descends to it); number of vehicles and pedestrians using the highway; and, finally, the character of the traffic. The statistics of accidents at crossings protected by gates show that they arise from the neglect of the gateman; from his inability to calculate the speed at which trains are moving; from inability of drivers to control their horses, and generally from the haste, inattention and indifference of the public, especially

* Writing on this subject in their annual report for 1891, the Massachusetts Board of Railway Commissioners states: "About a year ago a member of the board, in coming from Beverly to Boston on the train leaving Beverly at 4:10 p. m. and arriving at Boston at 5:05 p. m., counted one hundred trespassers on the track. The count was made in the middle of the afternoon. There were probably more people on the tracks then than there would be in the forenoon, but by no means as many as at the beginning, the end and the middle of the day."

pedestrians. By far the greater number is occasioned by the refusal of passersby to regard the signals of the gateman.

In the United States, as in most new and poor countries, railways have been encouraged to cross highways at grade. Many roads could not have been built had the cost of overhead bridges and tunnels been added. The need of railroads was imperative. Theoretical perfection or the higher standard were not regarded so long as a road was reasonably safe for passengers and freight. While this method of construction was unavoidable, it entailed hardships both on the carrier and the community. It is impossible to prevent accidents under such circumstances. Every crossing invites them, while the use of the track as a highway by pedestrians, which public opinion does not condemn and magistrates will not punish, adds to the list. The grade crossing is the *bete noir* of railways. Its abolishment is generally demanded. But the impracticability of such a course is not given due consideration. The owners and managers of railroads are fully alive to the advantages to be derived from the abolishment of these crossings, and as fast as their resources warrant it the change is made.

But like business men in other walks of life, they are governed by their income. Where resources permit it, and in many cases where they do not, safe crossings are provided. This is especially so in the vicinity of cities. There is every inducement for railroads to make such provision as rapidly as possible. It relieves them from public criticism, expedites business and in many instances lessens current outlay. Judicious agitation of the subject within these limits is not harmful. But action must be conservative. It must take cognizance not alone of the desirability of the change, but of the financial ability of the railroad to make it. In some cases the cost should be borne by the railroad company, but in many instances it should be borne wholly or partially by the community.

I have already referred to the grade crossings in Germany. The safeguards that the government aids the railroads in throwing around these thoroughfares are at once minute and comprehensive. Thus they must be strictly guarded and it is required that they shall be provided with strong and visible gates. For pedestrians turnstiles must be put in. Bells are required to be rung by the attendants at crossings before closing the gates. Gates operated from a distance are allowed only on highways upon which there is little travel. Dangerous crossings must be minutely watched. It is required that gates shall be closed three minutes before the arrival of trains. This limit cannot be shortened without the permission of the authorities. Gates at private crossings may be kept locked. If the travel is light, the gates at public crossings may be kept locked if permitted by the local government board, but they must be opened at the request of persons desiring to pass; this the latter indicate by ringing a bell, with which every such crossing is provided. Women, in many cases, act as attendants at crossings and are found to fill the positions efficiently.

While the German roads are governed with military precision and employes are held to a rigid accountability, the public, on the other hand, is also required to observe the rules provided for its government. Thus, no person except an official or employe is allowed on any track, embankment, bridge, or other portion of the property not especially designated for the use of the public, without special permission. No one may cross the tracks except when the gates are opened. At crossings where automatic gates and turnstiles are used, the track must not be crossed when a train is in sight. In every instance expedition must be observed in crossing, and the public is forbidden to open a gate, disturb a fence, climb thereon, or hang anything upon it. Within certain precincts of a station no one except those connected with the line is permitted. Fines are imposed where regulations are disregarded, and railway employes are clothed with police power to enforce regulations, and it is mainly owing to this that accidents on German railroads at crossings and through trespassing are so much more rare than in America.

Another phase of the subject of accidents is the protection that may reasonably be afforded where railroad tracks cross each other. Each day adds to its interest and importance. The general practice in America was to cross at grade, an overhead bridge being the exception. At many points the expenditure of a small sum would have avoided a grade crossing, but the added cost could not be borne. The inconvenience of grade crossings is not appreciated in the early construction of railroads. It is only when trains become frequent that the danger and embarrassment are fully realized. When trains were few and crossings far apart trains crossed without stopping, but as traffic increased and roads multiplied it was found necessary to discontinue the practice. Where, however, crossings are protected by interlocking switches, referred to elsewhere, it is not necessary to stop if the track is clear.

Whenever a safety appliance is practicable, and within the means of a company, its adoption will follow as a matter of course. Extraneous interference is not necessary, but governmental supervision can do no harm if not animated by demagogical influences. The pecuniary interests of owners compel them to be vigilant. Diminution of prestige, destruction of property, falling off of revenue, increased expenses, delay of traffic, loss of the confidence of the community afford all-sufficient incentives to them to adopt every reasonable measure to prevent accidents. A mishap, however unavoidable, is a reflection on the company. If occasioned by the ignorance or inefficiency of an employe or the lack of reasonable appliances, the case is aggravated The owners of railroads are thus compelled in self defense to adopt every reasonable precaution. They do this in their physical appliances, in the servants they employ and in their methods of government. There is no incentive so great as that of self-interest, and it is to this interest of owners that we may safely trust. To say, as we frequently hear it said, that every human precaution should be taken to prevent railway accidents is to magnify the subject. The revenues of the world would not meet this requirement. As soon might the people be taxed to provide precautionary measures that would render an accident on the streets or highways impossible. Danger attends every movement of our lives, and we must not expect to be free from it on railroads any more than elsewhere. All that can be asked is that precautions proportionate to the income of properties shall be taken. The safeguards that railways can provide depend, as in the case of private individuals, upon this. A company with an unproductive traffic cannot keep up its property to the maximum standard, nor provide many things desirable in themselves. This is true of every new country and of many old countries. Where means justify it, the care of railroad companies will be evinced in the heightened discernment of the force; in the strength and durability of the permanent way; in stable bridges and culverts; in well equipped cars and locomotives; in the character of the signal service and the precautions taken at stations and crossings.

A company operating an unproductive property cannot be held responsible for the omission of non-essential safeguards any more than private individuals can be expected to bear the burdens of the public in other walks of life. But in speaking of poor companies reference is not had to those whose resources are frittered away through public interference with well-known economic laws. Every accident that occurs where the inability of the carrier to prevent it grows out of the interference of the state, or its disregard of the laws of trade, should be paid for out of the public treasury.

The mishaps that attend life in new (and poorly governed) countries are much greater than in older and wealthier communities. Life is more highly esteemed in the latter than in the former. The inducement to live is greater. Men are influenced by their environment. When we are sick we straightway employ a doctor, if we are able; if poor, we put off calling him until the last moment. To the former, he is a necessity; to the latter, a luxury. The analogy holds good in the operations of railroads. The necessities of carriers are: equipment, tracks, yards, stations and men. These are the essentials of life. If there is more than enough to operate the property and pay interest on its capital, then luxuries may be considered, such as stone culverts, steel bridges, fully appointed cars, a signal service, well guarded crossings, and so on. Such things depend, however, wholly upon the productiveness of a property. When business does not warrant it, railways can only afford the essentials of life, and all must be content therewith.

A very large proportion of mankind does not possess the instinct of life; does not know how to preserve the body against common accidents or the diseases that nature imposes as a penalty for violated laws. Nothing except a personal attendant can prevent this class from getting in the way of moving trains or succumbing quickly to the casual dangers of life. In providing safeguards, therefore, they can, unfortunately, receive only cursory attention. They are fated! God himself has denied them the instinct of life, i. e., the disposition to guard it with reasonable care.

In the operations of railroads it is possible to adopt so many costly precautions against accidents as to prevent carriers rendering the accommodation necessary to enable the people to live comfortably. This is the case where the money used in constructing one needed road is sufficient to have constructed two needed roads along moderate lines of construction. There are many things in the world of much greater consequence than isolated accidents to men. Such things, however much we may regret them, are not by any means the greatest calamity a community can suffer. For this reason the adoption of precautionary measures by railroads must be left in the main to those who are familiar with the properties and their duties to the public as

Carriers. They only are able to weigh the good of the community as a whole in the balance against the vicissitudes of the few.

The enactments of different countries are not uniform in regard to the precautionary measures railways shall take to prevent accidents. While in many cases reasonable, they are unjust, unwise and excessively severe oftentimes. The safeguards that carriers should be required to enforce should, as already pointed out, be in harmony with business needs. Anything in excess of this is a restriction upon the Necessaries of life. The English people pay altogether too high a price for their arbitrary enactments in regard to safety appliances. Their effect is to add greatly to the operating expenses of railroads, and in so far as this is the case commercial facilities are restricted and the simple needs of the community cut off.

The power of the state to enforce safeguards is now everywhere recognized, but, after all is said, the possession of this power is valuable mainly for its quieting effect on the public mind. It should be used sparingly. There can be no doubt of the disposition of carriers to take up such matters as rapidly as circumstances permit. When so taken up, the work is done intelligently and without sacrificing greater interests.

Arbitrary interference of governments, while beneficent in particular things, in the end results in much greater harm than good. Such interference, moreover, when frequent and systematic, is to be deplored, because it lessens the responsibility of carriers. They shield themselves like children behind the government. Thus it becomes necessary for the latter to take the initiative, and in this way the owners and their experienced servants give place to the spasmodic and ill-conceived efforts of a less trained and less interested body of men.

The safety devices of railways, not less than other devices, require to be passed upon by practical operating officers who are in their way experts. Theories are thus held in due subjection to practical needs.

To attain the highest ends possible in connection with the train service, to secure the right thing at the right time, governments must restrict their operations mainly to suggestions and co-operative effort. Referring to this subject, the Royal Commission of Great Britain said most admirably: "We are not prepared to recommend any legislation authorizing such an interference with railways as would impair in any way the responsibility of the companies for injury or loss of life caused by accident on their lines. To impose on any public department the duty and to trust it with the necessary power to exercise a general control over the practical administration of railways would not, in our opinion, be either prudent or desirable. A government authority placed in such a position would be exposed to the danger of appearing indirectly to guarantee works, appliances and arrangements which might practically prove fauity or inefficient, or else of interfering with railway management to an extent that would soon alienate from it public sympathy and confidence and thus destroy its moral influence and with it capacity for usefulness." Governments should intermeddle only in extreme cases, and their acts should be discriminatory, i. e., should recognize inequalities of properties, traffic and location. In the protection of seamen it is not provided that vessels shall all be alike or all supplied with like utensils. Conditions are adjusted to conform to the ability and character of the carrier. The same rule should be observed with railroads. It should be remembered, always, that carriage of persons and property is the primary feature. When a company is able to do this with reasonable facility and profit it may be asked to go further and apply a portion of its surplus for accessories or luxuries of the service. Not that any company should be permitted to use unsafe vehicles or structures of any kind, but further than this, and the due exercise of the common precautions of the service, it is not desirable to go if the income of a company does not justify it.*

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* It has long been a very general practice, on some of the best managed railroads of America, to use a portion or all of their surplus income, each year, in improving their property and adding to its facilities. These expenditures seek the most urgent channels, but in any event contribute much to the efficiency and safety of the line. It is thus steam has been introduced into cars for heating purposes; gas in place of oil lamps; the air brake, and so on.

The precautions adopted by the railways of Great Britain to prevent accidents are the most perfect in the world. The enormous sums that they have cost are, however, a burden in many ways. Thus, the block system greatly increases the expense of operating and adds to the interest burden on first cost, and when we remember the number of accidents that have attended the use of the system, the expediency of its general introduction, regardless of the income of properties, may very well be questioned. It lessens the danger, but does not obviate it. On the other hand, it entails lasting burdens. It is a tax on the internal commerce of the country. The accommodation the English roads are able to render the community would be much greater except for this load. The block system, like other safety devices, should be adopted wherever business needs justify, and not otherwise. Practical, not utopian, theories should govern. Railway appliances not warranted are simply "fads." It would be much better for the community if many European roads upon which expensive appliances have been provided to prevent accidents were operated under the simple and inexpensive methods of America.

When a company is too poor to afford the luxury of safety appliances, it enforces, in their absence, such simple and inexpensive devices as practical sense and experience dictate. Thus, if a track is not properly ballasted or drained, or a bridge or culvert is weak, trains are run slowly to insure safety. Primitive methods of operation are resorted to. The nature of the business does not warrant anything else. It is only on lines where adequate precautions are taken that fast trains are possible.

In conclusion, the following is a brief and imperfect summary of railway construction upon which the safety of life and property in a measure rests: Drainage must be such as to prevent the track being undermined. The ballast must be sufficient, and of the right kind, to secure needed elasticity. Ties must be sound and stable. The rails must be sufficient to withstand the weight of trains. The track fastenings must be such as to prevent accidents from this source. Bridges and culverts must be sound and strong and must be carefully looked after, as must all the appliances of the track. Waterways must be sufficient to carry off the maximum quantity of water that may fill the streams. Overhead bridges at public crossings, or, in their absence, gates and gatemen, supplemented by stringent police regulations rigidly enforced, add to the security. Regulations preventing trespassing upon the right of way will still further increase the safety of a line. The protection of grade railroad crossings by interlocking switches or other devices, whereby two trains will be prevented access to a crossing at the same time, are necessary to insure reasonable safety where trains are permitted to cross without stopping. The use of the block system, whereby it is attempted to prevent two trains being upon a given section of track at the same time, is valuable as a means of preventing accidents. Where there are two or more tracks, overhead bridges at stations add to the security, and the placing of such fences as may be necessary to render it impossible for the public to gain access to the tracks, except under due regulations, will tend still further to prevent accidents. Uniformity of signals and efficiency in handling them are essential things; in this case uniformity embraces incidentally the locating of the signal posts, which it is the general practice to place on the left-hand side of the track to which they refer. Short arms or discs are valuable at stations and junctions for facilitating switching operations and as precautionary measures. They, in a measure, do away with hand signaling, which is attended with more or less danger. Among other devices and methods of business intended to facilitate affairs and prevent accidents, I may mention the introduction of the swallow-tail, or arm, in place of the signal devices of earlier days; the general adoption of a particular color as a signal of danger; the unification of the block system so that, as far as practicable, it shall be uniform; providing facing points with a locking bar and bolt and the interlocking of the same with the signals and electrical apparatus that control them; care in constructing, inspecting and maintaining equipment; the fitting up of locomotives and cars with the automatic air brake; the use of steam for heating cars; the use of electricity or gas for lighting cars; the avoidance of running engines backward; the running of switch engines at moderate rates of speed; the providing of means of signaling the engineer from the car; the raising of passenger platforms to a uniform height and fitting cars with high continuous footboards; the arrangement whereby the sills as well as platforms of cars coincide, so that in the event of collision or similar accident the full strength of the vehicles is opposed to their tendency to telescope; the removal of the driving axles of locomotives under carefully calculated provisions; the fastening of tires more securely; better car wheels and brake shoes; the providing of check rails on curves with a radius of ten chains or less; the avoidance of grade railroad crossings at stations, or, when this is impossible, the introduction of interlocking switches; the fitting of cars with automatic couplers; the avoidance of overwork by employes; the annulment of rules not intended to be carried out; the running of trains according to the provisions of the time table; the providing of signalmen in case of fogs; the use of "catch points" on inclines of track so as to prevent vehicles running away, etc. All these things and many more I might mention are, in the main, highly necessary for railways that can afford them, but as a rule totally out of place in other cases. The reader will readily note, in looking over the list, what is fundamental and what is not. To force a company to provide non-essential things when it has not the means to do so is robbery; confiscation of property. Instead of asking such a company to sink the private fortunes of its owners in a vain effort to secure ideal safety appliances, it should be encouraged to make the most of what it has; to carry out that which is practicable, among other things to see that its train force is well instructed and disciplined and that due care is exercised in running trains if the track or bridges are at all insecure. I need not say that railway companies will do this without suggestion, but the public seems to feel the necessity of government officials exercising some authority in such matters, and it may be exercised in this direction without injury to a country or the railroad properties which form so great a part of its wealth. England, as I have pointed out, has sunk vast sums in building ideal railroads to meet ideal wants, and thus it is burdened and ever will be with outlays which its people are more and more coming to believe might have been avcided had better judgment been exercised in the first place.

CHAPTER XI.

HEATING CARS.

It is not probable that there ever existed a time when mankind did not possess a knowledge of artificial heat. Fire had its origin, so far as the uses of man are concerned, in the blazing volcano and the lightning of heaven. For ages it filled him with wonder and superstitious awe. When he had become somewhat civilized his curiosity led him to investigate and experiment, but it is only in comparatively recent times that he has been able to create fire at will, by heat generated by friction or concentration of the sun's rays.

All primitive people, it is probable, have at one time or another believed fire to be a sacred thing. The native Australian carries with her everywhere a burning brand; to protect and foster this is one of the objects of her existence. The fire of the Samoan nobleman is never allowed to go out. The happiness of the Corean family is dependent upon the preservation of the ancestral flame. The ancients kept a fire constantly burning in their public buildings. In Egypt a fire was kept alive in every temple, and among the Greeks, Latins and Persians in every town and village.

In some countries national fires were kept lighted upon some great promontory or temple.

The temple of Vesta, the Roman goddess of fire, stood near a fountain, thus affording the people convenient means for procuring both fire and water. When from any cause the fire in the temple of Vesta became extinguished, all public and private business ceased until it could be relighted. The people believed that the connection between

heaven and earth had been broken, and that before anything further could be prudently done it must be restored, either by lightning from the clouds or new fire created by the priests rubbing together pieces of wood, or through concentration of the rays of the sun. The armies of Rome and Greece carried with them everywhere an altar on which the sacred fire was kept burning. Grecian colonists carried live coals with them from the altar of Hestia with which to kindle the sacred fire in their new home. It has been claimed that the buildings erected for the protection of the sacred fires of the ancients were the beginning of architecture, suggesting, as they did, to man a similar abode for himself.

The Romans believed the sun radiated life as well as heat; it was the seat of their household gods, the dwelling of deceased persons, and a place where a supply of souls was kept ready to be sent into existence by new births. They took great care to keep the flame of their hearth fire pure, and fed it with certain kinds of wood which had been stripped of bark and dried. In case the family fire went out, a new fire was produced by friction of two pieces of wood, as the borrowing of fire from a neighboring family was considered an improper mingling of the blood of the two families.

According to the belief of primitive peoples the characteristics of the family hearth applied also to the sun; the one gave life to the family, the other to the universe. Both were portions of the same substance. The poet Ovid, of the Augustan age, asserted that the goddess Hestia was identical with the earth. He believed fire was the soul of nature, the predominant quality of everything that had shape; in fact, the giver of shape. Everything in nature, great or small, was supposed to owe its existence to this element. The Aztecs regarded fire as the "father and mother of all gods."

Among the hardy progenitors of the human race fire as an agent of warmth was unknown or despised. No such use attached to it. It was an object of worship solely. The people of that period, who were to us what children are to men of mature years, believed fire to possess the same perceptions and sensibilities as themselves, except that it was of a purer and more exalted nature. To them all things were sentient. The trees which looked down upon them, the rocks that slumbered on the sides of the mountains, the babbling brooks, the floating clouds, the swiftly running rivers, the broad seas, the denizens of the deep, the birds floating in the air, the animals that traversed the forests and plains, had the same thoughts, reasoning powers, feelings and passions as mankind; they were believed to revenge themselves on those who displeased them, smile on those they liked—love, hate, reason and suffer in all respects the same as men and women. But fire, because of its brightness, vivacity and potency, they believed to be of heavenly origin. Thus, it did not merely represent the goddess Vesta in her temple in Rome, it was the goddess herself. Those who sat before a fire as it burned on the hearth believed they were in the very presence of the goddess. Nothing unclean was allowed to be thrown into the hearth fire, and it was sacrilege to commit an indecent action before it. Indeed, to extinguish a light with the breath was thought to defile the flame and, therefore, to be an offense.

Man's superiority is a thing of recent occurrence. In his earlier stages he was completely dominated by the wild beasts of the forest and the natural laws of the universe. The former he could not overcome and the latter he did not understand.

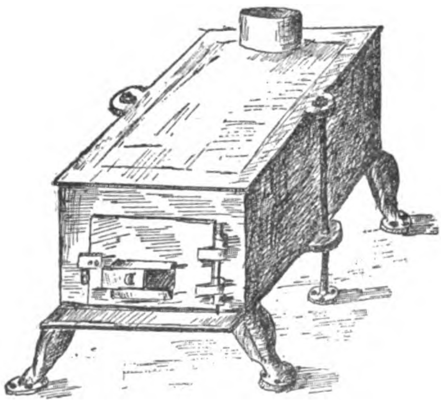
The practical uses to which we put fire were not recognized in the early history of the world. In the first instance men did not cook their food. This effeminacy came long after, when man had emerged from savagery.

When men first began to use fire for purposes of warmth and cooking it was lighted on an open hearth in the center of the great living room of the house where all slept, ate and rested in common. The family with its retainers and dependents clustered about this central spot. The smoke from the burning wood found its way out through the roof or through the opening and closing doors. The fireplace with its attendant chimney to carry off the smoke came later and was a great advance. The stove was a still more important invention. The uses made of hot air and steam for heating purposes are comparatively recent. The steps by which we have reached our present eminence have been progressive, but widely separated as regards time, places and peoples.

In the evolution of man many different uses have been made of fire. It has been, as I have pointed out, a religious and a superstitious symbol; an object of worship; religion itself. Then again, the badge of leadership and sovereignty. Its highest use among the ancients was that of a deity or protecting genius of the domestic hearth. It is only within a short period that it has been used for cooking, to give warmth, to afford power. In employing it for heating purposes we use it directly and indirectly; directly to warm us by its rays, or, indirectly, to furnish steam, heated water or hot air. It is in connection with its uses for purposes of heating the cars of railways that we have to consider it here. The problem has been a difficult one from the start. While apparently simple, it is really exceedingly complicated. The subject has exercised the ingenuity and thought of inventors and railway managers from the start. It is not a question simply of warming the car; danger in case of accident also intervenes.

With the introduction of the system of heating by steam from the engine the difficulties of the situation were sensibly lessened. Indeed, so great has been the progress in this direction that it seems as if perfection had been reached. But here, as in every other department of affairs, we shall quickly discover how crude are our designs; how much they may be bettered and cheapened. We know this to be so because with each stage of man's progress his inventive genius expands. This is partly because his needs are greater. His intelligence is sharpened by the demands made upon it. With each step he also grows more exacting. His complaints are louder, his effeminacy more pronounced. It is not enough that he must be warmed; he must be coddled. The very demand for artificial heat is an evidence of his enfeebled state.

In the question of heating cars it is manifest that climate has much to do with the method employed. Thus, in Great Britain receptacles containing live coals or heated water are considered quite sufficient. A cylinder containing hot



water is a means generally employed; it is placed in the bottom of the compartment and upon this the passengers rest their feet. It is not claimed to be adequate, for it is not, but with the aid of warm rugs the robust inhabitants of that sturdy island keep from freezing. The warmth of a good fire is quite as much needed in Great Britain as elsewhere, but because the people are robust and in little danger of succumbing to the cold the subject is passed over lightly. In many Southern countries there is no provision whatever for heating cars or affording warmth of any kind. In the Northern States of America careful provision is required. Generally speaking, it is not an exaggeration to say that in no other country have railway managers given the subject the careful attention they have in America. The progressive steps of the latter evince this and the perfected methods employed testify to the generous provision of the carrier and the skill of those who have devoted their minds to the subject.

In the days of stage coaches no attempt was made by the proprietors to warm their vehicles, except, perhaps, by heated bricks or bottles of hot water, or sheet-iron receptacles filled with live coals. Similarly, railway cars were at first left unprovided with stoves, and passengers made the best provision they could to protect themselves. But in America at an early day large stoves were introduced. These were placed in the middle or at the ends of the cars. Sheet-iron stoves in which wood was burned were first used. Later heavy cast-iron stoves, largely, took their place. In these both coal and wood were burned. Afterward stoves especially intended to burn coal were provided, and these were very generally used except in districts remote from supply.*

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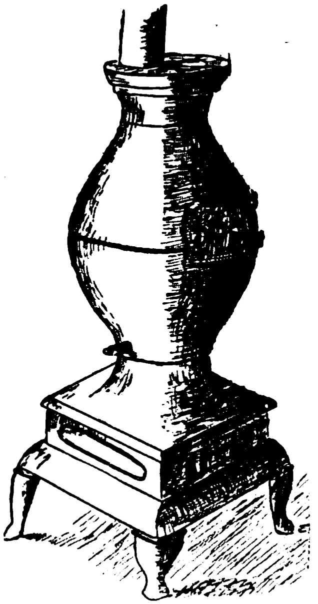
* In localities where crude oil is abundant and cheaper than wood or coal, and facilities have not been provided for heating cars from the locomotive by steam, it is used more or less for heating purposes in stoves especially adapted therefor.

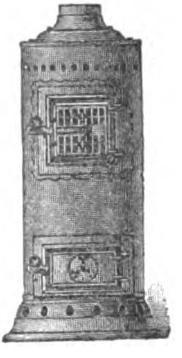
These methods, while much superior to those that merely contemplated warming the feet of



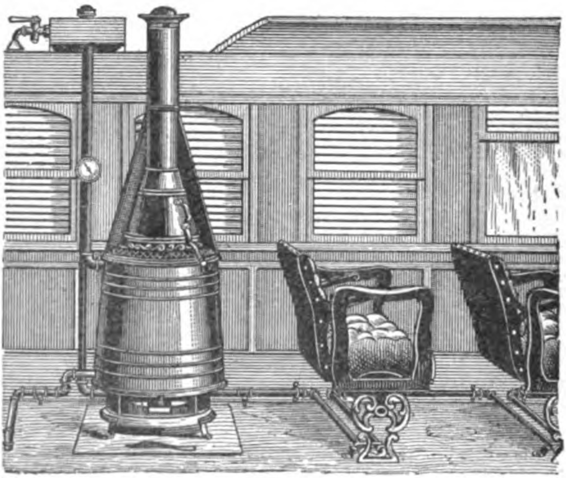
passengers, were still inadequate. Those who sat near the stoves were often too warm, while those more remote suffered greatly from the cold. However, matters were, in a measure, equalized by frequent exchanges of place. But, with all the discomforts of travelers, which were great, the danger of fire from the intensely heated stoves was never for a moment absent, not only menacing the property of the railway, but the lives of those it carried.*

* The practice of heating a passenger car with one or two great stoves, so general in America, has never been practicable in those countries where the cars are divided into compartments, as in Europe and the far East. In such cases simple devices like those adopted in England for heating the feet of passengers, and thus keeping up the circulation, have been as a general thing the rule. All this will be changed as the higher knowledge we have acquired, of heating directly from the engine by steam or hot air, or both, is generally diffused. A stove cannot very well be introduced into every compartment, but every compartment can be heated by steam from the engine, as simply as the rooms in a hotel may be heated from a boiler in the basement.

No practicable substitute for the stove presented itself to carriers for many years. Every device for heating a car contemplated furnishing the heat from the vehicle itself. Ingenious methods grew up by which cars were heated by hot water and air, but always from within, and always with the dangers that attend such systems. In the best of these stoves the fire was inclosed in a jointless cylinder of cast iron; this was incased in another cylinder of wrought iron, and the latter, in turn, was covered by a cylinder of sheet iron, a space of four inches being allowed between the cylinders for the circulation of the air. A radiating pipe was coiled within the fire. This pipe ran up to and from thence down from a drum on top of the car, and thus extended the entire length of both sides of the car, about six inches from the floor. The iron drum was an air and water reservoir; the lower half contained five or six gallons of water, the upper half afforded a chamber for the air escaping from the hot water. The air confined in this chamber acted as a cushion, or elastic head, which was compressed as the water was expanded by the heat. The radiating pipe was also filled with water, and, when necessary, the supply was replenished from the drum. A gauge and supply cock fastened to the side of the drum at high water line indicated the height



of the water; this also acted as a funnel through which water might be added when necessary. It may be remarked, however, that the waste of water caused by use was very slight. A safety vent attached to the top of the drum afforded an opening through which the confined air and part of the water in the drum might escape in case

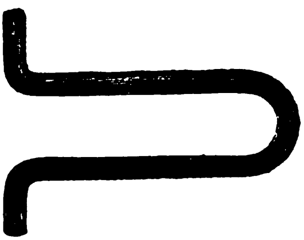


the pressure exceeded a certain limit. The condition of the fire was ascertained by an indicator attached to one of the perpendicular pipes in the car. The danger arising from freezing was prevented by the use of salt in the water. For this purpose a fine, dry salt was used, and as much put into the water as it would hold, but care was required to be exercised to see that no undissolved salt was put in. If desired, the heat of the fire can be replaced by the heat of steam drawn from the locomotive. The steam is conducted from the locomotive by means of a train pipe to the car, being carried and introduced into jackets which surround the radiating pipes in three different places. The result is a more uniform heat than that produced by the heater I have been describing. An increase of the average temperature of the pipes throughout the car is also thus obtained, and in a much shorter time.

Steam generated in and applied from the locomotive is recognized as the best form of heating. It is at once easily regulated, occasions an agreeable temperature, and frees the passenger from the danger of fire.

In the earlier experiments steam from the locomotive was admitted directly to the pipes within the car by means of a train pipe. This is known as the direct system of steam heating and has decided merits, especially in the case of cars used in suburban service, which are detached part of the day and require to be heated from the engine when taken up. The radiators consist of two two-inch pipes secured to the sides of the car. Steam is conducted to each side independently from a cross in the train pipe, which conveys steam from the engine. In case the two pipes do not give sufficient radiation, larger radiators may also be placed in each end of the car. A regulating cock allows the steam to enter into both radiating pipes when desired, or it may be shut off from the upper pipe. When no heat is required, the steam may be shut off entirely. The condensed water in the radiating pipes is controlled and discharged through a drip valve placed under one of the seats of the car. Great difficulty has been experienced in controlling the heat in methods of direct steam heating, but with the introduction of the regulator described above this obstacle was measurably overcome. At stations where suburban cars are detached for a portion of the time, it is becoming more and more the practice to establish local heating plants for the purpose of warming the cars before attaching them to the train.

Another method of heating is known as the hot water circulating system, by which the cars receive their heat from steam carried through a train pipe. Dry steam is taken from the locomotive boiler and the heat conveyed to the water circulation within the car by induction or through metallic surfaces. In other cases steam is injected directly into the body of water to be circulated. The circulation is aided by the action of the steam causing a motion of the water. Rapid circulation causes the transmission of heat more evenly through the pipes.



Radiating Pipe.

The vacuum system of heating has been used with very satisfactory success. Two pipes extend the entire length of the train—one for supply, the other for exhaust. They are coupled by hose between the cars. A vacuum pump on the tank of the engine is attached to the exhaust pipe. The exhaust steam from the engine is admitted to the supply pipe, and in ordinary weather is found sufficient to heat the train. When insufficient, live steam from the engine may be admitted to the supply pipe.

The so-called low pressure system of heating has been found to work very successfully under certain circumstances. The heater consists of two cylinders, one inside of the other. The inner one is made of brass, and is filled with small copper tubes. The outer is constructed of wrought iron and is connected to the heating pipes of the car by pipe. The inner cylinder is connected with the pipe which carries live steam directly from the locomotive in manner similar to that in the direct heating systems. The outer cylinder is partly filled with water; the heat from the steam in the inner cylinder converts a portion of this into steam, which circulates through the pipes that heat the car. The steam which condenses by coming in contact with the cold pipes flows back to the cylinder, where it is again converted into steam and again circulated through the pipes. Three gallons of water are said to be enough to heat a car under this method. It is claimed a car may be heated in five minutes after the steam valve connecting with the locomotive has been opened. No water ever remains in the pipes, the incline being so arranged that it is immediately carried back into the cylinder.

A method of heating cars with hot water from the engine and known as the multiple circuit system has its advocates. A heating drum made of wrought iron is placed beneath each car, near the center. Within this drum are four corrugated copper pipes attached to a cast-iron head. These are arranged in two separate steam circuits. A train pipe extends the entire length of the train, and connections are made between it and the corrugated tubes within the drum by means of a cast-iron head, a port being provided for that purpose. A second lower port is also provided for carrying off the water produced by condensation. The drum is connected to the heater pipes of the car, the latter being so placed as to make four complete circuits on each side, extending from the center to the end of the car, where they connect with the return pipe or inflow to the heating drum. A two-inch pipe leads from the outflow end of the drum to each side of the car, entering a distributing casting which has leading into it the two upper pipes. The water flows out through these two pipes to both ends of the car and returns to the center through two lower pipes. It is returned to the inflow end of the heating drum by a pipe. In this way the water in each of the circuits is brought into contact with the steam heated corrugated surface while its flows the entire length of the heating drum. When a water heater is used in this connection, the hot water is carried from the heater into the drum beneath the car, from which it is distributed to the car in a manner similar to that employed when steam heat is used. Users of this system claim that all parts of the car receive heat from the circuit in the same degree at the same time, as a difference of temperature between the outgoing and incoming pipes of but a few degrees will cause the circulated water to return to the heating drum and again rapidly circulate through the car.

A hot air system of heating cars consists of an air reservoir and a coil of pipe placed inside the front (extension) end of the locomotive. The reservoir extends back to the exhaust pipe. The coil of pipe is placed directly in front of the boiler flues, where it receives the direct force of the heat which goes through them. The air is forced by an air compressor fastened to the side of the locomotive boiler. This draws air from the atmosphere and forces it into the reservoir, from whence it passes through the heating coil and is carried to the cars by means of pipes provided for that purpose. Coils placed under the seats, passing down one side of the train and back the other, carry the hot air through the cars. After making the circuit the air is discharged to the atmosphere through a valve on the tender. Connections between the cars are made by hose and couplings. Safety and cleanliness are especial advantages attributed to this system of heating.

In France the experiment of heating cars by steam and compressed air combined has been tried successfully. The effect of air added to steam is the constant movement of the water as it condenses and its elimination from the pipes, thus preventing danger from freezing. The difference of temperature resulting from the addition of air is said not to be sufficient to modify the calorific (heating) effects to an appreciable extent. The mixed air and steam are carried through a pipe from the engine, running through the entire train and terminating in an automatic blow-off cock, which retains the steam but allows the condensed water and chilled air to escape. Heating tubes branch off from the main pipe, passing through the car and unite again. Admission cocks allow the steam to pass into the tubes. The coupling tubes are made of rubber, similar to brake tubes. One pump is, as a rule, not found sufficient to manipulate the brakes and also provide steam for heating purposes. Two pumps are, therefore, provided. The steam of the boiler by its expansion compresses the air, which is afterward brought into requisition for heating. The appliances on the engine consist of a steam valve on the boiler, safety valve and steam gauge.

The so-called storage system of heating consists of a four-inch pipe extending on each side of the car, inclosed in a wooden box having frequent openings fitted with registers. These pipes are partially filled with ocean pebbles, a small section at the bottom being separated from the rest of the pipe by a perforated copper plate extending horizontally. In this section the steam has free circulation. The live steam is applied to the train only at stations and the heat-retaining quality of the pebbles causes them to give off the heat so slowly that the car is kept warm.

The danger of fire from stoves has led the governments of many countries to prescribe rules for heating cars. In some instances stoves are forbidden, heating from the engine being prescribed. The trend is in that direction. As to the quantity of heat that shall be furnished governments are generally and discreetly silent. They wisely trust to self-interest to regulate the matter. The Swiss government, however, among its provisions directs that all passenger cars shall be heated from the first of October until the end of April in the event the outside temperature falls below forty-one degrees. During the months of December, January and February the heating must be maintained without regard to the outside temperature. If, however, during three days and nights successively the temperature remains above the point stated it may be temporarily discontinued. The average temperature required to be maintained in the cars is sixty degrees—enough to keep passengers from freezing to death—and they must be heated long enough before being used to insure a temperature at the starting point of at least fifty degrees. Thermometers are required to be provided for each car.

One of the difficulties attending the heating of cars has been measurably overcome by the introduction of an automatic regulator, by which the temperature of the car may be kept within a certain degree of heat. The importance of this cannot be overestimated. Provisions of this nature, like safety appliances, to be effective under all circumstances must be self-acting.

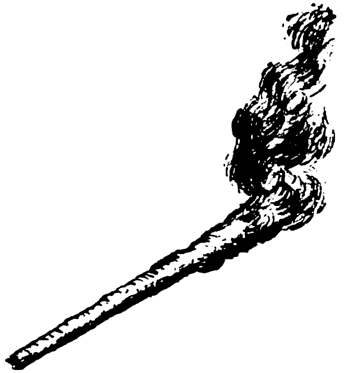
How far it will be possible to use electricity for heating purposes remains to be seen. It is, however, found practicable on lines operated by electrical power. Although expensive, its advantages are so manifest as compared with stoves that the added cost is fully compensated for in this class of service. The current is turned on and off in the same manner as in the case of electric lamps.

Such are the methods, primitive and otherwise, employed in heating cars. The description is not intended to be exhaustive, but suggestive. To those who desire to study the subject technically it will be merely an introduction. They will require to pursue their investigations in the shops of manufacturers and on the trains of railways, where the merits and demerits of different methods of heating may be practically studied. My object has been to familiarize the reader with the subject. It is important that it should be understood in its wider aspect by everyone connected with railroads. As scientific methods of heating come to be understood and the financial means of railway companies permit such forms to be introduced they will be everywhere adopted. It is a question largely of means. Such forms of heating are luxuries and, like other luxuries, only those who are well-to-do can afford them.

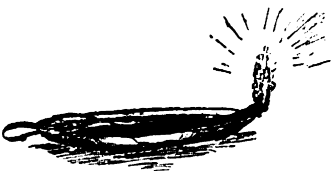
CHAPTER XII.

LIGHTING CARS.

It is, perhaps, not too much to say that there is no question connected with the comfort of the railway traveler which he esteems of greater importance than the agreeableness and adequacy of the method of lighting the coach in which he rides. And in no direction are railways more freely, and oftentimes unjustly, criticised than in this respect. But it is a mistake here, as it is so often elsewhere, to suppose that when



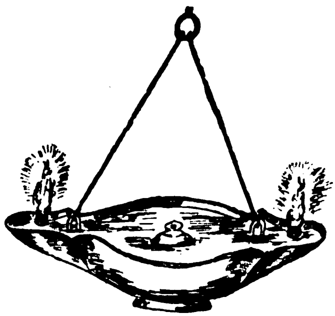
those who serve the public fail to adopt what are thought to be the best methods, the neglect arises from carelessness or indifference. Such is rarely the case. Railway officers, like other men, are loth to make changes; they involve risk, not only directly but collaterally. Oftentimes what seems to be desirable is only seeming. Conservative men will not abandon what they know to be practicable and within their means until after long and careful observation something else is demonstrated to be more desirable. Cost oftentimes precludes or delays changes that corporations would like to make. It is never safe to say that they are indifferent. The *esprit de corps* which leads every professional man to desire to excel also animates the owners of railroads and leads them constantly



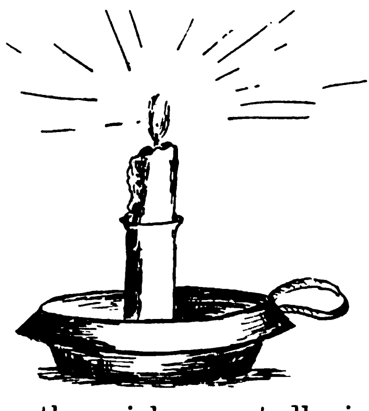
to seek to better their property and make it more popular with the public. This is so, at least, where railroads are owned and operated by private individuals. I am not prepared to assert that it is always the case where railroads are operated by governments. Individualism is there lacking; so is competition.

The demand for a method of lighting that shall be safe, brilliant and unobjectionable, is the outgrowth of a high and exacting civilization; of ever multiplying needs. Our forefathers were content with candles and rude oil lamps. But the esthetic taste of our time demands something inoffensive and that shall, moreover, correspond as nearly as possible with the light of day. Thus we progress. Primitive man had little or no use for artificial light. The sun by day and the moon and solemn stars by night were quite sufficient for his needs. He did not read; and if he traveled, his journeys were short and his conveyance and its appliances of the rudest kind.

When the social instincts of men began to assert themselves and they commenced to form



themselves into small communities, the blazing torch of common wood or resinous pine afforded them all the light they had except so far as they derived it from the fire that blazed on the hearth or in the open air. With the discovery of the properties of oil, it quickly passed into general use so far as men's tastes were cultivated and they were able to afford so considerable a luxury. From these

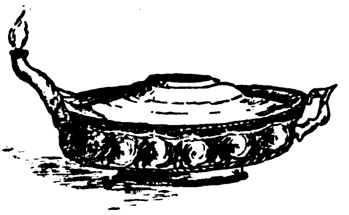


crude beginnings the genius of man has evolved the clear, steady, brilliant light of our time. Among other devices, the tallow candle marked a great stride in the progress toward something better. It will always be highly esteemed. At first it was formed by dipping the wick repeatedly in melted tallow. Afterward molds were substituted.

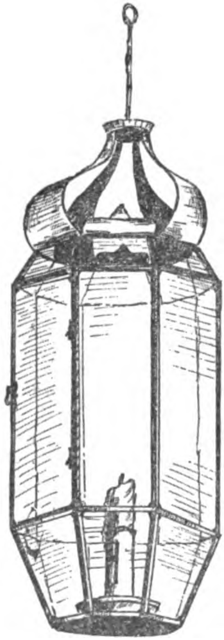
The torch of Agamemnon's time was succeeded in Greece by the oil lamp, which was used at an early day where permanent lights were kept. It came into domestic use in Greece about four hundred years before the Christian era. The lamp was made of terra cotta with a spout or nozzle for the wick and an orifice for receiving the oil.

The ancients were ignorant of the fact that pure light contained heat. They supposed they were enabled to see objects by means of something projecting from the eye. Aristotle is said to have been the first to question why he could not see in the dark as well as in the daylight if such were the case.

Modern lighting is looked upon from two points of view—from that of the inhabitant of the city, where gas and electricity are employed, and from that of the denizen of the interior, who knows only the oil lamp or candle. To the latter the primitive methods employed by railroads



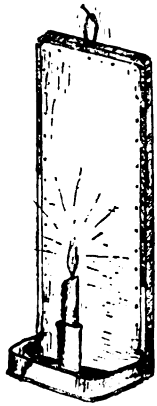
in their early history do not by any means appear obsolete. He is accustomed to them, and they appear, because of this, of the highest possible utility. But to the resident of the city, where early methods have long been abandoned, illustrations portraying them appear attractive, even picturesque, because of their quaintness and remoteness from his everyday life. It is because of this, as well as partly to portray the evolution of means of lighting, that pictures of primitive methods are embodied here. However, these methods are still more or less in use in lighting cars in remote districts.



In the early history of railroads (and, indeed, to a certain extent at the present time), all sorts of quaint methods were employed for lighting cars. Upon one road an old-fashioned lantern hung from the ceiling; on another, candles in primitive holders cast a faint glimmer from the sides of the car. Oil lamps, however, were more generally used than any other method. The light was better and the lamps more easily looked after. Besides, they were more satisfactory to travelers. An objection was the danger that attended their use. If through accident or otherwise the light was upset, it might serve not only to start a fire, but afford it food. Thus lives would be sacrificed and property destroyed. To be sure, disasters in this direction might have been avoided by the use of good oil, but proprietors were not then aware of differences of this kind. Deception was common, and in some cases the extreme poverty of the carrier was a strong temptation to him to use poor oil because of its apparent cheapness.

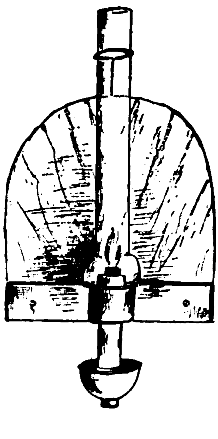
There are more systems of lighting cars than would be supposed: by candles, vegetable oils, mineral or petroleum oils, ordinary coal gas, carbureted coal gas, "rich" or oil gas, carbureted air, electricity and so on.

The use of candles for lighting cars is perhaps the most primitive. They are still used more or less in those parts of the world where mankind are slow-going or the purse of the carrier extremely diminutive. The candle is placed in a holder fastened to the side of the car. A slide in the candlestick is provided for raising the candle as required; this is manipulated by the trainmen or passengers—frequently the latter. Another form of candlestick has a spring which is pressed down into the socket by the candle. A cap with a hole in the top through which the wick projects is screwed down over the candle, the latter being forced up by the spring under it as fast as it is consumed. Sperm candles are also used, with a glass globe to shield the flame. In some cases ventilators are placed in the top of the car to enable the odor and smoke to escape. However economical, and in a certain sense, esthetic, the candle, it is apparent, does not fulfill the requirements of high grade railway service.

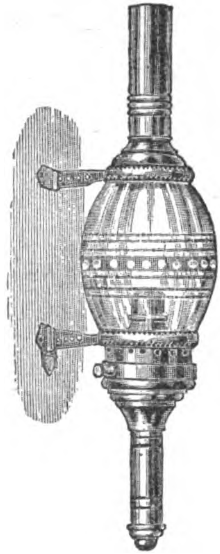


Vegetable oils are used in cases where refined petroleum is difficult to obtain. Rape seed oil, it is probable, has been put to this use more often than any other. Colza, oil derived from a variety of cabbage, has also been used for lighting cars in some instances.

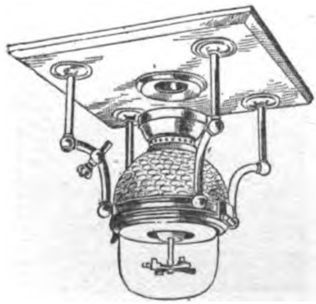
The common form of mineral oil lamp in general use consists of a reservoir of oil from which a wick passes out through a tube. The oil is drawn by capillary attraction through the wick to the top, where it is lighted. The flame is brightened and kept from smoking by a current of air against its surface. Metal deflecting surfaces are placed adjacent to the flame and a draft produced by means of a glass chimney. An improvement of the ordinary lamp is the invention of the central draft burner, which contains a flame separator for deflecting the upward air current through a central tube against the surface of the flame. In some cases a current is also directed against the outside of the flame by corrugation of the chimney or by means of a brass deflector. American railways have found the use of mineral oil very advantageous for lighting cars and it is in general favor in all parts of the world.

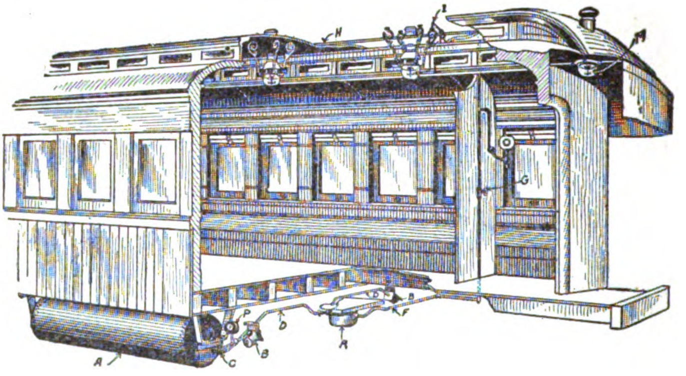


Ordinary coal gas for lighting cars is said to have been first used in England. It was stored in weighted rubber bags placed on the roofs of the cars. This primitive plan proved unsatisfactory, however, and was abandoned. In Belgium and other European countries carbureted coal gas has been found practicable for lighting trains. The gas is enriched and its illuminating qualities increased by passing it through vessels containing gasoline or naphthaline.



A device known as the pintsch light is favorably thought of in America. It is a representative of what is known as the oil gas system of lighting, crude petroleum being used in its manufacture. The gas is generated by vaporizing the oil at a high temperature in cast-iron retorts. It is compressed into receivers from which it is piped to cylindrical steel tanks attached to the car. The appliances on the car for using the gas may be studied in the accompanying illustration.





Pintsch Gas Light.

Pintsch system of lighting cars by gas. "A" represents the storage tank, in which a sufficient supply of gas is carried to maintain the lights in the car the desired length of time, the number and size of the tanks varying in proportion to the requirements of the service. The gas is supplied to these tanks under pressure at regular filling stations, a hose connection being made between the supply pipe and the filling valve "B," which in turn are connected with the storage tank by means of the extra heavy pipe "D" connecting into the tank valve "C." The pressure in the tank is at all times indicated on the gauge "P." From a branch in pipe "D" the gas is conducted through the reducing valve or regulator "R," in which the pressure is so reduced and governed as to maintain a constant pressure of one-third of an ounce on the outlet pipe "F," irrespective of the pressure in the tank. The regulator controls the gas pressure on the lamps in a perfectly uniform and automatic manner, whether the pressure in the tank is two pounds or one hundred and fifty pounds. From the regulator the gas passes into the car at any convenient point and terminates in a main pipe "H" extending along and on the roof of the car, from which branches "I" are taken off at each lamp, connection being made to one of the arms of the lamp, designated as the gas-way arm, which contains a tube through which the gas passes down into the burner of the lamp "L." The gas is turned off and on by means of a gas cock "K" on the gas-arm of each lamp, but if desired all of the lamps can be regulated at once by means of the maincock "G" placed in the pipe "F" shown on the wall, or the gas can be shut off entirely at this same point. "O" represents a bracket lamp for use in toilet rooms and passage ways. "M" is a vestibule lamp used for lighting the platform and vestibule of a car.

The illuminating properties of gas made from petroleum are much richer than coal gas, while it loses less of its power by compression. The flame it produces is steady and comparatively brilliant. It is reasonably economical and every way superior to those that preceded it.

Cars are also lighted by carbureted air.* An air storage tank is placed under the car, holding sufficient compressed air to supply light for several hours. The air is obtained directly from the train pipe of the air brake and is let through a pressure reducer and a regulator to the carbureters in the roof, one being placed over each lamp, through which it passes to the lamps underneath. Gasoline in the carbureters may be supplied sufficient to burn forty hours. The danger attending the use of volatile oils and the difficulty of regulating the quality of the gas are obstacles that have been encountered in connection with this system of lighting.

Sir Humphrey Davy's discovery of producing light from a galvanic battery occurred early in the nineteenth century. Shortly afterward the identity of electricity and magnetism was pointed

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*** A carbureter is made of cold rolled copper about one-sixteenth of an inch thick. A compact mass of wicking is placed inside two copper shells. Each carbureter holds about twelve pounds of wicking, which will absorb some four gallons of gasoline at a time. An outer casing made of a double thickness of kalamein iron packed between with straw board protects the carbureter from injury, keeps off the rays of the sun and furnishes a chamber in which hot air from the roof of the car may circulate around the carbureter and keep it warm. The compressed air passes through this carbureter and is sufficiently enriched by the gasoline to give out a bright light.**

out. A practical scheme for producing artificial light by electricity was first devised by Faraday in 1831. Progress has been steady since that time, so that to-day electricity is recognized as the highest form of lighting known. Many methods are employed for using electricity.* Recognizing the great merit of the light, experiments looking to the use of it on trains have been constant. Those first made contemplated the use of storage batteries. This, however, did not prove satisfactory, partly because of the detail to be intrusted to hands necessarily more or less unskilled, and partly because of the undue depreciation (wastage) of the batteries. A partial solution, for trains running a long distance, was found in the application of what is termed the direct current lighting system. The current is obtained by the use of a moderately high speed engine belted to a dynamo carried in the baggage car of the train. Little instruction is required to operate it. When the weather is not so cold as to preclude, the engine may be

*Among these may be mentioned: The primary battery system, in which some form of primary battery furnishes the current. The storage battery system, in which storage batteries charged with electricity from stationary plants furnish the current. The direct dynamo system, the electricity being furnished directly to the lamps from a dynamo on the train. The combined dynamo and storage battery system, in which storage batteries are charged by a dynamo on the train, the current from the one supplementing that from the other. The track wire system, in which the current is taken from an electric wire running along the line of road by a trolley or by a shoe on the train.

operated by steam from the locomotive. If, however, for any cause, the latter cannot furnish the necessary power, a car is attached to the train equipped with boiler, engine, dynamo and storage for coal and water. In cases of this kind a man is required especially to operate the engine and look after the lighting of the train. Water may be obtained for the engine from the locomotive tender by means of an injector pump, carried through a hose, or a special tender conveying water may be used. Trains are wired for electricity very much as buildings are wired. When an engine and boiler are provided to operate the dynamo, they may also be used to heat the train with steam, if desired, thus lessening by so much the drain on the locomotive.

The practicability of bringing electricity for lighting purposes within the means of railroads generally is only a question of time. We know that it is possible to thus light cars because there are many trains made magnificent by this method of illuminating. Its brilliancy and security exceed all others. Of this there can be no doubt. Moreover, by the use of pliant tubes and other simple devices the light may be brought to the elbow of the traveler so that he may pursue his reading without weariness to his body or fatigue to his eyes. The delight of this luxury cannot be told. Electricity as a light is devoid of offensive odors and its use is practically unattended with danger. Thus it may be safely taken into one's berth. This is not only practicable, but a matter of common occurrence, the light being placed at the head of the bed and so arranged as to be entirely at the disposal of the occupant of the berth. The cost of lighting by electricity compared with more primitive devices has been one objection to its general introduction by railways and a reason why its use has been confined to special purposes. An expert in such matters, Mr. George Gibbs, M. E., referring to questions concerning electrical lights, says: "In using the direct current system of electric train lighting it is not deemed practicable to light short-run trains. Owing to the fact that any car is liable to be called into service in local trains at any time, it would be necessary to equip every baggage car with dynamo and engine and to wire every car in the service for electric lighting. This, in view of the fact that such cars would be used but little when light would be required, would make the expense unwarranted. It is also claimed that in breaking up a train (that is, in taking on or setting out cars) there is a liability of injury to the lighting system. Where cars are set out at junction stations or elsewhere to be taken on to other trains it would be necessary to provide some other method of lighting them from the time they were disconnected until taken up by the other train." When electricity is used in cars it is apparent that they must also be equipped with lamps or other devices to meet emergencies. Indeed, this is true of all systems when the light comes from a central source that may, through mishap, be destroyed or rendered inoperative. This, it is apparent, renders a double equipment necessary, and thus adds so much to the first cost and also to the cost of maintenance.

In 1893 and 1894 certain of the great European railways adopted the practice of lighting parlor and sleeping cars by electricity, using a battery of accumulators in connection with a regulation dynamo operated by steam from the locomotive. Similar methods have been followed elsewhere successfully. Railroads in America that used secondary batteries reported them as, on the whole, too expensive for lighting purposes. In the main, the companies confine the use of electric lights to the Wagner, Pullman and similar cars on limited trains. Experiments with various forms of storage batteries seem, on the whole, to be generally unsatisfactory, resulting in America in the adoption of the direct current system.

The Biddle system of electric lighting provides for a connection between the axle of the car and the dynamo. When the car is in motion the current produced from the dynamo passes into a storage battery, from which it is taken up for use in lighting, as required. Under this method each car has its own lighting power, and may be attached to or detached from a train at any time without embarrassment. The perfection and cheapening of such a system of lighting as this is highly to be desired, as it would forever simplify the subject and render it practicable to light all classes of trains by electricity.

In this connection it is interesting to note, for the information of those not familiar with the uses of electricity, that, under the direct current system, the electricity is generated in and furnished by a dynamo (as it is used or burned), and in such quantities as the lights require. Under the storage system, the electricity is stored in cells or batteries for use as required. These batteries may be charged from a dynamo on the train, or at stations along the line. A difficulty that is experienced with storage batteries, and that has caused them to be looked upon unfavorably, is the fact that more or less electricity escapes. In other words, the storage is not perfect. Improvement in this respect is highly to be desired, as upon it great possibilities hinge. Experiments with storage batteries have, it is apparent, been the same everywhere—in England, where investigations of this kind are carried on with great thoroughness, not less than in America.

Cost of plant, expense of operation, maintenance and renewal are important factors in lighting railway cars. Safety is a relative thing. All known methods are attended by some element of risk, to be more or less regarded. Excessive cost, it may be said, will preclude the use of a device, no matter how desirable it may be. Railroad companies, like housewives, must bring their outlay within their means. Three prominent and justly popular illuminants for lighting cars are Mineral Sperm Oil of three hundred degrees

Fahrenheit fire test; a Fixed Gas; and Gasoline of eighty degrees Beaume. The first two are used with such approach to impunity as to make accidents the exception; because of this they may be called safe. Gasoline, however, one of the most subtle and elusive combustibles and explosives known, is registered as dangerous. It does not follow, however, that it may not, by adopting careful precautions, be made reasonably safe. The manufacture of gas for the pintsch light is claimed to be as free from accident as the manufacture of gas for use in cities. Accidents from both occur under similar conditions, such as the gasometers being struck by lightning, or the pipes leaking into parallel conduits of air, and thereby forming an explosive mixture. These are natural accidents, and not such as to properly exclude an article on account of the danger attending its use. In connection with the pintsch and similar systems of storing gas for use, accident may occur in charging the tanks, such as the moving of the car while the hose is coupled, thus rupturing the hose and, through some unfortunate circumstance, igniting the gas. Accidents of this nature have occurred, but not with such frequency as to make the risk noticeable. Many railroads that use this form of lighting have never had any accident of any kind in connection with it. There may be said also to be no risk of a tank exploding, either by heat or by concussion, or none worth mentioning. An accident occurred in Germany in 1887, caused by puncturing a gas tank and the ignition of the gas, in connection with the collision of two trains. It was not such as to justify excluding the light or excite particular apprehension.

Coal oil lamps have been the source of many accidents, but generally because of the use of inferior and unfit oil. Such oil was common, indeed almost universal, before the three hundred degrees Fahrenheit fire test oil was manufactured. Even now the supply of good oil is limited. When the higher test oil was introduced, it was some time before lamps were provided adapted to its use, or railways appreciated its superior excellence. Moreover, it was long before railroads adopted adequate methods for testing the oils they used. And in regard to this it will probably always be the case that there will be more or less roads that will never test their oils. This will subject them to impositions. Moreover, so long as the lighter and more dangerous oils are cheaper, and give as good or better light than others, they will find purchasers. It is claimed, I know not how truly, that every accident which has occurred from lamps exploding has been due to the use of low proof oils. A matter of interest in connection with the practice of lighting cars with lamps is that danger of fire arising from an overturned or broken lamp is so small in the case of high grade oils as not to make it an object of solicitude; the danger arises in every instance from the risk of explosion occasioned by the use of inferior oils.

More or less mishaps occur in car lighting which never become matters of public record. But the damage is not great. One reason why there are not more accidents than there are from oil lamps is due to the sensitiveness of the flame. A shock severe enough to break the lamp generally extinguishes the light. Moreover, oil lying loose on the bare floor of a car does not ignite so readily as when absorbed by a carpet. When we consider the great number of lamps that have been in use on railroads, and contrast this with the few mishaps which have occurred, the result is surprising. An objection to oil, and a good one, is that the light is insufficient; moreover, that the lamp is a source of continual annoyance and petty mishaps, both to carrier and traveler.

In the case of gasoline carbureters experience is so slight, when compared with oil lamps and compressed gas, that definite conclusions can hardly be drawn. In a wreck on an American road, it was demonstrated that the carbureters would not explode if the safety valve remained open. It is said that considerable trouble is experienced with this form of lighting in cold weather, because at such a time chilled gasoline does not vaporize readily. It is claimed not to have been demonstrated that the carbureter furnishes either a better or a cheaper light than is obtained from three hundred degrees Fahrenheit fire test oil or from compressed oil gas. As regards safety, it is accepted by many conservative managers as coming within the bounds of reasonable assurance; this notwithstanding it does not stand all the tests to which it is thought by many it should be subjected. The cost of lighting, under similar systems, varies appreciably in different sections and on different roads. Where oil is used the cost of equipping and, afterward, the expense of operating depend upon the lamps used. The depreciation in connection with the use of oil lamps is dependent upon the nature of the lamp and accessories of the service, including use and wear and tear from extraneous sources. It is said to vary from five to ten per cent. The cost of the pintsch system also varies. The price is dependent, as in other cases, somewhat upon the nature of the lamps. They may be very elaborate or commonplace. If more than one receiver is needed, the cost will be increased correspondingly. The manufacturers of the pintsch device claim the plant necessary for a railroad company to have, outside of the appliances it uses on its cars, should not cost to exceed an average of one hundred dollars per car. This, it is apparent, will depend on a number of contingencies not necessary to recapitulate here. They also claim the depreciation of fixtures and appurtenances of cars is lower for this system than any other because it is more simple. However this may be, it is apparent that it cannot be very great. The ornamental and reflecting parts are subject to the greatest depreciation. There must, however, it is apparent, be considerable depreciation annually in the case of the plant used to produce the gas.

The carbureted gas system requires but a small outlay off the car, a metal shed for storing the gasoline being about all that is needed. The cost of fixtures and appurtenances per car is estimated at about five hundred dollars. The depreciation is said to be less than for oil and greater than for compressed gas.

In considering the various systems of lighting cars, allowance must be made for relative cost of cleaning, attendance, breakages, small repairs, renewals and kindred outlays. In the case of oil, some allowance must be made for damage from spilled oil, etc. It is claimed that ten dollars per car per year is a reasonable estimate for such mishaps. The amount appears excessive.

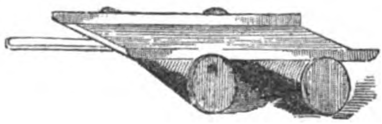
I may say, in concluding, that any account professing to represent the cost of systems of lighting, either as regards preparatory work or expense of operating, is not to be accepted absolutely because of the fact that cost is dependent upon facilities and other circumstances. Figures must, therefore, be considered as approximate merely. A treatise, moreover, that professes to describe particular systems must also be taken with allowance because of the constant changes that are going on. The general information it gives may be valuable, while it may be defective in particular things. It is in that spirit that I submit what I have to say in reference to lighting cars.

CHAPTER XIII.

CAR WHEELS AND AXLES.

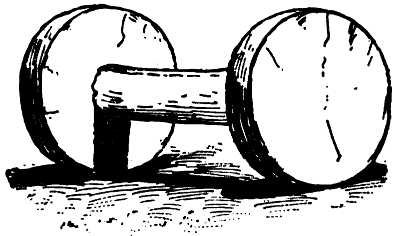
The importance of this subject, in connection with the train service, cannot be overestimated. It is a matter that directly interests trainmen as well as manufacturers. Treatises on such subjects, while of value in particular instances, are of greater value as illustrating themes of general and vital interest. In the constant changes that are going on particulars in regard to the form and manufacture of car wheels and axles will vary more or less, but attendant circumstances will remain substantially the same. In the accompanying chapter I have not only endeavored to elucidate particular methods, but to place the general subject in such a light that however details may change, the matter will still be worthy of the notice of practical men and students. I do not seek to exhaust the subject, but merely point out its more salient features. And as men are better able to understand what they see by knowing what others have seen, I shall, in the first place, briefly trace the evolution of wheels and axles. For to know the origin and history of a thing is to make us in sympathy with it, and therefore more likely to comprehend its peculiarities. This is the excuse I have to make for a habit I have, too often indulged in perhaps, of portraying the beginning of things. This is the more necessary in the case of objects that belong apparently to the commonplace. Thus, the wheel of a vehicle, whether of a railway car or a wagon, seems very commonplace, but when we trace its history, follow the ages of evolution it represents and the struggles of men through all their history to perfect it, we find the subject neither dull nor commonplace.

The wheel, above all other things, is the key to the vehicle and, therefore, next to power, the central idea of the art of carriage. In tracing its evolution for the last five thousand years we discover that from its first conception its development has kept pace with the needs of men and the highways they have constructed upon which to use it. The excellence of the highways of a country, it may be said, depends upon its settled and peaceable condition; upon the need of roads, in fact. Improved vehicles follow good highways, never precede them.



Syctalæ of the time of Alexander the Great, 332 B. C.

The axle and wheel of the ancient Grecian syctalæ represents, it is probable, the first conception of man. Thus, there can be no doubt but that the wheel and axle of the first cart that was ever constructed were one and revolved together. Afterward, as time passed, the axle was cut down more and more so as to leave the surface of the wheel as narrow as possible in order to reduce the friction.



The first form of Axle and Wheel.

This form of wheel and axle, amplified in detail, is still to be found in use in out of the way places on the frontiers of new countries and in the forests and mines of the world where great burdens are to be borne for short distances. It was, however, for many ages the only device known. The Aryans, as we learn from philological sources, had acquired the art of separating the wheel from the axle before they were scattered, many centuries anterior to the historic period. For a long time after the wheel and axle were made apart, the wheel itself was nothing more than a solid piece of wood with a hole in the center through which the axle, or hub, protruded. But this represented a great advance, a far reaching step. Later, but still in primitive times, much diversity

A Primitive Wheel.

existed in the construction of wheels, as in the present period. Progress in our day seems to be centered more particularly in the wheels of cars and locomotives, though the pneumatic tire and ball-bearing wheel may be said to be decided advances in the construction of the wheels of common road wagons.

In olden times, when the wheel was in process of being born, ideas concerning it were of very slow growth. After the wheel and axle had been separated, a rude linch-pin run through the axle outside the wheel held the latter in its place. Then the wheel (up to this time simply a section of a log) was strengthened with a crossbar, then with two, and so on.

It is a curious fact that with the advent of the railway, the highest form of carriage known, the axle and wheel should again be made to revolve in unison, as in the very dawn of intelligence among men, when the axle and wheel were a solid piece of wood. The ingenious manner in which the body of the railway car is borne on the journals that rest on the axles (outside the wheels) is one of the greatest, as well as most curious, achievements in the science of railways. Upon the first inception of railroads the wheel was, in some instances, made to revolve on the axle exactly as in our common road cart. But so much greater advantages were to be secured by

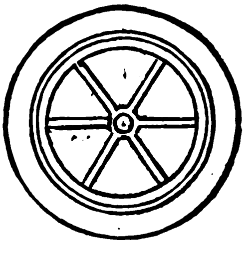
Wheel of an Ancient Roman Cart.

the revolution of the axle and wheels together that the latter plan has superseded the other.

The wheels of the war chariots of the ancients were at first solid; oftentimes made of bronze.

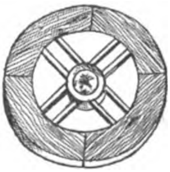
Ancient four-spoked Chariot Wheel of the Egyptians.

The conception of a division of the wheel, substantially on the lines of to-day, for road carriages and wagons, was a marvelous stride, the work of many centuries. In the beginning the tires, felloes, spokes and hubs were exceedingly rude, as shown by the illustrations we have of wheels in ancient times. At first the tire did not consist of metal, but of the toughened skins of animals, afterward of fibrous wood. Later, when mankind had learned to work in metals, bronze, hardened copper and iron were used in constructing wheels. Ornamentation was a noticeable feature in connection with the wheels of the ancients. The earliest form of wheel used by the Assyrians, who were the most progressive in this direction of any of the nations of extreme antiquity, had four spokes; afterward six. Every device was adopted to strengthen the wheel so as to enable it to withstand the rugged uses to which it was put in battle and in the hunting excursions of the king and his nobility.



Assyrian Chariot Wheel, 600 B. C.

Long before mankind had learned to strengthen the wheel by the free use of metal it was necessarily made very heavy and thick in order to afford the requisite strength. Thus the old driveway from Naples to Pompeii, still visible, indicates that the tread of the wheel even at that comparatively late day (40 B. C.), on the relatively good roads of Italy, was three inches wide. A distinctive feature of the wheels of ancient Chinese vehicles, and even those of a later period, is the heavy felloes.



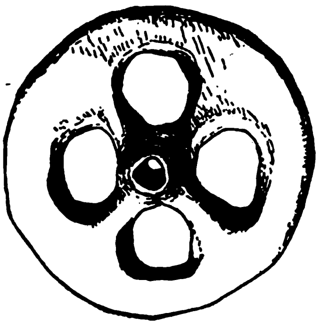
Ancient Wheel.

While the evolution of the wheel was slow, it was constant. As men acquired knowledge of vehicles they took great pains in constructing the wheel, for upon its strength and proper working the security of the occupant of the vehicle depended. In the shock of battle and in the wild retreat that oftentimes followed, the lives of the occupants of the vehicles depended upon the strength of the wheel to withstand the rough usage to which it was put. It was the most important part of the war chariots of the ancients, and on the tombs of old Egypt we find pictures of skilled workmen of that remote age occupied in constructing the different parts of the wheel and fitting them together. And while their work was exceedingly rude, yet the tremendous strain to

Ancient Egyptian Wheel

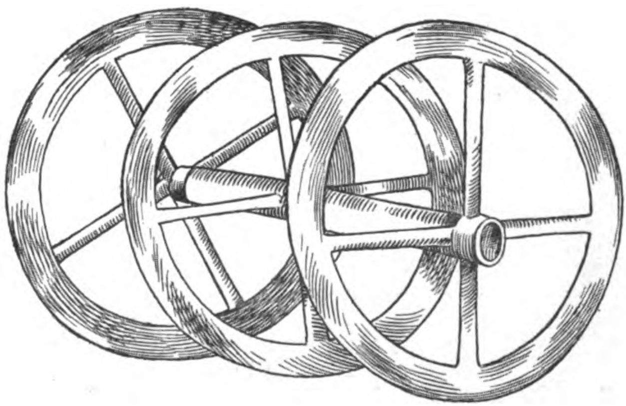
which the vehicles were put shows that they were durable, and in every way adapted to the needs of the times. One of these wheels, of which a cut is extant, shows a tire of wood, strapped to the rude yet strong felloe with bands of leather, the whole securely fastened to the hub by six spokes. The felloe in olden times, instead of connecting sharply as to-day, lapped over, the parts being riveted together.

Among the ancients the chariot was the great vantage ground of battle. Victory, as a rule, depended upon the number of such vehicles in action, the skill with which they were handled, and the courage of the occupants. In order to make them more terrible, long, sharp scythes and knives were attached to the wheels and axletrees of the chariots. The vehicle thus became not only a point of vantage, but in itself a destructive machine of war.


Primitive Wheel from Germany.

Some very interesting discoveries have been made of wheels used in Germany in prehistoric times. The more primitive of these were made lighter by cutting out the interior of the wheel, without materially weakening the structure. This form suggests the rude appliances of a far distant age.

Another exceedingly interesting discovery of prehistoric times made in the same locality is that of the axle to which three wheels are attached. The wheels and the axles were of bronze and revolved together. Exactly how this contrivance was utilized is somewhat a matter of conjecture. It is probable, however, that the structure formed the support of a war chariot,

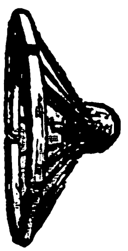


Ancient Bronze Wheels.

from which, perhaps, two or even more men may have fought from the bed of the vehicle, on either side of the center wheel.

The illustrations we have of the war chariots of the Assyrians, eight hundred years before the Christian era, show that high skill had been attained in the construction of the wheels of their vehicles. When we remember that, with the exception of a few great highways scarcely to be termed thoroughfares, there were no roads whatever, and that the chariot was brought into requisition in traversing the rough country and making incursions into the mountain districts, we may form some estimate of the strength and durability of the wheel and the vehicle it supported.

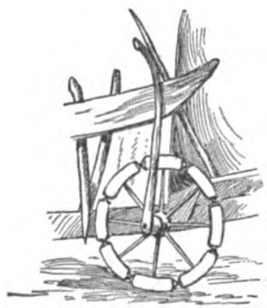
Among primitive wheels devised on the lines of those in use at present was one discovered in Cyprus. The spokes in this instance, instead of standing at right angles with the hub, projected outward, thus very much weakening their supporting power. Exactly what purpose was served by this form, or whether it represents a phase of evolution from the solid wheel to the spoke, it is impossible to tell. The lonely island where this wheel was found, represents in its history greater vicissitudes of fortune, perhaps, than any other spot on earth. At one moment enriched, the center of a high civilization; at the next its fortunes wrecked, the prey of one of the savage nations that surround it. Thus its fortunes have alternated. A few years ago it was dominated by the Mohammedan; to-day it is, for the moment, under the beneficent rule of Great Britain. To-morrow it may be a province of Russia. Who can foretell its future or would wish to share its fortunes? Here many rude



Ancient Wheel from the Island of Cyprus.

appliances connected with the carriage of earlier ages have been discovered.

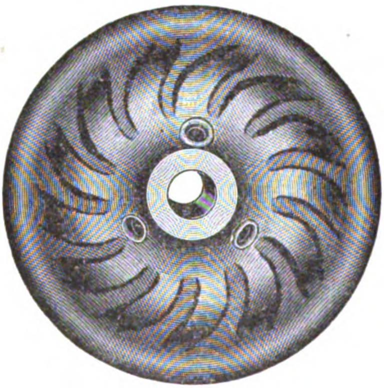
In Bulgaria an exceedingly primitive form of wheel is still to be found in use. The felloe, instead of forming a continuous ring, is disconnected, as shown in the illustration. As it was in this locality that the wheel was first invented, greater advance might have been expected. Under normal conditions this would doubtless have been the case, as the people are highly intelligent and progressive, but for all time it has been the battlefield of southeastern Europe and the scene of constant strife. Thus little progress has been made. Of all the primitive forms we have this wheel of ancient Thrace is one of the most interesting and apparently constructed on the least intelligent lines.



Bulgarian Wheel.

The spoke, felloe and tire represent the third great stage in the evolution of the wheel. With these perfected, we have come to a standstill, but only, doubtless, to make some further great advance. At present men are seeking to perfect the discoveries that lie back of each of these devices. In the casting of the solid car wheel of to-day the principle that underlies the original discovery is still observed.

The car wheel, however, differs much from any wheel ever used on road vehicles. Among other things, by the flanges with which it is kept on the track. Also by its conical tread for diminishing the resistance on curves. The axle bearings are outside of the hubs. This facilitates lubrication of the journals and the easy exchange of the bearings as the latter wear out or are rendered no longer fit for use. One reason why the wheel



Cast-iron Freight Car Wheel.

was placed under the body of the car instead of at the side was that the width of the vehicle might not be limited by the gauge of the track.

The form of car wheels in use in different countries is not the same, but has, in a measure, adapted itself to the weight of the vehicle. But preconceived notions have been a governing force. The wheel in America is heavier than in England, and we load our vehicles much heavier.

Business talent and experience are valuable in the making of car wheels as in the manufacture of other articles. Upon the skill of the manufacturer depends the quality of the goods. This is shown, not so much in the contour of the wheel (because those made by a hundred different manufacturers are very much the same), as in the constituent parts of the wheel. In its ability to withstand wear and tear and breakage.

Locomotive Tender Wheel—Cast iron.

Car wheels were at first very much like the ordinary wheels of a wagon. They were guided by flanges on the rails instead of flanges on the wheel, as at present. The rail had a raised lip on the outside edge to keep the wheel on the track. Flanges on the wheel were a later device and were first used in the latter part of the eighteenth century.

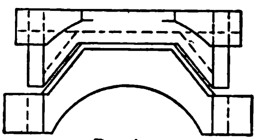
Various kinds of car wheels have been devised, and many kinds are in use. All are ingenious. One form is composed of a cast-iron center surrounded by a steel tire. It is made by heating the tire to a white heat and pouring the melted iron into the center of it, thus uniting the two metals. These wheels are sometimes made with hub and spokes, sometimes with hub and disk.

Wood, paper, oakum and other pliable substances are often placed between the center of a wheel and its rim as a packing.

A common form of wheel is that made of chilled iron without a separate tire. There are different patterns, according to the manufacturer's ingenuity.

A wheel made of a mixture of cast steel and cast iron is claimed by those who manufacture it to have greater strength than other wheels.

A cast-steel wheel is manufactured somewhat similar to the chilled wheel. It has no tire. This wheel, to use the manufacturers' phrase, may be "turned up" when the tread is worn and thus be made to do further service. Steel tired wheels are similarly treated.

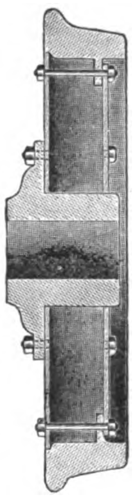


Bearing.

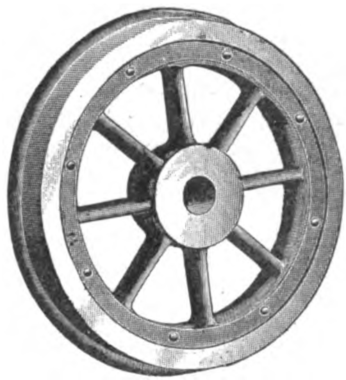
Car wheels were formerly keyed on the axle. A later plan is to make the hole in the center of the wheel a little smaller than the axle, into which the latter is thrust under pressure. The keyed wheel will become loose with use; the other will not.

The bearings of locomotive wheels, it will be noticed, are on the inside, while those of cars, locomotive tenders, etc., are on the outside.*

The severe strain and rough usage to which car wheels are subjected necessitate hardness of tread (that part which comes in contact with the



Sectional view of Paper Truck Wheel.



Locomotive Truck Wheel made of paper, with cast-steel center and steel tire.

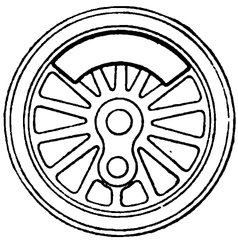
track) as well as great strength otherwise. A material which is claimed to very fully meet these requirements, and yet withal economical, is chilled cast iron. It is claimed that such

* The bearing is the device that rests on the journal; a journal is that part of the axle that projects through (outside) the wheel. The journal box is the covering for the journal and bearing and contains the oil and waste for lubricating the journal and bearing.

wheels are more economical than others. Instances are given where they have traversed a distance of two hundred thousand miles without being rendered unfit for use.

Paper has been used in the manufacture of car wheels with success. A compressed mass of the substance is placed between the iron hub and steel tire, inclosed between sheet-iron disks. The paper is first made into sections about half an inch thick; these are subjected to a heavy pressure and then quickly dried in hot air. The sections are then pasted together until the required thickness is produced.

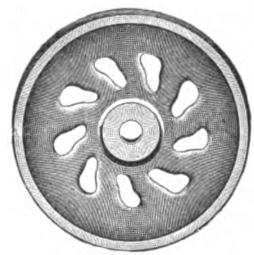
The cast-iron chilled car wheel is claimed to be an American discovery, and while not universally adopted by other countries for railroads, it has been generally used for street cars. It has contributed greatly to the economical operation of American railways. It is claimed that it can be produced cheaper, relatively, than any other wheel, and when worn out the refuse (scrap) represents a larger per cent. of first cost than that of its competitors. An expert in such matters, and a highly successful manufacturer, thus describes the process of manufacture: "When certain kinds of gray cast iron are melted and poured against a metallic mold, that portion of the iron next to the mold becomes hard, white, crystalline and



Locomotive Cast-iron Driving Wheel with steel tire.

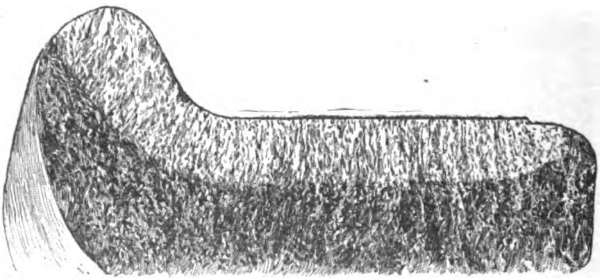
brittle, while the interior portion remains gray and more or less tough and fibrous. This conversion of the iron that comes in contact with the metallic mold into the hard, white variety, is called 'chilling,' and it is upon this principle that the manufacture of chilled car wheels depends. This property of chilling, which certain irons possess, must have been known to iron founders at an early day, for we have evidence of the fact that parts of plows, faces of forge hammers, punches for punching holes in wagon tires, rolls for rolling metal, and various other implements, were chilled, long before the manufacture of car wheels."

Some kinds of iron do not possess the property of chilling. Again, other kinds which may be chilled lack qualities which are essential. The early method of smelting iron ore was with charcoal, and it is probable that chilled castings and chilled car wheels were originally made from charcoal irons exclusively. Under certain conditions coke or anthracite irons have been found to possess the property of chilling, but they do not produce equally good results. Generally speaking, the process of chilling is attained in this way: a mold is formed, the bed of which is of sand, the rim of metal. Into this mold the molten iron is poured.



An ingenious form of Chilled Iron Wheel for Passenger Cars.

That which comes in contact with the metal is in the process of cooling chilled, or hardened, while the other simply coagulates. The center of the wheel is thus left comparatively soft, while the finest tempered file will not affect the tread. It is supposed the chemical effect produced in the latter is that of changing the free or graphitic carbon to combined carbon in the tread of the wheel, so rapidly cooled by coming in contact with the metallic mold.



Portraying the condition of the wheel after the metal has cooled. The white portion along the upper margin represents the chilled or hardened part of the tread and flange that strikes the rail.

A method at one time practiced was to remove the wheel from the mold as soon as the iron was set, and to then cover it up in hot sand or ashes, where it remained several days until nearly cold. Another plan was to lay the wheel on the floor and build a fire around the tread to bring its temperature up to that of the center of the wheel; the whole was then allowed to cool slowly.

The contracting chill may be described as follows: The ring constituting the chill is divided into ninety-six sections, or blocks, held in position by an outside hollow retaining ring which may be expanded or contracted. Before the metal is poured into the mold, steam is turned on through the outer ring, the expansion of which causes an increase in the diameter of the chilling surface. When the manufacturer commences to pour the molten metal, the steam is turned off and in its stead a current of cold water is passed through the ring, the contraction of which decreases the diameter of the chilling surface.

The manufacturer already quoted, and to whom I am greatly indebted, thus describes how the ordinary chilled wheel is made: "The iron first being properly mixed and melted must be delivered to the mold at a proper temperature; next, the iron should be so introduced into the mold that the flow of the metal will be uniform and rapid, otherwise irregularities in the formation of the chilled metal will occur which will make a defective and dangerous casting. The sand which forms the other portion of the mold must be moist enough so as not to wash before the molten iron, and yet not too moist, otherwise it will have a chilling effect upon the iron in the plates and hubs, thereby causing them to be hard and creating danger from the weakness which would follow. These and other things have a bearing on the production of a car wheel, and even though all the conditions up to this point have been properly observed, its good qualities are still in a precarious condition and are dependent upon further treatment. Thus, the wheel must be removed from the mold or flask before it becomes too cold, and yet not before it is sufficiently cooled. The wheel is then put into the annealing pit, which must be carefully closed and the wheel allowed to cool.* It generally takes the wheel from four to five days to cool. The cooling is not hastened by artificial means. The necessity of annealing arises from the fact that when the wheel is cast the outer rim or chilled portion (on account of its greater density and hardness) shrinks relatively more than the center (or plates) and is moreover cooler. When the wheel is put into the annealing pit the heat throughout becomes equalized, after which all parts are cooled at the same time. This reduces the possibility of an unequal strain or contraction, which latter would be a fatal defect even if the wheel were of the best pattern and manufactured with the greatest care otherwise. From the foregoing it will be seen that the metal from which the car wheel is made forms but an item, a defect in any item being fatal to all others. When the wheel has passed through the conditions described and has emerged from the annealing pit (if not taken out too hot), it is in a condition not to be affected by anything so far as the maker is concerned. It may be said in conclusion that

* The "annealing pit" referred to is oftentimes made of boiler plate iron, lined with fire brick and having an air tight lid, into which the wheels are placed while red hot and allowed to remain several days, after which they are taken out and further cooled before being cleaned, inspected and tested.

because no artificial heat is added while the wheel is in the pit the temperature never rises high enough to affect the chilled portion of the wheel."*

Serious injury to the chilled iron wheel is caused by undue application of the brake. Great heat destroys the life of the chill, and if from any cause its temperature reaches the red hot point, the effect is to transform the crystalline structure back into the semi-fibrous. Sliding of a wheel, from undue use of the brake, results in expanding the tread and cracking the plates (body of the wheel), oftentimes, in fact, ruining the wheel. Careful regulation of the brake is, it may be said, at all times necessary to the full usefulness and durability of a wheel.

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* Another intelligent writer, describing the process of making chilled wheels, says: "The latest and probably the best plan is to place the wheels, as soon as they can be removed from the molds, in tight pits lined with firebrick or some other substance that will stand the heat, ten or more in each pit. The equilibrium of heat between the tread and plates and hub, which has been destroyed by the rapid cooling of the tread by reason of the chilling process, is then restored, either by the development of latent heat, which occurs when so many hot wheels are confined in tight pits, to an extent sufficient to equalize the temperature of the different parts of the wheel; or by passing a current of cold air through the hubs of the wheels, which rapidly reduces the temperature of the center of the wheel until it approximates that of the tread; or by having the pits heated before the wheels are placed therein, and then by the application of additional heat rapidly raising the temperature of the tread until it approximates that of the plates and hub. The wheels are allowed to remain in the pits several days and are not removed until all tendency to fracture from strain has been removed."

While so far as outward appearance is concerned cast-iron wheels are all alike, the resemblance is more apparent than real. No two wheels are exactly alike. Certainly the wheels of different manufacturers are dissimilar. But beyond this, the wheel must be adapted to its use. Thus, those suitable for a level country are not suitable for heavy grades requiring undue and prolonged application of the brakes. Under such a strain the chill of the wheel is softened while its other parts remain unaffected. This change in the integral structure results oftentimes in destroying the usefulness of the wheel, but in any event in undue wear and tear.*

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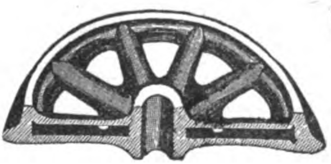
*"The conditions of service on roads having heavy grades, in contradistinction to those which are comparatively level, have developed the necessity of a difference in construction to correspond to the different degrees of service. A well chilled wheel, weighing six hundred pounds, which is perfectly safe on a comparatively level road, is very apt to crack or break when operated under the extraordinary conditions developed by heavy grades. To overcome this, wheels for mountain service must be either made softer or with a less chill, or made with correspondingly heavier plates to stand the greater strain. The first remedy would be too expensive on account of the fact that it would not be economical to reduce so large a mileage; for, after all, the mileage made by a wheel is what governs its value; and a comparatively light reduction in the chill or softness of the wheel would reduce the mileage service twenty-five per cent. Therefore it has generally been conceded that it is better and cheaper to make the wheels for mountain service at least ten per cent. heavier in weight than those for level service. The additional cost is reduced by the fact that the railroad company has ten per cent. of increased return scrap, so that the additional expense is nominal; at the same time the high chill may be maintained without risk of breakage, and thus greater mileage obtained."—*T. A. Griffin.*

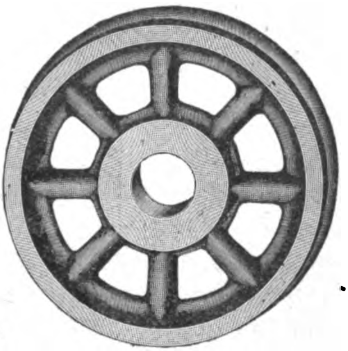
The first chilled iron wheels were of the spoke pattern with a split hub, held together with a wrought-iron band. Afterward new forms were introduced, among others the single plate, double plate, hollow spoke and solid spoke wheel, as shown by the illustrations. The double plate is claimed to have an advantage over the single

Single Plate Wheel

Double Plate Wheel.



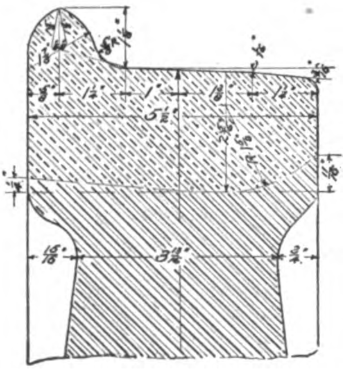
Hollow Spoke Wheel.



Solid Spoke Wheel.

plate wheel in this, that should one of the plates break or crack the other has sufficient strength to hold the wheel for the time being.

Steel tired wheels were at one time esteemed to be necessary to the passenger service of railroads; safer, in fact, than the chilled wheel. The latter has, however, been steadily coming into

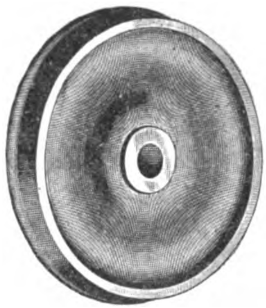


Section of Steel Tired Cast-iron Wheel.

favor, with increased weight and improvement in manufacture, till it has reached a point where it is claimed to compare favorably with the steel tired wheel. Excessive cost is an objection to the latter. In its manufacture the making of a proper connection between the cast-iron center and the steel tire has been a difficult problem to solve. Retaining rings have been used in this connection successfully, but they have added to the cost. Steel tired wheels are sometimes made in this way: The tire is manufactured in advance, the mold for the center of the wheel is arranged, and a space left for placing the tire in the mold, so it will form a part thereof; the mold is opened, and the tire, heated red hot, is placed within it; the mold is then closed and the metal for the center of the wheel poured in. In this manner the two metals are perfectly welded, the flared form of the tire carrying off the gases as the cast iron is poured in and comes in contact with the steel.

Scrap iron is also used for wheels with a wrought forged center. In preparing the scrap iron for this use the pieces are piled in such a way that the grain in the finished wheel has no uniform direction. This prevents a crack extending any distance should one start. These wheels also have steel tires.

The thickness of tire of a steel tired wheel varies; generally speaking it is from two to three and one-half inches thick. When worn to the thickness of an inch it may be said to be no longer fit for use.


Cast-iron Car Wheel with steel tire.

The wrought-iron wheel of French design is made as follows: The rim is first cut and bent to a proper radius and the ends welded together while the rim is heated. It is divided into as many sections as there are to be spokes in the wheel, into which grooves are cut ready to receive the spokes. The hub is formed of two rectangular iron bars rolled around a conical mandrel under a hammer operated by steam. Recesses are then stamped therein, when heated, for placing the spokes. When the wheel is set up it is placed in a furnace so constructed that the flame does not come in direct contact with any part of the wheel. The maximum heat is applied to the center and transmitted gradually to the other parts of the wheel, which, after reaching a welding heat, is placed in a die under a steam hammer and given a few blows, and again heated and hammered in order to insure perfect welding in all parts. The wheel is then cleaned and passed to the turning and boring mills, from which it comes out ready for use. The French driving wheel is manufactured in the same way substantially. Sometimes the wheel is heated and hammered a third time before it is finished.

Usage has demonstrated that greater durability is insured by allowing a wheel periods of rest. The molecules of iron disintegrate, and are finally destroyed by continuous vibration. Engines have more frequent periods of rest than passenger coaches, with the result that the wheels of the former are found to be in better condition after like service. This holds true also of passenger cars that make short trips, compared with express cars which make long and continuous journeys.

The heating of the journals has been an obstacle to overcome in the use of car wheels. Experiments have demonstrated that large journals have less tendency to become heated than small ones. Another important feature is the cost of lubricants. Different styles of axle boxes, ingenious in the highest degree, have been constructed with a view to minimize the embarrassment arising from hot boxes and reduce the cost of lubricants as much as possible.

In the operation of railroads the flange of the wheel is of the utmost importance, as may naturally be imagined; upon its strength depends the safety of the train. It is the flange that keeps the train on the track; this is especially imperiled at curves and cross-overs. Its efficacy, however, in a measure depends upon its relation to the wheel gauge and track gauge. To secure the maximum safety, they must be uniform. This uniformity requires co-operative effort between the machinery and track departments. In the evolution of the track and car wheel, differences in this respect have caused many disasters. Moreover, both wheels and track wear out much quicker if uniformity is not observed. Each day, however, lessens embarrassments of this nature. In the case of locomotives with three driving wheels on each side, the flange is usually omitted from the front or middle driver. With this exception all wheels used on railways have flanges.

Referring to the action of car wheels on the rails, an expert on such subjects* has this to say: "The form of car wheels exerts a much greater agency in the motion of trains than is generally supposed. Car wheels are controlled by two opposing forces which manifest themselves whenever the two associate wheels have unequal distances to travel, as on curves, or for other causes. On leaving a tangent unequal conditions are imposed by the relative change in the direction and length of track, causing a disturbance; whichever wheel of the pair is at the moment carrying the greater load is proportionately retarded by the greater traction, while the opposite one is impelled forward by the momentum of the

* Mr. E. L. Taylor.

train; the two, as will be readily observed, exerting a compound twist upon the axle. This is an unnatural condition, as the axle is supposed to be a neutral member, favoring and supporting each wheel alike. This condition may also result from the wheels being of unequal size. Efforts have been made to obviate this last named cause by coning the tread of wheels, which device never had anything to recommend it, either in practice or philosophy. A train when traversing a curve at slow speed, the outer rail being somewhat elevated, the wheel running upon the lower rail or shorter curve, bears against the rail at its largest diameter, or next to the flange, while the other one runs toward the smaller diameter, or in the direction of the apex of the cone; while with the train traversing the same curve at a high speed exactly opposite conditions exist; the wheel on the longer curve or outer rail runs on its greater diameter, and the other on the shorter curve on its smaller diameter. It is easily determined how much the outer rail, at certain degrees of curvature, should be elevated providing for a certain speed per hour. But in an undulating and mountainous country it is difficult or impossible to obtain this condition and then maintain it. The effect of this is often observable and has many times come under the writer's observation on curves where every scientific rule and requirement had been, apparently, complied with, and where comparatively regular high speed and unmixed trains were used, the inside of rail of shortest curve being smooth, bright and much worn away, while the other or longer one was dull in color, showing no evidence of unusual contact with flange of wheel. In many places rails made of the best material, iron or steel, put down in the best possible manner, on a good roadbed, and kept in good condition, present a bright, polished surface with every evidence of wearing away rapidly. The crown does not present a continuous plane of polished surface (although exceptional cases do occur), but generally in a succession of short planes or scallop in the direction of length of the rail, very materially depending upon the hardness of the rail."

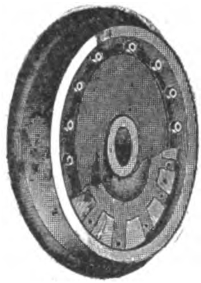
The practice of attaching the car wheels to the opposite ends of the axle makes the two wheels practically one, neither being able to move without the other. For this reason they must be alike in construction and application.

One of the problems in the manufacture of car wheels has been the difficulty of making accurate allowance for shrinkage. Thus, wheels made side by side and exactly alike, seemingly, in every particular, oftentimes show a great difference in this respect.

The weight of wheels will depend, measurably, on the grade, the load to be carried and the speed attained. Thus, the wheels of hand cars are lighter than those used on other cars. A method of manufacturing the wheels of hand cars is thus described: The tire is pressed out of one piece of wrought steel curved over on the inner edge to make the flange, and the outer edge turned down to provide for attaching it to the wheel plate. The tires are pressed, then reheated and rolled until perfectly smooth and cylindrical, the surface of which by this process is polished. Two disks of sheet steel form the center of the wheel, the outer edges of which are separated by a felloe of wood and bolted to the tire. The hub is cast in three pieces, one forming a distance piece between the disks, the others forming the wheel seat and flanges for holding the center of the wheel together. These are also fastened by bolts. The manufacturers of this wheel claim it cannot shrink, warp, shake to pieces or collapse, and that climatic influences have no effect upon it.

For another style of hand car wheel the tread, flange, plate and web are all in one piece. This wheel is made by what is known as the drawing and spinning process. It is claimed that the spinning leaves every wheel perfectly round and true, and that its shape will still be retained after the tread has worn through. Still another steel wheel used on hand cars, railway velocipedes, etc., is made of a single plate of steel about a quarter of an inch thick, the flange of which is corrugated so that the high points on its sides stand in planes at a distance apart equal to the usual thickness of a flange. The hub of this wheel is of solid forged steel.

Many foreigners are surprised when told that American manufacturers use paper quite extensively in making passenger car wheels. Similarly, it seems strange to us when we are told that in England teak wood is extensively used in the manufacture of passenger car wheels. In some instances the entire center of the wheel between the tire and hub is made of this material. It is held in place by side plates and retaining rings. The tire is made of steel. In the more common form of wheel the hub consists of two wrought-iron rings bolted together and fastened to the wooden center. In another form of wheel blocks of wood are forced into pockets in the center of the wheel, as shown in the illustration. In this wheel the blocks come in direct contact with the tire, which latter has an internal flange by which it is bolted to the center of the wheel through the radial arms forming the pockets. The oval part, around the hub of the wheel, is hollow, thus lightening and cheapening without weakening the structure.



English Car Wheel.

In examining the question of car wheels and accessories thereto, I have become interested in the views of Mr. Samuel Porcher. They are authoritative to the extent that he has had great experience as an engineer of motive power on a great American railroad. Starting out with the general proposition that cast iron is not as good as wrought iron or steel, that the tendency of a rotating wheel to burst is directly proportional to its diameter, and that the difficulty of making a perfect casting increases with the diameter thereof, he points out that cast iron would receive no attention whatever for use in the manufacture of car wheels except for its great cheapness as compared with wrought iron or steel. This cheapness, coupled with its utility, makes it very desirable for freight service and is the cause more or less of its use in the passenger traffic. "Steel, on the other hand," he says, "notwithstanding its great cost, is coming more and more into favor, and has the great recommendations of strength and safety. It is also of such a nature that wheels tired with it run much longer before being unfit for further service than those made of cast iron, and consequently renewals are less frequent."

He believes that a combination of steel and cast iron would be very desirable if it were not for the weakness involved in the manner of joining the two kinds of material together and the excessive cost thereof. Referring to the diameter of wheels, he goes on to say that, "allowing that on the score of economy cast iron must be used for wheels in freight service, we are led to reflect that here heavy loads are carried, and there is a growing tendency to increase them by letting the floor of the car down to a level with the draft timbers. All this makes it desirable to have the wheels strong and small to avoid bent axles and broken flanges. The truck must also be strong and the dead weight of the car reduced to a minimum. I should say that no wheel larger than thirty-three inches in diameter should be used under freight cars." In regard to the passenger service, however, he does "not believe we can recommend one diameter for all wheels, although such a state would be most desirable. For instance, in a sandy country, where competition is active and, consequently, speed is high and maintained for a length of time without interruption, I would scarcely hesitate to recommend the use of cast iron for car wheels, because steel will wear out so rapidly in such a place that its use will be unsatisfactory. If, then, cast iron is used we will find that we cannot make with it as large a wheel as we may determine is desirable when steel is used. And, just to follow this line out to its close, I will state here that we find that thirty-six inches seems to be the maximum diameter for cast-iron wheels. A thirty-six inch wheel rides well and gives immunity from hot boxes, a most fruitful source of annoyance in sandy districts. It is also easily applicable where all modern appliances under the car are found, including good brake rigging. In all passenger service, then, I would recommend thirty-six inches as the best diameter for cast-iron wheels." Referring to steel wheels, he says that, "allowing that the method of manufacture does not limit the diameter of a steel wheel as it does a cast-iron one, the claim that the largest diameter is the best is open to debate at least. It is claimed that increasing the diameter of a wheel increases its total mileage in proportion, or even more. Whether this be so or not, there are two very objectionable features that come with an increase in diameter —thus, the wheel is more costly and weighs more, and without giving, in all cases, proportionate return; we have to do more work in starting and stopping a large wheel, and in lifting it over the hills; when the diameter exceeds a certain figure we have also to pay more per thousand miles run. I am very firmly convinced that the matter of dead weight should receive more attention than it does, with a view to reducing it." With the greater speed of trains he believes that railway companies must more fully avail themselves of the braking power of each car. Heretofore this has not been the case. He argues that, as the height of the car or the length of the truck cannot well be increased, it is necessary to keep the size of the wheels within the limit that will permit efficient brakes being placed on all those that carry any weight. "A large wheel increases the liability to bent axles in curving on account of greater leverage, unless the size and strength of the axle are increased to correspond. The wheel itself must be made stronger. A four or six wheel truck will not retain its squareness and dependent good riding qualities so well with forty-two inch wheels as with thirty-three inch ones. Besides the brakes, the pipes for air and steam under the cars interfere with large wheels. As a consequence, forty-two inch wheels have been replaced by thirty-three inch wheels to some extent. On one road in particular, so strong is the inclination away from large wheels that thirty inches is advocated as a proper size for passenger cars. On the other hand, there is no doubt a car wheel may be too small, for the tires of small wheels probably do not get as much working up under the rolls, and, therefore, are not as tough or homogeneous. Small wheels are most destructive to frogs and rail joints. They revolve faster at a given speed, and when below a certain size increase the liability to hot journals. Speed alone, I am not willing to admit is the most prolific source of hot boxes. The weight per square inch upon the bearing is a very important factor. I have found by careful examination in a great many cases that the number of hot boxes bears a close relation to the weight per square inch on the journal and the character of lubrication. We find, furthermore, that while a three and three-eighths inch journal on a thirty-three inch wheel is apt to heat under our passenger coaches, a three and three-fourths inch (or when worn three and five-eighths inch) journal on a thirty-six inch wheel runs uniformly cool. In 1890 on one division I noticed about one hundred and eighty hot boxes (with the small wheel), against twenty-nine with the larger one, with a preponderance of the latter in service, the weight of the cars being the same. I do not know that there is any more tendency for a large wheel to slide than a small one under the action of the brakes, but large wheels wear out more brake shoes than small ones, if there is any difference in this particular."

The cast-iron wheel, so common in America, is hardly known in Europe, where wheels are steel tired. The latter are generally similar to the steel tired spoke wheel manufactured in America. The greatest possible rivalry exists between manufacturers of various kinds of wheels. This is one of the concomitants of trade and good results grow out of it. While those who manufacture steel tired wheels profess to see nothing that is good in those made of cast-iron, manufacturers of the latter, on the other hand, make light of all claims to superior excellence upon the part of their rivals. They point to the fact, among other things, that the million, approximately, of freight cars in the United States are, in the main, equipped throughout with chilled iron wheels, while a large percentage of the wheels under locomotives and tenders are also made of this material. This speaks well for their general excellence. Moreover, it does not stand to reason that the owners and managers of American railways could be inveigled into using an article of such vital importance that did not have great and inherent qualities to recommend it. In saying this, it is not sought to disparage the steel tired wheel. Far from it. The great use made of each wheel is indisputable evidence that each has, in its way, commanding merits. Statistics in reference to the breakage of different forms of wheels are, unfortunately, not as full or accurate as could be desired. In Germany, however, where seven different kinds of steel have been used in the manufacture of tires for wheels, the breakage is reported to be about thirty-four one-hundredths of one per cent. per year. This is much greater than the percentage of breakage for chilled iron. On the other hand, manufacturers of steel tired wheels claim that the percentage is greatly increased by the fact that the German government was experimenting with all kinds of steel—good, bad and indifferent; whereas, in case of tires made of open hearth steel the percentage of breakage is only one-third the average given above for all kinds. Rivalry in Germany as between the various kinds of steel seems, on the whole, to incline to the open hearth tire, the number in use having grown from fifty-three thousand in 1884 to two hundred and eighty-four thousand in 1889; and while the number was much less than tires made of Bessemer steel, which amounted to five hundred and ten thousand, the first named showed an increase in the number used of two hundred and thirty-one thousand in the six years, while the Bessemer only showed an increase of one hundred and thirty thousand.

The axles of cars, which form so important an auxiliary of the wheel, require, like the wheel, that the utmost care should be exercised in manufacturing. It is not too much to say that both must be, of their kind, perfect. The axle is, in the main, manufactured from wrought-iron scrap. The process of manufacture, however, varies in detail. But, generally speaking, the scrap is made up into packages or small piles, and placed in a furnace and heated to a welding heat, and then hammered by a steam hammer into a slab.* This slab is cut nearly in two, then doubled over and returned to the furnace for a second heat; it is then hammered into slabs about five inches wide by two inches thick. Three of these slabs are again heated to a welding heat and hammered into a single slab, one-half of which is finished into axle shape and the other half (on account of not being hot enough to finish) is again reheated and hammered. After being allowed to cool, the metal is made the required length by a cutting-off machine.

The weight of a car axle varies from four hundred and twenty-five to four hundred and seventy-five pounds. Driving axles are manufactured in much the same way, with the exception that they are given more heatings and hammerings, in order to more thoroughly remove impurities from

* Before putting the scrap into the furnace it is placed on a board. The width and length of the board vary, say, from eight to eight and one-half inches in width, and from eighteen to twenty inches in length. The weight of the scrap placed thereon also varies, say, from one hundred and twenty-five to two hundred and twenty-five pounds. The piles are placed in the furnace by means of the charging peel suspended from a swinging crane.

the iron. Steel axles are made from billets, arranged in piles of different sizes, according to the kind of axle to be manufactured. The billets are heated and hammered in the same way as iron axles.

Questions affecting the manufacture and use of wheels and axles are among the most important that engage the attention of those interested in the movements of trains, and my only regret is that I cannot give the matter greater attention here than I have.

CHAPTER XIV.

COLOR BLINDNESS.

Details relating to color blindness are considered of vital importance in connection with the operation of trains in all the countries of the world where railroads are known. They therefore find an appropriate place here. The disease or defect known as color blindness is defined as partial or total inability to distinguish particular colors. The latter manifestation is exceedingly rare. Color blindness is, in many cases, hereditary. Frequently, however, it is caused by disease or the use of alcohol or tobacco. It is also occasioned by overtaxing the eyes, accidents, a sudden jar or similar cause. A person, therefore, who has good eyesight to-day may not be similarly blessed to-morrow.

Color blindness is not due to any particular color of the eyes, and those who are thus afflicted may still possess good eyesight so far as distinguishing objects is concerned. If hereditary it is incurable, but in other cases it frequently yields to treatment. The disease is much more rare in women than in men. People who are color blind are oftentimes not aware of the fact, i. e., they are not conscious that other people do not see things as they do.*

Those who are color blind are oftentimes very sensitive about it. In many cases man's intelligence and judgment supply the deficiency of a defective eyesight. Dr. Stilling says, as a word of warning to those who are testing for color blindness: "It is a well known fact that color blind persons, by exercising their faculty of judgment, can aid their want of sensibility and so conceal their defect to a certain extent. They have learned the names of colors quite as well as normal sighted people, and by the help of every outward sign they have acquired a certain knowledge of those pigments to the characteristic tints of which they are blind." †

Those who are color blind "can sort and place in correct order a series of shades of red or green much better and more quickly than the normal eyed, because to them the color is but so much light and dark. A color blind person is asked to buy a skein of red worsted to match a pattern. He asks the attendant in the store for red worsteds, and selects the one which corresponds in luminosity with his pattern. Such a test apparently forbids the idea of any chromatic defect.

* This is true also in regard to those who are afflicted with astigmatism. In my own experience I was unaware, until I was forty years old, that everybody did not see objects exactly as I saw them. The discovery that my eyesight was not accurate in this particular was purely accidental.

† "Color Blindness; Its Dangers and Detection," by B. Joy Jeffries, M. D.

But, we will suppose the worsted attendant is away, and another, who is also color blind, hands over the greens to the purchaser; the latter will then complacently select the one which matches in luminosity with his red pattern. If he is green blind, he will select a lighter green—if red blind, a darker—than his pattern. This sensitiveness to light shade has enabled color blind painters to follow their profession with success, and even avoid discovery, until accident or design has interchanged, for instance, their reds or greens."* The unconsciousness of color blind people of their defect illustrates in an apt way the common defects of temper and perception. Thus, men understand a thing in a certain way and believe others who differ with them to be stupid or ignorant or wilful, wherever the difference is inherent.

Many shades of difference exist in regard to the peculiarities of color blind people. Thus, some see certain colors perfectly while they cannot distinguish others, or at best see only a shade of difference. It is this shade of difference that deceives them into believing they see objects as other people do, and renders the mere apprehension of a person in regard to a color not at all conclusive. To be certain that he is not color blind, it must be demonstrated by comparison and selection. The orbit of our vision is exceedingly restricted. Dr. Jeffries, in his admirable book, says: "Our point of best vision on the retina

* Jeffries.

is directly in the center, and over but a small space here; so that, to see an object distinctly, we must carefully turn the eye, to keep the picture on this portion. In looking at a long word on a page, we unconsciously travel along it to catch all the letters. If we keep our eye fixed on one point, and move a letter away from this point, its form is soon lost, and we fail to recognize it; let one eye be closed, and the other fixed on a bright red object, like a wafer, held before it; when moved gradually out from the central field of vision, the wafer will decrease in brightness, and finally appear black. Its form we may still discern. This is not color blindness. Whenever the retina is tired out with one color, it can only perceive the complementary one. If with one eye we gaze steadily for some seconds at a bright green disk on a white ground, and then quickly look at another white surface, we shall see a red disk. Gazing fixedly at the setting sun when a deep red, and turning quickly to the east, we shall see a rising green sun. I hardly need say this also is not color blindness. The crystalline lens in the eye becomes, with age, harder, and of a yellowish color—up to positive blackness. When opaque, it prevents, of course, the passage of light through the pupil; it is called cataract. This opaque lens we then remove from the eye, and replace it by a strong convex lens in the spectacles. This is not true color blindness. Another physiological fact in relation to color perception is very important, and seems to be generally quite unknown or neglected. Around the point of best vision in the center of the retina is a zone where we perceive all of the three so-called base colors—red, green and violet. Outside of this there is another zone, in which we have a perception of only two, namely, green and violet; and again, beyond this, on the retina, only blue or violet is perceived." A person who is color blind would be likely to paint a blue sky pink or rose color, or a red object green, or a brown house olive.

The study of color blindness is comparatively recent. Several books have been written on the subject. The first case which attracted general attention was that of an English chemist named Dalton, in 1794. In many countries, color blindness has been denominated "Daltonism." Thomas Young and Professor Helmholtz, who have given the subject of color blindness most exhaústive study, describe its physiology as follows: "There are in the eye three kinds of nerve fibers. Stimulation of the first produces the sensation of red, the second that of green, and of the third the sensation of violet. Objective homogeneous light excites these three kinds of fibers in varying degree according to the wave lengths. The red perceptive fibers will be strongest stimulated by light of the greatest wave length, the green perceptive by light of medium wave length, and the violet perceptive by light of the smallest wave length. Here must not be excluded, but rather accepted in explanation of a series of phenomena, that each spectral color excites all three kinds of fibers--but one less, the others more strongly. Simple red strongly stimulates the red perceptive, less the other two; sensation, red. Simple yellow stimulates moderately the red and green perceptive, feebly the violet; sensation, yellow. Simple green stimulates strongly the green perceptive, much less the other two; sensation, green. Simple blue stimulates moderately the green and violet perceptive fibers, feebly the red; sensation, blue. Simple violet stimulates strongly the violet perceptive, feebly the other fibers; sensation, violet. Equally strong stimulation of all the fibers gives the sensation of white or whitish colors. The term color blindness indicates a genuine blindness to one of the primary colors. In this way, therefore, we distinguish, according to the kind of element wanting, three classes of blindness—red blindness, green blindness, violet blindness. Blindness to red is due to the absence or paralysis of the organs perceiving red. Red blindness has, then, but two fundamental colors, which, adhering strictly to the theory, are green and violet. Green blindness derives its origin from the absence or paralysis of the perceptive elements of green. The green blind has, therefore, but two fundamental colors, red and violent. Violet blindness (or blue) is due to the absence or paralysis of the elements perceiving violet. The two primitive colors of the violet blind are, then, according to theory, red and green."

As to exactly how color blind people see, Mr. William Pole, who was thus afflicted, has described his experiences: "In the first place, the color blind see white and black, and their intermediate or compound gray (provided they are free from alloy with other colors), precisely as others do. Yellow and blue, also, if unalloyed, we see, as far as can be ascertained, in the normal manner. But these two are the only colors of which we have any sensation. We do see all such things, but they do not give us the color sensations correctly belonging to them; their colors appear to us varieties of the other color sensations which we are able to receive. Take first the color red. A stick of red sealing wax conveys to me a very positive sensation of color, by which I am perfectly able to identify, in a great number of instances, bodies of this hue. But, when I examine more closely what I really do see, I am obliged to come to the conclusion that the sensation I perceive is not one that I can identify separately, but is simply a modification of one of my other sensations, namely, yellow. The appearance of green to the color blind corresponds exactly to that of red. Green, in its true aspect, is invisible to them, and, consequently, when neutral—i. e., unmixed with any other color—it presents, to their eyes, the appearance of gray. When, however, it is mixed with yellow (and most of the greens in nature are yellow greens), they see the yellow only, but diluted or darkened by the invisible green element; and in less frequent cases, where the green is mixed with blue, they see the blue element only in like manner. It is therefore easily understood how so simple a defect of vision gives rise to a complex series of symptoms. Take first the color red. If it is a scarlet variety, as the majority of reds are, presenting the appearance of yellow to the color blind, they may naturally confound it with the latter color, as well as with orange, with yellow-green, and with brown, all of which cause to them the same sensation. If, on the other hand, the red contains a predominance of blue, it may be confounded, on the same principle, with blue or violet. If it is a neutral red, lying between the two, it will be confounded with black or gray. A pale pink, though very distinctly colored to the normal eyed, often offers so little color to the color blind as to be mistaken for white or very light gray. The same explanation will apply to green. Its yellow varieties may be compounded with red, orange, yellow and brown; its blue varieties with blue and violet, and its neutral hue with black or gray, or, if pale, with white."

Those who cannot distinguish red are said to exceed all others in the ratio of four to one. Professor Holmgren says: "He whom we call color blind is not, correctly speaking, at all blind to colors. He perceives, in the main, the same kind of light as the normal observer, but sees a part of it in another manner. In the system according to which he arranges his colors, he has fewer kinds than the normal observer. A color blind person can no more accustom himself to seeing colors as the normal observer does, than the red blind can see color in the same way that the green blind does, or conversely. To judge correctly of color blindness, and the various practical questions connected with it, it is of the highest importance to distinctly observe the difference between the manner in which the color blind person sees, and the manner in which he names colors."

From statistics gathered from the examination of ten thousand people, it was found that four per cent. of men have seriously defective eyes, so far as their ability to discern red and green colors from each other is concerned. The seriousness of this conjunction is apparent when we remember that the danger signals of many carriers are red or green.

Testing for color blindness is required by many governments, and is practiced more or less systematically by carriers, of their own volition. Attempts to legislate in regard to it in the United States have met with much opposition, and laws passed to enforce examinations of those connected with the train and signal service of railroads have in some cases been repealed because of the opposition of railroad employes. This opposition, however, it must be confessed, serves rather to excite than allay apprehension. If the defect is only occasional and unimportant, why oppose examination? If serious, it is important to other employes, as well as those who travel, to know the exact risk they run. If other devices than colored signals were possible, the dilemma might be overcome, but unfortunately they are not.

Color blindness being established as a fact, the question naturally occurs, how may it most surely be detected? By taking those to be examined to the different signals of railroads and asking them to describe them? No. It must be done scientifically. Otherwise, those who wish to conceal the fact will oftentimes be able to hide their defect, or to render its presence questionable. Different methods have been suggested by scientists for detecting color blindness by simultaneous contrasts of different colors, such as the use of colored shadows, colored glass, colored paper, the spectroscope, and other means. Professor Holmgren's method, recommended by Dr. Jeffries, is described as follows: "Our method demands neither costly apparatus nor a special place for the examination. The only necessary elements are a number of variously colored objects. It consists of taking one from a number of objects promiscuously thrown together, and asking the person examined to select from amongst them all the others corresponding with the first in color." Prof. Holmgren considers woolens preferable to paper, glass, wafers, powders, solutions, thread, wood or porcelain, and gives good reasons for his preference. He says: "One of the chief advantages of Berlin worsted is that it can be procured in all possible colors corresponding to those of the spectrum, and each in all its shades from the darkest to the lightest. Such selections may be found in trade, and are easily procured when and where desired. It can be used at once, and without any preparation for the examination, just as delivered from the factory. A skein of Berlin worsted is equally colored, not only on one or two sides, but on all, and is easily detected in a large pile, even though there be but one thread of it. Berlin worsted is not too strongly glaring, and is, moreover, soft and manageable, and can be handled, packed and transported as desired, without damage, and is conveniently ready for use whenever needed." His selection of colors would include: "Red, orange, yellow, yellow-green, pure green, blue-green, blue, violet, purple, pink, brown, gray, several shades of each color, and at least five gradations of each tint, from the deepest to the lightest. Green and gray, several kinds each of pink, blue, and violet, and the pale gray shades of brown, yellow, red and pink, must especially be well represented. According to our method the examiner selects from the collection of Berlin worsted in a pile on a convenient table and lays aside a skein of the special color desired for this examination; then he requires the one examined to select the other skeins most closely resembling the color of the sample, and to place them by its side. The chromatic sense of the individual is decided by the manner in which he performs his task. The result of comparison which the examined makes—in other. words, the little skein of worsted which he selects and places by the test—shows us in reality what colors seem alike to him, and thus tells us his relative color perception. The rapidity with which this examination is made does not seem to directly correspond with the nature of the chromatic sense, but to depend wholly upon the character of the person examined. One of intelligence, with a quick, practical mind, is examined in less than a minute. In this time, in fact, a normal eye could easily find the four or five skeins of the same color as the sample, and the color blind make a sufficient number of characteristic mistakes to thoroughly establish the diagnosis. A practiced surgeon can often detect color blindness by the first gesture of the examined, and make his diagnosis before the end of the trial. He can, according to the manner in which the task is performed, form a judgment of a feeble chromatic sense in instances which are proved correct by the final result. He also can and must see whether the result is erroneous simply on account of a misunderstanding or a want of intelligence, just as he can see whether the really color blind succeeds, in a certain degree, from much previous exercise or a considerable amount of caution. In short, the method supplies us with all necessary information; so that, by an examination made with its assistance, a defective chromatic sense, no matter of what kind or in what degree, cannot escape observation. The principle of our method depends, as we have said, on the test calling for the selection of but one color among many. It may be asked, what need of such a number of colors? Would not a smaller answer? We reply that the color blind avoids detection with more difficulty, and the diagnosis hence is more readily made, the greater the number of the various colors. The normal eyed readily selects the right ones from the mass; whilst the color blind, although the right ones are directly before him, picks out the wrong ones, thereby disclosing the character of his defect. Therefore the greater the number of colors the better, of course, within certain limits. What color shall we take for our sample? It is necessary to select as a suitable color for discovering a feeble chromatic sense either the lightest or darkest shades. The well defined kinds and degrees of a defective chromatic sense confound only colors of mean intensity. I have selected, to determine whether the chromatic sense is or is not defective, a light green (dark green may be also used), because green, according to the theory, is the whitest of the colors of the spectrum, and consequently is most easily confused with gray. For the diagnosis of the especial kinds of partial color blindness, I have selected purple (pink); that is, the whole group of colors in which red (orange) and violet (blue) are combined in nearly equal proportions, at least in such proportions that no one sufficiently preponderates over the others, to the normal sense, so as to give its name to the combination. Purple is of especial importance in the examination of the color blind, for the reason that it forms a combination of two fundamental colors—the two extreme colors—which are never confounded with each other. In fact, from a color blind point of view, one of two things must happen, according to the theory; either it excites but one kind of perceptive organs, or it excites them all. It appears, then, either like a simple color—that is to say, like one of the two colors of the combination—or like white (gray). Experiment has confirmed this hypothesis. Our sample colors, therefore, are the two complementary colors of each other—green and purple. In the examination of the chromatic sense of a large number of individuals, it is, of course, of importance to decide quickly, first whether the chromatic sense of the individual is or is not normal. It is only after establishing the existence of a defect that its nature or degree must be determined. The sample colors are, therefore, employed with more advantage in a certain order, as the test must be accomplished, as a whole, according to a plan that experience has proved the surest, most rapid and, finally, most suitable for the purpose. The Berlin worsteds are placed in a pile on a large plane surface, and in broad daylight; a skein of the test color is taken from the pile, and laid aside far enough from the others not to be confounded with them during the trial; and the person examined requested to select the other skeins most resembling this in color, and place them by the side of the sample. In the first place, it is necessary that he should thoroughly understand what is required of him; that is, that he should search the pile for the skeins, making an impression on his chromatic sense independent of any name he may give the color, similar to that made by the sample. The examiner should explain that resemblance in every respect is not necessary; that there are no two specimens exactly alike; that the only question is the resemblance of the color; and that, consequently, he must endeavor to find something similar of the same shade, something lighter and darker of the same color, etc. If the person examined cannot succeed in understanding this by a verbal explanation, we must resort to action. We must ourselves make the trial by searching with our own hands for the skeins, thereby showing, in a practical manner, what is meant by a shade, and then restoring the whole to the pile, except the sample skein. As it would require much time to examine each individual in this way, it is advisable, when examining a large number at the same time, to instruct all at once, and, moreover, to ask them to attentively observe the examination of those preceding them, so as to become more familiar themselves with the process. By this, time is saved, without loss of security; for no one with a defective chromatic sense finds the correct skeins in the pile the more easily from the fact of having a moment before seen others looking for and arranging them. He makes the same characteristic mistakes; but the normal observer, on the other hand, generally accomplishes his task much better and more quickly after having seen how it must be done, and this is the advantage of our method. The principle of our method is to force the one examined to reveal by his own act, the nature of his chromatic sense. The method of scrutiny here described is able to detect, as we have seen, not only complete or incomplete color blindness, but a feeble chromatic sense. Moreover, it has been proved that there is a perfect gradation, from complete color blindness on the one side to the normal chromatic perception on the other. The question then naturally arises, from our practical point of view, whether it is possible to draw a dividing line between the kinds and degrees of defective color vision which would except those who could not cause any inconvenience to the railway service, and, in case of an affirmative answer, where such limit is to be found."

It is not possible to give more than the salient features that arise in connection with color blindness as it relates to the operation of railways. Dr. Jeffries amplifies the subject in its different phases, especially its prevalence and the means of detecting it. He gives the methods and results of those who have experimented in connection with the matter. He urges that safety requires an examination of railroad employes, with a view to the exclusion from the service of those who are unable to distinguish correctly the colors used for signals. He lays especial stress upon this, that color blind persons are generally able to distinguish signals by the difference in light and shade alone, and will be able to do so in many cases if examined merely by the signals to which they are accustomed. He also insists that only experts can conduct examinations. Acting upon these representations, the legislature of Connecticut in 1880 passed a law requiring that all trainmen, station agents, switchmen and signalmen employed by railroad companies in that state, be examined in regard to color blindness and visual power.

Upon putting the law into effect, many trainmen who had never been suspected of any difficulty in distinguishing signals were found unable to correctly match the colored worsteds or fulfill the other tests required. The first man rejected was one of the oldest engineers in the state. He could not distinguish letters and figures three-eighths of an inch in length, twenty-five feet away. Instances occurred in which persons whose vision was normal were unable to pass the examination, simply from nervousness. One man fainted away under the ordeal. Great indignation grew up in regard to the new measure among railroad men. Finally a mass meeting was held at which the fairness of the tests was questioned. It was demanded that they should be made by the signals in general use and the letters on the signboards of the railroads, the men examined to be at their usual posts. The leaders of the opposition in the legislature made so much political capital out of the matter that the law was repealed.*

In Massachusetts the legislature referred the matter to the board of railroad commissioners. Their report presented a very interesting résumé of the subject. Among other things, it said: "It is unsafe to employ a man afflicted with color blindness. But it would be at once foolish and cruel to remove three or four per cent. of our railroad employes if they are in fact fully qualified to perform their duties. Persons who have been pronounced to be color blind prove on examination to have full perception of the colors of lanterns when placed at great distances and under trying circumstances. Employes who are theoretically color blind promptly distinguished white, red, blue and green lights at a great distance while engines were going out and coming in, with all the attendant annoyances of smoke and steam. The same men also distinguished by daylight red, green and white flags at a like distance without failure, while a person totally color blind who happened to be present on one occasion pronounced a scarlet flag to be black when it was held directly before his face. Nor is any

* It should be remembered in this connection that nearsightedness and defective sight disqualify a man for a place in the train service. Engineers, firemen and others must not only be able to distinguish colors, but must also be able to clearly discern objects at a distance. Their eyesight must in fact, to sum it up, be normal.

case recorded, so far as is known to this board, of a color blind man who could distinguish red from green in clear weather and who has mistaken red for green in foggy weather. The existence cf color blindness, total and partial, is a well established fact, and there are men who, by reason of such defect, are unfit for positions on railroads requiring ability to distinguish color signals. The extent of dangerous color blindness (i. e., such color blindness as unfits persons for railroad employment) has been greatly exaggerated. We find that examinations may be properly made by persons not medical experts, and that such examinations will certainly be sufficient if doubtful cases are referred to such experts. The board recommends that every railroad company shall have an annual examination of every employe whose duties require or may require capacity to distinguish form or color signals, and that no one shall be so employed who has not been thus examined. The examination should refer to color blindness and to other defects in vision. It should include all who are in any way connected with the movements of trains." The legislature of Massachusetts finally passed a law requiring all railroad employes whose duties required them to distinguish form and color signals to be examined at least once in every two years for color blindness and other defective sight.

American practices are not so searching in regard to color blindness as those of Europe although the subject is receiving more and more attention. It is noteworthy, however, that not a single accident on an American railroad has been definitely traced to color blindness. But this does not prove that such accidents have not occurred. Cases are known of collisions of vessels because of color blindness of pilots. But it is probable that accidents would be more likely to occur at sea from this cause than upon a railroad. The engineer of a train can stop in the event of doubt, while this would, in the majority of instances, be impossible in the case of a vessel.

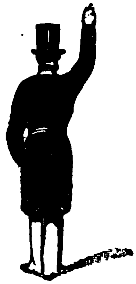
CHAPTER XV.

SIGNALS.—PART I.

The use of signals by railways for the purpose of conveying intelligence, while new in application, is not new in fact. It is the oldest form of speech known to man. Before words were invented or language dreamed of, men communicated their ideas to each other by means of signs, gestures and looks. At first speech was unknown and men knew not how to articulate. Taciturn and savage, their utterances were those of animals. Language had its origin in constant reiterated sounds which acquired particular meanings and slowly assumed the form of speech. In this way men acquired the means of communicating with each other by words instead of by gestures and gutturals as before.

The signals of carriers on land and water are the highest known forms for communicating quickly between man and man where speech is impossible. The need of signals on railways was early discerned. The accompanying illustrations portray some of the primitive methods employed and the quaint uniforms devised for signalmen in Great Britain.

"All right."



"Caution."

"Stop."

A survey of the tracks and yards of railway companies renders apparent the efforts put forth by railway companies to make use of every form of signal or device by which life and property will be rendered more secure, or business expedited. Wherever danger threatens or business may be expedited, there signals gleam. At night they consist of lights of different colors. By day greater latitude is possible, symbols supplementing color.

In no branch of railway service has there been greater desire to progress than in the signal service. This was to be expected, for upon it depend largely the operation of trains and the preservation of life and property, but here, as elsewhere, in matters of a business nature, economic conditions have had to be considered. Every measure intended to render life more secure has the warm sympathy of railway owners and managers, but expenditures in this field, as well as in others, must be prudently made, lest worse evils follow.

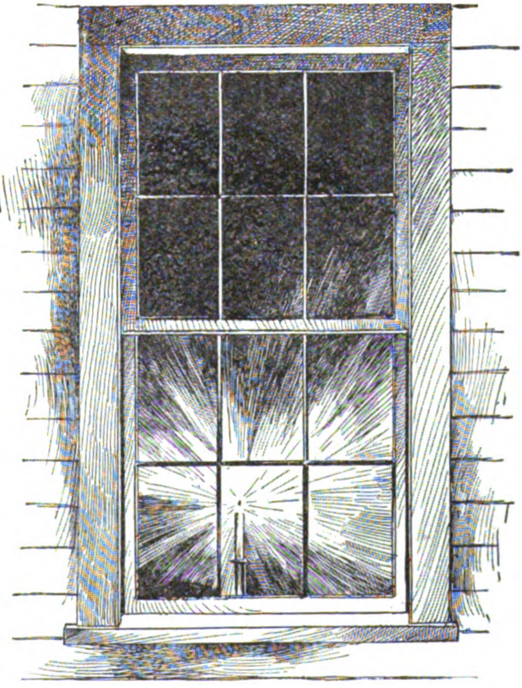
Many instances might be cited where lavish outlay in this direction has restricted the scope of carriers, reducing the number of railroads by reducing the means to build them, and thus crippling commercial intercourse and enhancing the value of the necessaries of life.

At the start each railroad sought to be original; to have signals different from those of its neighbors. Experience is teaching the shortsightedness of this. Under ordinary circumstances we commend individuality in men. Managers who do not possess it are apt to be lacking in enterprise, but when it is applied to train rules and regulations, including signals, we are inclined to prefer co-operative effort. This is rendered necessary more and more every day by the increasing intercommunication of railroads.

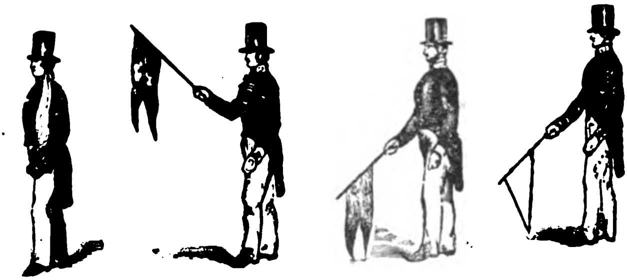
So far as practicable, train signals and methods should be the same everywhere. But in adopting uniform practices provision should be made to insure continued inquiries and experiments. Railroad associations should keep the standard regulations always before them with a view to securing something better. Unless this precaution is observed, uniformity, here as elsewhere, will prevent progress by deadening individual effort.

Signal devices were in the beginning very simple, and such as men had at hand or could manufacture. The mile post and the sign board, at road crossings, were among the first form of fixed signal. The former marked the termini of sections, and afforded the engineman needed information, while the latter warned public and trainmen alike.

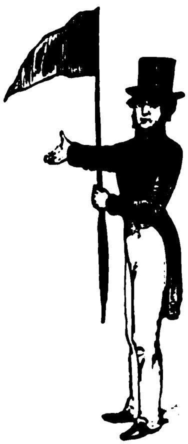
When railways were first opened in England, no signals were used. Then, as a precautionary



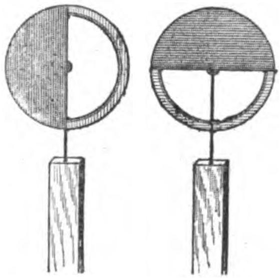
measure, pans filled with fire were affixed to the front of the engine and the rear of the train at night. One of the earliest station signals was a board which was swung across the track, like a gate, to stop the train. On the Stockton & Darlington Railway (where railway carriage was inaugurated), a lighted candle placed in the window of a station house served as a signal for the en-

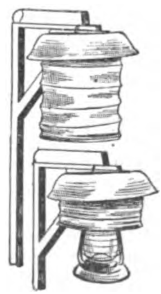


gine driver to stop. In the absence of a light, he took it for granted that he was to proceed without stopping. Flags waved by hand or on poles were among the first day signals. Red or white lights hoisted on posts were among the first night signals. The disk is said to have come into use in the year 1837. It was placed on a pole about twelve feet high, and was surmounted by a lamp. If the light was red and the disk faced the approaching train, the driver stopped. If the edge of the disk was toward the train and a white light showed from it, the driver went on. The disk signal gave place to the semaphore. The latter indicated three conditions:



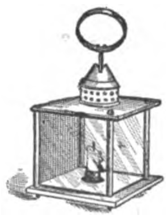
"all right," "slacken speed" and "danger." Another form of disk was invented, made of metal. It was worked by a man standing on the ground. It consisted of a round piece of metal balanced on its edge on a pole. One-half was solid and painted red; the other half was cut away, leaving a thin rim of metal. The disk had a double motion and could be turned by a cord fastened in a groove around the edge, or twisted as one would twist a coin to spin it. It could be made to assume four positions. When turned edgewise to the driver, it meant both lines were clear. When the open portion was downward and turned across the line, both lines were blocked. If the right or left hand disk was open, it was a sign the corresponding line was clear and the other blocked. The plan of interlocking the levers by which signals were worked was devised later on.





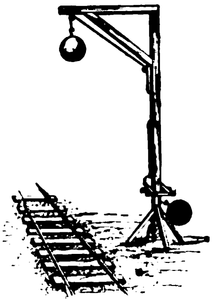
An early signal appliance at telegraph stations consisted of a cylinder of red flannel, about eighteen inches in diameter and two feet in height, distended by wire rings and hung under an inverted tin pan, at a point where it could be seen by approaching trains. It was lifted or dropped by a rope from the office, as occasion required. When raised, it was hid in the pan; when down, it was a conspicuous red object. At night a lantern hanging inside of it gave a red light when the balloon was down and a white light when it was raised.

The bell rope or cord, one of the most important of train appliances, was first introduced in America. The cord ran over the top of the cars, and was wound on a reel at the rear of the train, and the attendants were compelled to climb to the top of the cars, no matter how fast the train was running, in order to use the cord or adjust it in case of mishap. The cord was afterward run under the roof of the cars, one length for each car, the whole being coupled together by an ingenious contrivance when the train was made up. This proved a comparatively easy means, though an unsatisfactory one, of communicating between the trainmen and engineer. Then came the air signal, which, by pulling the cord, gave an instantaneous alarm in the engine cab. However, for fear of mishap, the bell cord was still retained. A writer on the subject thus explains how the bell cord first came to be used: "Once in a while the conductor found it desirable to eject some would-be dead-head passenger between stations, but as there was no means to let the engineer know, except by sending word by a brakeman, and as he usually had to climb over a number of cars before he could attract the engineer's attention, it often happened that the train reached the passenger's destination before it could be stopped. A pioneer conductor on the Erie road got tired of this, and one day tied a stick of wood to the end of a long rope, and hung the stick in the engineer's cab and carried the rope over the cars to the rear of the train. His idea was to pull the rope and agitate the stick of wood when he wanted the engineer to stop the train. He had to lick the engineer before the latter would consent to recognize such an innovation, but it worked like a charm, and led to the introduction of the bell and rope system of signaling on cars." The following is one of the many bell signal codes: One beat—acknowledgment. Two beats—go on, all right. Three beats—look out, something wrong. Four beats—shut off steam, pull up, and stop at next station. Six beats—danger, stop at once. The rules attaching to the use of the bell cord required that conductors should see that it was in order and extended the whole length of the train before starting.



On some of the American roads before the bellcord or steam whistles were invented, when it became necessary to communicate with the engineer, the conductor ascended a ladder to the top of a car and went forward until within hailing distance of the engine. He held up one finger if the train was to stop and two if it was to proceed without stopping. A lantern used in 1832, that has been preserved, has three sides of glass and one of iron. The corner posts were round, of solid metal, about half an inch in diameter and about eight inches in height.

One of the signaling devices of early days consisted of a white ball lowered over the track, by means of pulleys, when it was desired to stop a train. It was operated from the ground by means of a cord.



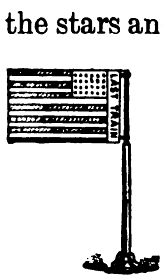
A primitive system, more or less used, is thus described: A pole similar to those now in use for carrying telegraph lines was erected at each station. It had strips of wood nailed to it, forming a ladder. The agent would ascend this pole and by means of a spy glass look for the expected train or in the event he could not see it gather information in regard to it from the next station. If the train was coming he showed a flag. If there was an accident or delay, he showed a large ball. These signals could be seen by the waiting passengers and also at the next station. Thus, news of the train was telegraphed to those interested in its movements.

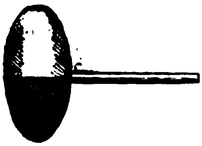
In another instance a signal post was erected commanding a good view of the line. If the track was clear and trains might proceed, a white light over a red light indicated the fact. Flags of similar color were used during the day. If the red was placed above the white, the train was required to stop.

The regulations of a New Jersey road required the forward brakeman to ride on the tender while the other brakeman was expected to ride on the front platform of the rear passenger car, each being alert to give or receive signals. The same company required, in the event trains did not meet at stations according to the time table, that they should wait thirty minutes, after which they were required to proceed on their way with caution, sending a man ahead at curves with a red flag by day and a red lantern by night.

If traffic was great it was a practice with some companies to picket the line with flagmen in sight of each other. They were supplied with flags by day and lanterns by night. They signaled the approach and passage of trains in such a manner that there was always one flagman between a train and that preceding it. This might have been called a primitive block system.

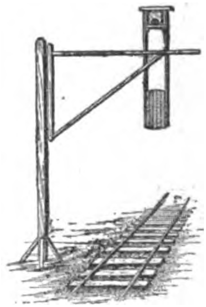
A flag made of metal, representing the stars and stripes, carried in front of the locomotive indicated on one line that it was the last train going in that direction for the day. Another device carried in front of the engine for conveying the same information was an egg-





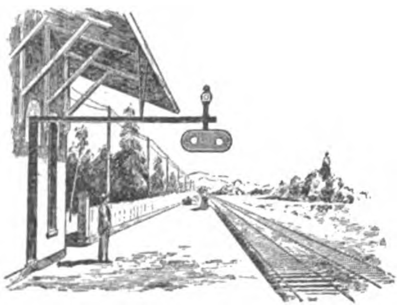
shaped ball, one-half of which was painted blue, the other half white.

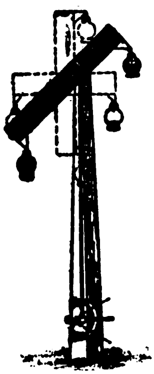
As appliances became more advanced, a gate signal was designed and placed at the intersections of crossings. It was so arranged that the arm would swing over either track. The arm was painted white, the signal red. At night a red light was placed over the top of the arm. Another signal on the same railway was made of slats of wood so arranged that they were reversible. The slats were painted red on one side and white on the other, and were manipulated from the ground by a cord or rope. Red indicated that trains should stop; white that they should go ahead.



Gate Signal, 1870.

A signal at one time in quite general use at railroad crossings consisted of a mast having a cross-arm pivoted in such a manner as to assume three positions: horizontal, inclined and vertical; inclined indicated stop to both roads; horizontal, meant clear for one road; verti-

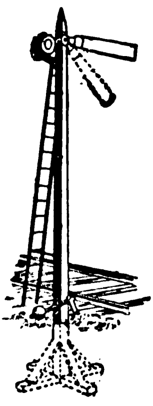




cal, clear for the other. At night, a red light hung at each end of the cross-arm made the various positions distinctly visible. The signal was so placed as to be seen at a great distance by approaching trains.

A primitive device for notifying brakemen to apply brakes was for the engineer to hoist a flag on the tender. Before the whistle was used engineers sometimes gave the signal of danger by raising the valve stem on the dome of the engine, letting the steam escape with a loud hissing noise. When the whistle was finally introduced, great diversity existed among railroads as to the meaning of the different signals it conveyed.

When a train followed another, it was indicated by the forward engine carrying a red flag by day and a red lantern by night. This is still the practice in some cases.



A form of semaphore for railroad crossings, more or less used, consists of a vertical rotating shaft having a cross-arm fastened to the top in a horizontal position.

When set at right angles with one track, it served as a block to any train thereon and at the same time disappeared from view on the other track, giving trains a clear right of way. No means are provided by this signal for blocking both tracks at the same time.

In the movement of trains safety of life and property depends upon the facility and intelligence with which signals are manipulated; upon the employment of the right signal at the right moment and its instantaneous interpretation, the safety of trains rests. This being so, it is apparent that their use should be stripped of all ambiguity and reduced to the least number possible.

Moreover, a correct understanding of the subject requires that we should remember that trainmen are not wedded to a particular company. They are constautly changing from one road to another. A thousand causes conspire to bring this about. In making the change they understand generally their duties, but may be unacquainted with the peculiar methods of their new employer. At different periods they may have served many companies. This varied service has familiarized them with many systems of signals. Herein lies the danger. In a matter requiring so much definiteness, diversity of knowledge (familiarity with many systems) may be fraught with danger. They know that upon one road green is a signal of safety; a signal to go ahead. Upon another it is a signal of danger; its warning is imperative; it says, "Stop!" death, perhaps, lies beyond. But suppose an engineer has but recently entered the service of this last named company after being many years with the other. They are always making changes of this kind. This engineer is a skillful mechanic, and noted for his watchfulness and fidelity to duty. He is looked upon as a valuable acquisition, and so, after a month or two, is given the through night express. This train is heavily loaded and makes no stops, but keeps pace hour after hour with the flying clouds. As it plunges ahead through the darkness the engineer notices a green light on the track. He has seen it many times before. It gladdens his heart like the face of an old friend, relieving the monotony of the night and telling him that everything is right. As he is whirled past the gleaming light he leans in a friendly way out of his window, but the signalman, wild with fright, hurls the lamp full at his face. In an instant he comprehends the truth: upon this line green is a signal of danger! A chill, as of death, seizes him. Too late he reverses his engine and sounds the whistle. The engine trembles with the strain, struggling to stop, but, alas, too late, and so in the stillness of the night, in the far-off country, the great black engine with its cars filled with sleeping passengers, plunges to destruction.

This is what a diversity of signals means to the tired and nervous traveler. How far are his fears justifiable? Could the case I have supposed actually occur? True it is that the signal that says "all right," "go ahead," "track clear," on one line means upon a neighboring road, "stop," "the line is blocked." Many accidents occur upon railways that are inexplicable; are enveloped in mystery. The religious frequently attribute them to God. Are any of these disasters occasioned by confounding the rules and regulations of different companies?

An investigation of train signals elicits many curious things. Thus, upon one line two green

lights in front of an engine is a notice that the track is clear and no trains are following. Upon another line these lights indicate that a train is following and that all other trains must keep out of the way. Thus a trainman, acting upon the signal first mentioned while in the employ of a company using the latter, would bring his train in collision with another, unless some fortuitous circumstance prevented.

Great progress has been made towards systematizing and bettering signals, but much remains yet to be done; more, it is probable, than will ever be accomplished. I first took up the subject of train regulations, including signals in 1877. No attempt to secure uniformity among American railroads had then been made. I took the regulations of all the principal companies in America and from them made a code. This code is the basis of that adopted afterward by associations designed to facilitate the train service. While organizations of railway officers formed for the purpose of reconciling differences and obtaining uniformity of practice in matters of joint concern have been in existence almost from the start, it was only after many years that the subject of signals was taken up with a view to uniformity of practice. Great progress has since been made, but if uniformity should be secured in the United States, the reform would still be incomplete. Trainmen are cosmopolitan; this year in Canada, the year following in Mexico, and so on. Uniformity should be general. An instance of grotesque dissimilarity occurred on a road with which I was connected when young. The red lantern used on so many roads to indicate danger was there used as a badge of office by superior officials. Thus, employes carried white lanterns about their business, while officers carried red lanterns to indicate the distinction in rank. Afterward the idea was abandoned and the red lantern became an emblem of danger. However, the use of the red lantern in the manner indicated was no more absurd than similar practices elsewhere. In the early days of railroads both appliances and methods were extremely crude. Thus, it was believed by the managers of one company that in order to be effective, signal flags should be large, and accordingly they were made three or four feet square. One device was to attach a large white flag of this description to one end of a pole and a large red flag to the other end, either to be used by the signalman as occasion required. Men were not only ignorant of the needs of the service, but inexperienced in every detail. This was to be expected. They came from every walk of life. Some had been sailors, others military men. The fire departments of cities furnished more or less recruits. The stage and canal companies a still greater number. So far as men had previous knowledge of signals they endeavored to make them apply to their new calling. Fortunately, traffic was light and the need of signals not great. Railroads were widely separated and opportunities for consultation few and far between. Signals and rules were invented and applied as needed, without regard to the usages of other companies. Some were adapted to the purpose, others not; but so long as no serious mishaps followed, the disinclination of those who introduced them to make any change caused their retention. With growth of business, however, roads were brought closer together and lack of uniformity became embarrassing. The hamlet that was proud of a single railway became a great city and the center of a vast network of lines. Each operated its trains under its own code of signals. In some cases different roads used common tracks, stations and yards, so that trainmen were called upon constantly to observe two entirely different sets of signals. The danger arising from such a condition of affairs, while perhaps more apparent than real, nevertheless invited inquiry. But how could a change be brought about? Not by legislative action, nor by taking the signals of a particular road. That would excite jealousy. Besides these deterring influences there was the supposed embarrassment and danger that would attend change of any kind.

The purposes for which signals are required are many, but the means are few. The latter consist of standards or structures of particular form and position, signs, stationary and hand lamps, flags, manipulation of the arms, strokes of the engine bell and gong, the whistle, torpedoes, fusees and electrical and pneumatic devices.

Considerable variety is possible in the form of permanent signals, and many devices have accordingly been invented. Generally speaking, they indicate the position of switches, or whether the track is clear or not. The semaphore is a favorite form in the latter case. It consists, as is well known, of an upright post with an arm hinged at or near its top so that it may be raised or dropped on a line with the post, the arm being most prominent when at right angles with the post. This position is therefore used to indicate danger. The arm dropped on a line with the post indicates that everything is all right. The arm is so weighted that, in the event of derangement, it will rise of its own volition to the position of danger. Many authorities, however, insist that "all right" should be indicated by a positive signal, and not by the absence of a danger signal. Some of them would use for that purpose a position of the arm prominent enough to attract attention, but sufficiently distinct from that used for danger as not to be confounded with it. Others advocate the use of the position of the arm intermediate between that for safety and that for danger to indicate caution. Others, again, are wholly opposed to the use of the caution signal. They say that if the line is not entirely clear no train should be allowed to proceed without coming to a full stop and learning definitely the nature of the obstruction and receiving permission to go ahead.

The same principles apply in other cases of a similar nature.

The semaphore was used in ancient times for the purpose of communicating information from point to point. To facilitate this, high posts were erected with arms attached, so connected as to be made to assume different positions. "Probably the first account of the semaphore we have is that described by Polybius in ancient Grecian history. Semaphores were exhibited in France as early as 1700. A Prussian semaphore had three arms, capable of indicating 4,000 different signals. The semaphore was introduced into Russia in an elaborate form by Emperor Nicholas I., with a view to transmitting civil and military messages."

Night signals are confined mainly to red and green lights. White and yellow are not favorably regarded by many companies because of the possibility of their being taken for other lights in use near the track. This danger is thought to be especially great in cities where the tracks are numerous and dwellings abut closely upon them. Moreover, the breaking of the glass in a lamp or semaphore would create a white light, where some other color should be shown. Nevertheless, white is largely used to signify safety. It has been generally used in England, but it is remarked that the signal lights in that country are displayed from taller posts than has been the custom in America, hence there is less danger of their being confounded with other lights. The objection to blue and violet is that they can only be distinguished at a short distance. During the day a greater variety of colors may safely be allowed, but it is generally recognized that the night and day signals should be closely related, though white is sometimes substituted for green in the day time.

Red is the color generally used to indicate danger. It is, however, sometimes used to indicate possible danger or caution merely. Some roads use green to indicate caution. One red light may indicate caution and two such lights danger. A lamp outside the rails may mean one thing and between the rails another. In all such matters, however, uniformity of practice is desirable.

The number of flags or lanterns which may be used effectively for a particular signal is limited. Moreover, signals must be displayed in definite positions, thus on the front or rear of trains, or on the station platform, at a considerable height therefrom. Intermediate positions are objectionable.

The movements of the arms and hands (also of lamps and flags) available are, generally speaking, the motions up and down, across the track, over the head, and in a circle. The number of strokes of the engine gong or blasts of the whistle are also restricted, though considerable latitude is possible in the case of the whistle by ability to make long and short sounds or combinations of each. But if reliance is placed on the difference between short and long blasts, the distinction must be very plainly made.

To make full use of the limited materials at hand for signal purposes requires ingenuity and practical knowledge of the needs of the service. The best possible code, when framed, will still be very limited in its scope.

A difficulty in the way of forming a uniform signal code is the honest differences among managers, based on their experience and observation. One will say that the best system is the simplest system; that all visual signals should be similar; that as the semaphore signal to stop is the arm extended at right angles to the post, so the hand signal should be the extended arm of the man; by night the same position of the arm should be indicated by repeatedly raising the lamp to a level with the shoulder and dropping it the full length of the arm; similarly, as the signal of caution by the semaphore is the arm placed midway between danger and safety, so the same signal should be given by the hand by dropping from the position of danger for a short distance, repeating the operation as may be necessary. Motions slowly given would be interpreted to go slow. The signal to go ahead would be given by the semaphore arm being dropped nearly or quite on a line with the post; the same signal would be given by dropping the arm of the man; moving the arm on a level from side to side would make the order positive; a horizontal motion of the lamp by night would mean the same thing. The signal to back would be given by the semaphore by raising the arm nearly perpendicularly above the post; similarly, the hand of a man by day or a lamp by night, swung above the head, would indicate the same thing. These would be the theories of one manager. Another would not attempt to harmonize the permanent and hand signals, but would still adhere to the idea that hand, flag and lantern signals should be the same. That each should be simple and, while distinct, the transition from one to the other should be easy and natural; gentle motions of the hands should indicate gentle motions of trains; swinging motions, horizontal and over the head, should indicate go ahead or back up, each being easy at first. Perpendicular motions being naturally energetic and imperative, and also distinct, should be a signal to stop—the most important of all orders and one to be quickly obeyed. Another authority would urge that each signal should be the one best adapted to the particular purpose, without reference to other signals, except that it should not conflict with them. Thus, the signal to "stop" by night would be a light swung across the track, as being the most natural thing to do in case of danger, and one that an outsider, knowing nothing of signals, would be most likely to adopt. Such movement, moreover, can be made without putting out the light, and covers a wider range of vision than any other, and is, therefore, most likely to attract attention. For "go ahead" he would swing the lamp over the head, because that is the natural motion for all right, is easily seen and does not involve danger of extinguishing the light. To "back," he would motion up and down as being plain, easily seen, and giving, if necessary, an idea of the distance required.

Thus, while everyone may agree as to the desirability of uniformity, they will not be equally agreed as to what is best. Compromise is, however, possible.

The signals to the engineer by strokes of the gong were copied, it is said, from those in use upon vessels; one stroke meaning "go ahead" or "stop" and two strokes meaning "back up." In practice, it was found that in the event a train parted, the strain of the cord would cause one stroke of the gong. If, then, the engine was stopped quickly, the detached portion was likely to come into collision with the forward part of the train. Many companies, consequently, prescribed two strokes as a signal to stop.

As an illustration of the diversity of signals, the only one practically uniform when I made my examination was that of the engineer when about to back, namely, three short blasts of the whistle. Upon many roads the signal to apply brakes was one short blast, the signal to release brakes being two blasts. Many roads, however, preferred two blasts for "stop" and one for "let go," claiming that two blasts for "stop" were more distinct and more likely to attract attention than one, and that the interval between the blasts might be made to indicate whether the train was to be stopped quickly or not. Noticeable diversity exists in the signals for public highways, some companies prescribing one long blast, others two long blasts followed by two short ones, and so on.

Great diversity is noticeable in signals other than those governing the movement of trains, but as their use relates merely to matters of convenience, uniformity is not important, although it would be valuable in a disciplinary way.

Certain combinations or strokes of the gong or blasts of the whistle may mean one thing when a train is standing and another thing when it is moving. This principle is recognized as a valuable one in framing a code of signals.

In the use of whistle signals, it is impressed on the minds of trainmen that too frequent use of the whistle impairs its value as a warning of danger. Both the bell and whistle are necessary as signals, but nuisances of the most pronounced kind otherwise. While we recognize their necessity, we deprecate their use. No one ever can become habituated to them. From afar off they are not unpleasant; on the contrary, may, perhaps, carry us back to the time when, as children, everything about a railway was viewed with wonder and delight.

The whistle and bell, briefly summarized, should not be used except when absolutely necessary; should not be used an instant longer than safety requires and should be moderated as much as possible, the former being no louder than necessary and the latter no harsher than the service demands. Undue use of the whistle grows out of a laudable desire to make sure that everyone hears the warning. This feeling, while commendable, assumes sometimes the dogged persistence of a craze. Men become monomaniacs on the subject. As a rule, the service will be benefited by restricting, rather than enlarging, the use of the bell and whistle.

The value of signals depends very much upon the frequency and speed of trains, but whatever the system may be, it should be intelligently and faithfully carried out. The nature of a country, it is remarked, governs somewhat the use of signals. Thus, on a straight, level road, where the atmosphere is clear, a minimum plant will answer, while in a country where contrary conditions prevail, a more elaborate system will be necessary.

Signals have a positive and a negative value. They are intended, among other things, to supplement the intelligence and watchfulness of operatives; to call attention to their mistakes and omissions; to prevent them from acting thoughtlessly or unadvisedly in the discharge of their duties. That these necessary objects are only partially accomplished emphasizes the incompleteness of our methods. Nevertheless, man has taxed his ingenuity to the utmost to attain the objects signals are intended to conserve. I think a study of his inventions and discoveries in this direction will bear me out in saying this.*

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*Railway signals may be generally classified as follows, as a writer on the subject has been to the trouble to point out, viz.:

Manner of Indication—Visible, audible, visible and audible.

Means of Operation—Mechanical, pneumatic, hydraulic, electrical.

Combination of two or more of the above by manual, automatic, or partly manual and partly automatic means.

- Automatic—Operated entirely by moving trains or by switches.
- Automatic—Depending for indication upon the condition of track.
- Automatic—Operated by trains in connection with natural forces, as gravitation or pressure.

Different ways in which signals may be classified:

Time signals, the normal condition of which is "all clear" and which are set to danger on the passage of a train, remain-

Signals that depend upon man for their efficiency, at any time or place, are defective, and we should never cease our efforts until we have devised something that eliminates him altogether; until we have, in fact, devices by which, if signalmen make mistakes or omissions, or men fail to observe signals, an intermediary force, not dependent upon either, will correct the oversight or make it so strikingly apparent that neglect to observe it can only arise from willfulness.

In considering generally the subject of signals, it is admitted by carriers that they should make use of the best methods that come within their means. This requires that they shall keep themselves posted as to what is best. Ultimately, signals adaptable to the wants of roads of every grade will, it is probable, be approximately evolved. Supply will follow demand. Such devices carriers may not, however, at once be able to adopt, but in the natural order of renewal and substitution they will.

Color, as a means of signaling, is at best an imperfect and crude device, involving the risk of obscurity, omission, color blindness, and so on.

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ing displayed for a certain definite time and then returning to their former condition, whatever be the position of the train.

Space signals, which are set to danger by the passage of a train and remain so till the train has arrived at a certain place, however long it takes to reach there.

Automatic signals according to principles of operation:

Electro-mechanical, pneumatic, electric, atmospheric.

Automatic signals according to use:

Special signals, line block signals—absolute and permissive, etc.

Nor is the sounding of the whistle or the ringing of the bell to be depended upon absolutely. The reasons why they are not are too obvious to require enumeration. But all these appliances, and many others, are useful as adjuncts. The French, who are very ingenious, use a detonator in connection with their home signals. The detonator lies on the rail when the signal is at danger, and is mechanically withdrawn when the signal indicates that the track is clear. It is desirable, in every case, to supplement visible by audible signals in cases of fog or other obscuration of the track. When there is a dense fog in England, the system known as "fog signaling" is put into use. Thus, a man is stationed at the foot of each distant signal post. When the signal arm is raised to danger, he places two detonating signals on the rails, which explode when the train passes over them. The engineer is thus advised that the signal is at danger, and acts accordingly. When the signal indicates that the line is clear, the detonators are removed. This work is performed by trackmen, who, during the fog, are unable to pursue their accustomed labors. The men are supplied with a hut for shelter, a fire to warm them, and overcoats. Every three hours, when on duty, refreshments are furnished them. If at the end of twelve hours the fog has not lifted, relief gangs take the place of those on duty. A difficulty formerly experienced was in getting the fog signalmen to their posts quickly, more especially if the fog came on during the night, because of the distance of their dwellings. This trouble has been overcome by building cottages for trackmen and others needed for fog signaling in the immediate vicinity of the signal posts. By means of an electric bell the fireman or person designated is able, when the emergency arises, to call the men from their houses to the post of duty in a few seconds.

A common audible signal has the form of a flat capsule made of metal. It is filled with material which explodes under pressure.

It is called a detonator and is fastened to the rail by metal clasps and explodes as the engine passes over it. The possible danger that it may fail to explode or may not be heard renders it necessary that it should always be used in duplicate, i. e., that two should be placed on the track.

Numerous automatic devices for placing detonating signals on the track have been invented for use in connection with permanent signals. In one case it is accomplished by attaching a lever to the semaphore arm in such a way that when the arm is moved to "danger" the lever places a detonator on the rail, withdrawing it when the arm of the semaphore is changed. Another curious torpedo machine has a magazine holding five torpedoes, connected to the signal lever so that when the signal is thrown to danger a torpedo is placed in a position to be exploded by the first wheel that passes over it. When the signal is reversed the torpedo is withdrawn, if unexploded. Another plan for giving an alarm contemplates placing an inclined plane on the track, so arranged that it will come in contact with a rod suspended from the locomotive and connected with the steam whistle or gong. It is designed to place this device in position by the arm of the semaphore. Thus, when the arm of the latter is raised to indicate danger, the device referred to is by the same motion placed in position on the track. When the locomotive passes over it, the rod opens the steam whistle or causes a hammer to strike the gong, thus warning the engineer. When the arm of the semaphore is removed from the danger position, the plane is mechanically withdrawn.

It has been pointed out that, if practicable, locomotives should be supplied with an audible signal which would sound on passing a danger signal. Such a device would be extremely valuable. Many accidents that have occurred emphasize the necessity of some mechanical means of thus warning the engineer. It would be especially valuable in tunnels and obscure places where obstacles intervene, such as the darkness, smoke, fog, noise, confusion, etc. Wherever a visible signal is likely to be obscured, it is desirable that it should be supplemented by an audible signal operated mechanically. In no case should safety of life rest on a signal that the engineer may be unable to see or hear, if it is possible to avoid it.

One of the most ingenious and simple devices for signaling that has been introduced is the semaphore—the extended arm or blade. So far as visual signals are concerned, it is very effective. A writer terms it a sentinel that never tires, never sleeps, never forgets; that acts automatically, saying to the engineer one of two things, and so clearly that he can never confound the one with the other by night or by day, "the track is clear, go ahead," or, "the track is blocked, stop." It is especially valuable as a day signal, and the illumination of the surface of the blade, it has been pointed out, will make it equally desirable at night. Its provisions, while variable, are thus stated: Horizontal and red—danger. Horizontal and green—caution. Inclined and white—safety. The parabolic semaphore renders the display of colors possible at night as well as by day.

A requisite of every signal is that it should not indicate safety except through some premeditated act; except for such act it should always indicate danger. Signals should, moreover, be simple and not require too much attention nor too many repairs. "The foundation principles of signaling and interlocking ought to be both few and simple, and there should be no attempt at too great a refinement and consequent perplexity in what should be the broad and essential principles. Thus, there will be room for individual variation in the non-essentials, as the requirements of each locality and the difficulties of each particular case may call for."* The better protection of trains, whether moving or stationary, it may be said in conclusion, requires and receives each day the earnest thought of those whose duty lies in this direction. Each day adds something to their knowledge of the subject. This knowledge they use in perfecting old and in introducing new methods. The block system of early days is thus being improved and other and better systems are being introduced. Primitive methods depended upon man. Modern practice looks to devices that shall be self-acting; to trains that shall be automatically guarded; that shall be safe whether men sleep or wake, or are stupid, inexperienced or neglectful. How far such appliances can be perfected time only will tell. The disposition, however, is as manifest to introduce self-acting machinery in connection with the operations of trains as it is in connection with the operations of manufacturers. The success attained by the latter justifies the belief that substantial success will be attained by the former.

* C. A. Hammond.

CHAPTER XVI.

SIGNALS—PART II.

A writer on the subject says that signaling performs two important functions in the operation of railways, namely, safeguarding the operation of trains and facilitating their movement. It is divided under two heads—block signaling and interlocking. The American Railway Association, in its definitions of block signaling, recognizes three systems, as follows: first, the telegraph block system, or that in which the signals are operated manually upon telegraphic information; second, the controlled manual block system, or that in which the signals are operated manually, its construction requiring the co-operation of the signalmen at both ends of the block to display a clear signal; third, the automatic block system, or that in which the signals are operated by electric, pneumatic or other agency actuated by a train, or by certain conditions affecting the use of a block. In the first of these systems entire reliance is placed upon the carefulness of the man manipulating it, there being no safeguards to check the display of wrong signals. With careful discipline, the system may be worked satisfactorily, except where the traffic is very heavy. The second, or what is known as the controlled manual system, has been brought to a very high degree of perfection. Mechanical safeguards are provided in connection with it that prevent the display of wrong signals. This system is highly esteemed for heavy traffic. Under it the home block signals, when at stop or danger, give audible warning, both by torpedo and gong, in case the signal is over-run. All the signals go automatically to danger on the passage of a train or engine. Repeaters to indicate position of the signal and condition of the lights are provided in the towers; also an auxiliary set of signals and block instruments, to be used in the event of a failure of the regular apparatus. In reference to the third, or automatic signaling, a development in connection with it is the operation of the semaphore type of signal by electricity, by means of a motor fixed to the signal post. In other cases, the automatic semaphore is operated by compressed air, controlled by electricity, requiring a power plant for every installation. The system of interlocking, so valuable to railways and so interesting in its operation, I have described in another place.

There is no feature of railway practice which is so distinctly American as its methods of automatic block signaling. Mechanical interlocking was derived chiefly from English sources, and is extensively applied in connection with switches and signals at junctions and terminals and grade crossings,* but it was recognized by the bulk of American managers that they could not apply such system to the blocking of their lines as a whole, owing to the cost involved for construction and operation. American inventors, therefore, directed their attention more particularly to visual and audible signals; afterward to signals of this nature operated mechanically. The automatic devices sought to be perfected were classified under two heads, viz.: danger signals that would be maintained for a certain length of time after a train entered a block, and danger signals that would be maintained while a train occupied a block, thus warning other trains to stop or to go slow. The former was known as a time signal, but being found on practical trial to be undesirable and dangerous in many respects, was abandoned. The other proved more satisfactory. For a main line and high rates of speed the automatic visual signal has been found preferable to any other makeshift of this kind. Automatic block signals in America thus came in time to signify visual signals, placed at the entrance to blocks; these working mechanically, showed a line to be blocked when a train occupied it, the danger signal remaining in its position until the train had passed out of the section.

* Semaphore signals have been in general use in England much longer than in any other country. In America a distinction is made between block signals and interlocking signals. In England signal boxes on the main line are also used to operate switches as well as to signal. Accordingly, they are placed in a position convenient for handling switches.

The mechanism of the various devices intended to work automatically was operated in different ways, three of which I may briefly summarize as *a*, mechanically, by having the train, upon entering a block, operate a crank connected with the signal by a pipe line, in such a way as to set the signal to "danger," and by the reverse movement of the train as it passed out of the block set the signal to "line clear;" *b*, by means of the "electro-pneumatic" system, in which the controlling agency is electricity and the operating agency compressed air; *c*, wholly by electricity, both the controlling and operating agency being electricity.

Owing to the difficulties of operating long pipe lines on surface roads, the first named system has been more largely confined to elevated lines. The cost of the electro-pneumatic system and its complexity as well, caused it to be, as a rule, restricted to terminals, where power could be obtained from the same source as that operating the switches electro-manually controlled. It is claimed that for open line working, with blocks of one-half mile or thereabouts in length, the cost of installing and operating this system is too great for the bulk of railroad companies to bear. On the other hand, objectors to the first named systems claimed that the purely electric automatic system is applicable to the most complicated terminals, with attendant and frequent train movements, and to single and double track work as well.

In proof of their assertion, they point to the fact that the system has been extensively introduced in America, the results obtained being generally satisfactory, and this notwithstanding the great variety of conditions under which the system has been tried. I am indebted to an expert in the matter for the following description of the system and its working.

Apparatus Employed.—The instruments essential to the automatic electric block system are the

PLATE I.

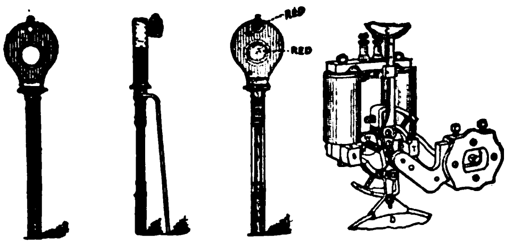


FIGURE 1. FIGURE 2. FIGURE 3. FIGURE 4.

Automatic Electric Block Signals.

signal itself; the electro-magnetic circuit closers, or relays; the electric batteries; the rail bond wires and plugs; the insulated splice bars, wire and (if there are switches) the switch instruments, indicators and blocks.

Signals.—The signals commonly employed are of the disk type, as shown in the accompanying plate I. In figure 1 is shown a front view of the signal, when line is "clear"; in figure 2, a side view of the case, showing position of ladder and lamp; in figure 3, a front view of the signal when line is "blocked." In figure 4 is shown the detail of signal mechanism. D is the large cloth disk of suitable color by which the day signal is given; C, a smaller glass disk for the night signal. One practice is to use a red disk for "stop"; a green disk for "caution" and the clear signal is indicated by the clear, white opening by day or a white light by night. The disk C is attached to the upper and disk D to the lower part of the doubled flanged "S" shaped armature L, L, R, R, which rotates on shaft W, between the prolonged concaved cores S and T of electro-magnet. As disk D is heavier than disk C, the natural or "gravity" position of these disks is as shown in figure 4, and they assume the horizontal or "clear" position only when the electro-magnetic coils are energized, causing the armature to rotate so that wings R, R, move upward toward S and L, L, and downward toward T, carrying both disks out of sight in the case and causing the display of the "clear" signal. It will thus be noted that anything that prevents the energizing of electro-magnetic coils will cause a "stop" signal to be displayed, thus providing against the false display of a clear signal through any failure of the parts.

Relays.—In Plate II is shown a cut of the relay employed to control the operation of the signal. When this relay is magnetized, the armature is drawn upwards and the metal strips attached to it are brought into electrical contact with corresponding stationary metallic points, making what is known as a "front contact" and closing the signal circuit; when the relay is demagnetized, the armature falls by "gravity" breaking this "front contact" and opening the signal circuit.

PLATE II.

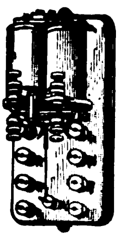
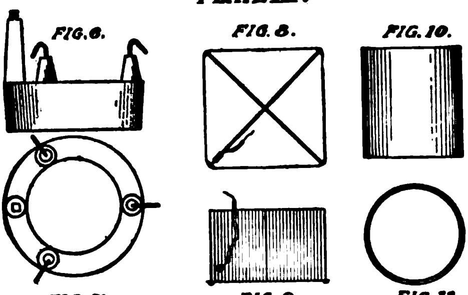


FIGURE 5.
Relay controlling operation of automatic electric block signal.

The batteries usually employed for both controlling and operating purposes are of the ordinary gravity type, employing, however, elements of special design and construction, which vary somewhat from those ordinarily employed for telegraphic purposes. The zinc element is of the shape shown in figures 6 and 7. It weighs, when new, four pounds, and is an alloy consisting of ninety-six per cent. of commercial, virgin spelter and four per cent. of mercury. The copper

PLATE III.



Elements in Battery—Automatic electric block signals.

element is of the form shown in figures 8 and 9. Employing these elements in the ordinary "6x8" jar (figures 10 and 11), with rain water, and about three and three-fourths pounds of copper sulphate crystals, it is possible to secure an almost uniform output of current for a considerable period without attention. The usual output on a single charge of copper sulphate is about two hundred and seventy-five ampere hours, and as the signal requires only one-tenth ampere of current for its operation, it will be seen that the life of such a battery is very great. Its maximum discharge on short circuit is, approximately, 1.2 amperes, and as the minimum interval resistance of such a cell is 0.85 ohms, it may be depended upon for

PLATE IV.

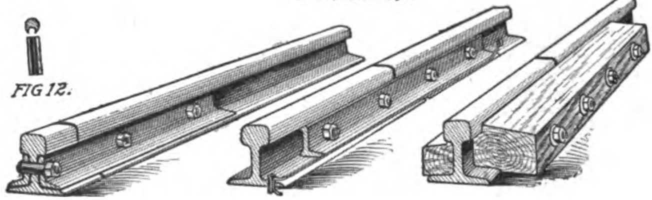


FIG. 13. FIG. 14. FIG. 15

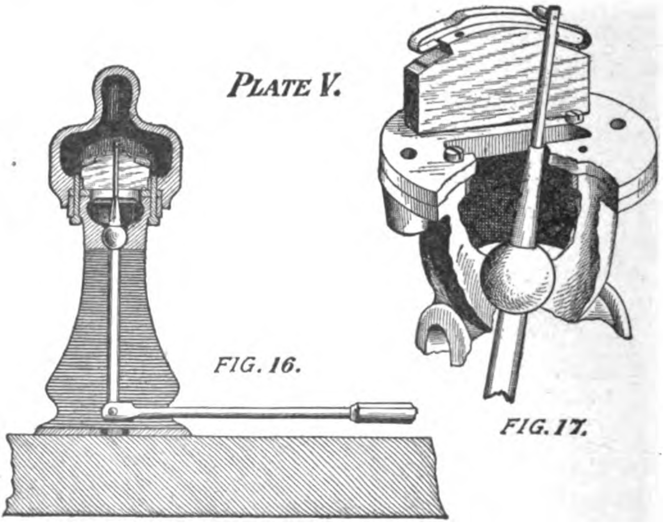
Bonding and Splice Bars—Automatic Electric Block Signals.

track circuit work, where any battery of lower internal resistance would be liable to frequent failure, from long continued short circuiting.

Railroad Wires and Plugs.—The bond wires are as shown in Plate IV, figure 14, and consist of ordinary E. B. B., galvanized No. 8 B. and S. gauge iron wire, fastened by plugs (figure 12), as shown. Most of the bonding has been done in this manner, though the best practice is to bond through the web instead of through the flange of the rail.

Insulated Splice Bars.—The track circuit sections are electrically insulated from each other either by the use of wooden splices and fiber end posts or by fiber between rail and planed down angle bar, fiber end posts and bushings, as shown in figures 13 and 15, Plate IV.

Wire--For overhead lines, bare No. 8 B. and S., E. B. B., gal. iron wire is usually employed; for



Switch Instruments—Automatic Electric Block Signals.

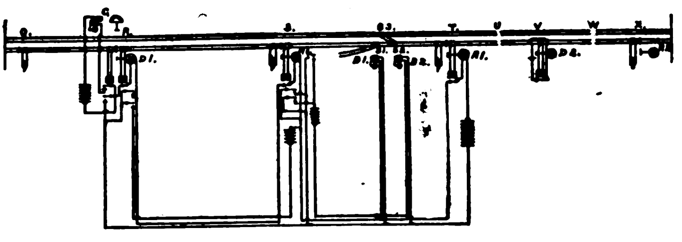
underground work, a No. 14 B. & S. rubber insulated copper wire is used for signal and indicator circuits and a No. 9 for track circuits.

Switch Instruments—These are as shown in Plate V, figures 16 and 17. The movement of the switch rail causes roller to pass onto or off of raised position of contact stop, opening or closing the circuit.

Switch Indicators.—These are either visual or audible, some railways using one, others using the other type. The visual indicator is simply a miniature block signal mounted in an iron box with a glass front, placed near the switch, so that the switchman may easily observe whether it is at "clear" or "danger."

The audible indicator is simply a well constructed vibrating electro-magnetic bell, placed in a suitably constructed box opposite the switch. When it rings, warning is given the switchman that he must not "open" the switch.

PLATE VI.



Circuits employed in the control and operation of a block system.

Switch Locks. — Electro-magnetic locks are sometimes employed to lock the switches in their main line position and thus to absolutely prevent the movement of this switch from its proper position when a main line train is approaching it.

In Plate VI is a diagrammatic representation of certain circuits employed in the control and operation of a block system employing Advance, Home and Distant signals, and affording the usual protection for switches, highway grade crossings, etc. In this cut the circuits for the lower track only are shown. This track is divided into what are technically termed track circuit sections, Q R, R S, S T, T V, V X. At one end of every such section is placed a "track battery," consisting usually of two multiple connected cells of gravity battery, the zinc elements of which are electrically connected to one rail of the track and the copper elements to the other; at the other end of every such section is placed an electro-magnetic circuit closer or track relay, on the armature of which are carried the several circuit-closing contact pieces, controlling the operation of the signals, bells, etc. When there is no train in a track circuit section, and all switches in such section are properly set for main line movement, these relays will be energized, the front contacts will be closed and the back contacts broken; when there is a train in such a section, and the switches are open, relays will be demagnetized, back contacts will be closed and front contacts open.

With this preliminary statement, it is easy to understand how the signals operate.

The circuit under consideration is what is known as a "normally danger" circuit, in which the usual position of the block signals is "danger" or "stop," the signals being cleared only when a train approaches them. At location R is shown a highway crossing bell C and a distant signal D1; at location S, a home signal, H1; in section S T are two switches S1 and S2, and in the opposite track, switch S3; oppósite switch S1 is a switch bell B1, and opposite switch S2, a switch bell B2; at location T is an advance or starting signal A1; at location V, another distant signal D2, and at location X, another home signal H2.

Normally (with no train between Q and X on signaled track and with all switches set for main line movement) signal D1 is at "caution" and signals H1 and A1 are at "stop" position; crossing and switch bells being silent. But immediately upon the entrance of a pair of wheels into section Q R, track relay in this section is demagnetized and the back points carried by this relay are closed, causing highway crossing bell C and switch bells B1 and B2 to ring, thus warning any travelers upon highway at R, and any train that might be on siding near S1, or about to cross over from the other main track through S2, of the approach of a train. At the same instant signals D1, H1 and A1 are automatically set to "clear," for the passage of train from Q to X. It should be noted here that section Q R, technically known as a "preliminary section," may be of any desired length and in practice varies from a few feet to two or more miles, depending upon the local requirements.

When first wheels of train enter upon section R S, distant signal D1 is restored and locked to its "cautionary" position; when train has wholly passed out of section Q R, crossing bell C ceases to ring, but the switch bells continue to ring and signals H1 and A1 remain at clear.

When first wheels of train pass into section H1, that signal is restored and locked to its "danger" position; signal D1 remains locked to "caution," signal A1 is clear, and bells B1 and B2 are ringing.

When first wheels of train enter into section T U V, signal A1 is restored and locked to its "danger" position; and when entire train has passed into this section, bells B1 and B2 cease to ring, thus giving permission for another train to enter signaled track, either from the siding or cross-over; signal H1 is also unlocked and is now in condition to be cleared by a following train which may enter under "cautionary" signal D1 into section R S, thus providing against holding trains unnecessarily from entering station block, either under home signal H1 or by means of switches, from a siding or from another main track. Starting signal A1 remains locked at "danger" until entire train passes out of track circuit sections T U V W X—that is, under the protection of the next home signal in advance.

In general practice a distant signal is placed at a sufficient distance from its home signal to admit of a train which passes it at full speed coming to a stop before reaching such home signal. Thus this distance varies according to the grades, speed of trains, etc. The home signal is usually placed at a similar distance from the nearest switch in the block section governed by it. The starting or advance signals are generally so placed that the engineer of a train making a stop at a station, or other usual stopping point, can observe it from such point, thus avoiding the necessity of making a second stop in case signal is at "danger." The length of a main line block section, as from T to X, varies with the number of trains using such block, grades and various other local conditions. In practice such blocks are sometimes as short as six hundred feet and as long as ten miles.

All switches on a block section are so connected that the opening of a siding switch in the track governed by a block signal, or the opening of either switch of a cross-over connected with such switch, sets such signal to "danger" and its corresponding distant signal to "caution." Each main line switch is also provided with either a visual or audible "Switch Indicator," as shown in Plate VI, and such indicator will always show to a trainman desiring to throw a switch in order to make a movement from one main track to another or from a siding onto a main track, whether he can make such movement in safety. Any portion of a train occupying the main track or any part of a siding within fouling distance of main track, and, generally, a broken rail, will set to "danger" the block signal governing such section of track. The signals have been extensively applied, not only to the continuous blocking of long sections of line, but to special cases, such as the protection of draw-bridges, gauntleted tracks, tunnels, heavy grades where trains are likely to break in two, outlying switches, crossings, etc. In certain cases, also, in addition to the use of indicators at switches, electro-magnetic locks are automatically applied to absolutely prevent the movement of switches from their main line position while a train is approaching them.

In fact, so numerous are the uses to which such signals have been applied that it is impossible within the scope of a chapter to do more than to refer to them briefly.

The claims made for the automatic electric signal systems are mainly that they can be installed at comparatively low cost; that, installed in the manner above described, they are absolutely reliable and afford much greater protection than can possibly be secured under the usual manually controlled block, and at a cost for maintenance and operation of only a small part of the cost of the latter system, which requires at least two men daily at each block station. It is only fair to add that the experience of the railways using these signals seems to fully justify the claims made for them.

The signal described herein is of what is known as the "disk type" and it should be added that standard semaphore signals of the usual size, provided either with the regular or special fittings, are being successfully operated on the purely automatic electric plan and are preferred by some railway managers to those of the "disk" type.

Before the telegraph came into service in England the fixed signals at certain points along a line were kept at "danger" for a specified time after a train had passed before another was allowed to follow. This system I have referred to elsewhere. As traffic increased, the delay and confusion caused much embarrassment in moving trains. Another system was to telegraph from station to station in regard to the passage of trains.

The telegraph, when introduced on railways, straightway became an important factor. One of the systems based upon it and one greatly esteemed, is thus described: The main track is divided into a series of consecutive sections with a telegraph office at each end of the section of the track. These telegraph offices are, so far as possible, located at existing railway stations. When these are too far apart an intermediate telegraph office is built. In this way a division is divided into sections varying from three to five miles in length, and within each of these sections only one train at a time is permitted to enter. The stations are connected with each other by an independent telegraph wire, used only for handling trains under the system. The wire is broken at each station, and consequently each station communicates on that wire only with the next adjoining station on each side. This renders possible instantaneous communications from one station to the next and permits of very rapid work in passing trains from one section to the next. The movement of trains is controlled by a double-arm semaphore signal on a high pole near the station and operated by a wire cable from that station. These signals are located where they can best be seen from a distance by the engineers of approaching trains. The semaphore signal has two projecting arms or blades, one on each side, and the engineer is governed by the position of the arm on the right as he sees it. If the blade is in a horizontal position, the engineer knows that the section of track ahead of him or between that semaphore signal and the next is occupied by a train. He, accordingly, brings his train to a full stop before reaching the signal, and does not proceed until the semaphore blade is allowed by the operator to fall to a diagonal position, indicating that the section ahead is clear. Each telegraph operator keeps a record by reporting from one to the other all trains that enter or leave a section at his own station and at the station on each side, so that the operator always knows whether a section on each side of his station is clear or not and can thereby give the proper signal to trains. In addition to the signal telegraph wire, the general telegraph wires of the company are run into each station, and consequently every station is in direct communication with the division train dispatcher, to whom the movement of trains is reported and who from time to time issues his orders for the movement of trains.

There are many different methods in vogue for protecting trains from front and rear collisions. Several of them I have referred to. The highest types contemplate automatic action. The original form of block system is still employed successfully and was for a long period the only system of protection worthy the name. It was designed for use upon roads having two or more tracks, but its advocates claimed that it might be used effectively on a single track road by placing signals on both sides of the road, as if there were two tracks, and making the blocks, or sections, extend from one side track to another. Under the old-fashioned block system the road is divided into short sections or blocks—hence the name. At each end of a section there is a signal station and attendant. When a train passes onto a section the track is closed by means of a signal to all following trains until the attendant at the next signal station reports it as having left the station. It contemplates two methods—one absolute, one permissive. Under the former, one train only is allowed upon a block at a time. Consequently, a collision is impossible if the precautions are observed. Under the other, two or more trains may be upon a block at the same time, but provision is made for notifying each train that thus enters a block that it is occupied. When a train leaves a block, the fact is noted by the signalman and telegraphed back to the signalman at the other end. The latter then signals that the track is free, but until the receipt of the notice the line is kept closed by the display of the danger signal. The block system contemplates keeping the engineer advised as he proceeds as to whether the track is free or not. Notwithstanding its great cost and the expense attending its working, it was quite generally adopted in Great Britain. A number of American lines also introduced it. It is relatively more valuable on a road with two tracks than with four. The latter permits of a better classification of trains and their assignment to tracks according thereto; however, in the event of omission, or the detachment of a car, the danger is as great upon a four-track road as upon the other.

A block system to possess every valuable attribute should take cognizance of every attending circumstance. Thus, if a train breaks in two and the forward part continues on its way, it should be impossible for the loss not to be observed by the operator, and the block kept closed until the obstruction can be found and removed. In theory, the block system is thought to be perfect. As a matter of fact, it is efficient only according to the intelligence and care of the men in charge. It is better than nothing, but falls far short of what is needed, namely, something not dependent upon the intelligence or watchfulness of signalmen or trainmen.

An obstacle to the general adoption of the block system by American railways is the cost. It entails a very large outlay for telegraph apparatus, signals, towers and attendant paraphernalia. Afterward, it involves a continuous outlay for maintenance and operation. It was this that set inventors to work to produce something less costly; something that would be cheaper to construct and that would warn trainmen of obstructions without the intervention of signalmen.

Some of the electrical devices invented utilize the track rail as a conductor; others, overhead wires. In some instances the two are combined. One requirement recognized as essential is that in case of any derangement of the apparatus, the signals shall automatically assume the position of danger. And here a possible objection is offered, namely, if the apparatus is so complicated or delicate as to be easily subject to derangement, thus giving the danger signal frequently when no danger exists, it loses its value because of the delay of business and uncertainty as to its operations. It must, to be desirable, be simple, effective and easily maintained.

A writer* who is practically familiar with such matters has been at considerable pains to classify and explain certain signals that have come within the scope of his experience and observation. He divides signals into two classes—"those meant to be seen at a distance, or far enough away for the fastest train to receive seasonable notice of the condition of the track, and those intended to indicate near at hand the particular track which the train should take. In the first class are

* C. A. Hammond.

distant and home signals, masthead signals, block signals, draw-bridge signals and right of way signals, giving one train the preference over others on the same road, or over any train of another road crossing it, or giving the right to pass yard limits or to enter a station, or to pass from the main line to branch or other line. In the second class are yard signals, indicators, switch targets, etc. It is, of course, important that the subordinate signals should be in harmony with the distant signals, and so there was naturally evolved the idea of interlocking an entire system of signals at a given point. Every section of track constituting a block should have a special block signal at each end, whatever other signals the exigencies of any particular case may require. These block signals should be interlocked if they are to control opposite movements, or trains on the same track. All conflicting signals should be interlocked. Each divergent route should have its own advance signal. Semaphore arms, which give signals to an engine when facing or running toward them, should, for right-handed and single track roads, be seen on the right-hand side of the signal post, and for left-handed roads on the left-hand side of the signal post; those seen by the engineman pointing in the opposite direction having no meaning for him; and on double track roads the main line signal posts should be located on the outside of the track run on, and not between the tracks. Where several semaphore blades are placed on the same post, they should indicate the track beyond them in regular order, beginning from left to right, as circumstances may require, main line signals being always at the top; but whatever system is adopted, it should be uniform for the entire road. No engine or train should pass the danger signal (horizontal red) or approach within a prescribed limit of the same. No engine or train should be allowed to pass a caution signal (horizontal green) unless under full control, so that it can be safely brought to a quick stop within the distance, say, of three train lengths.* No engine or train should be allowed to pass any semaphore signal at schedule speed unless a distinct and unmistakable 'all clear' or safety signal (inclined white) is seen at the proper distance. In foggy weather, or when for any cause not clearly visible at the proper distance, all semaphore signals, except distant signals, should be regarded as danger signals until known to be otherwise. No locomotive engineer should be allowed to take the word of the conductor or any other employe as to the position of the semaphore signal, but should see for himself whether it is right or wrong before moving his engine. Exceptions to the foregoing may be noted as follows: Where the block limit overlaps its entrance signal, for the purpose of allow-

* It will, of course, be understood by the reader that in the operation of signals, as described in this work, the colors named are simply in the way of illustration and not intended as an implication that other colors may not be properly used.

ing the engineman to see safety signal change to danger for the protection of his train against a following train, the rule forbidding an engine or train to pass the danger signal or approach within a prescribed limit of the same will not, of course, apply, provided the engineman sees the change made while he is within the lap distance. When, through known failure of apparatus, signals remain at danger, trains may proceed upon written orders, or under the protection of red and white flags or lights in the hands of the signalman."

In the operation of railroads, as I have already pointed out, signals dependent upon the intelligence or watchfulness of men are valuable for expediting business and conveying intelligence, but they should be adjuncts merely, so that if they fail to operate, or are overlooked, something that will avert danger will intervene ; something not dependent upon the action of anyone at the moment; a precaution provided in advance for the purpose of remedying man's mistakes and omissions, and that will be brought into play by the action of the train itself. Something that will mechanically divert an engine or train that would otherwise come into collision with another engine or train. An especial need in this connection (but only one of many needs) is a self-acting device by which trains will be protected while standing on the main track at stations from being run into by other trains; a device not dependent upon signals or air brakes; something that will derail or divert a train approaching within a given distance; a device whereby a train, as it approaches a station, will mechanically disconnect the track in its rear and also in front (if it is a single track), and in due sequence, as the protected train passes on its way, will automatically reconnect the track in its rear.

I have described, at considerable length, several mechanical appliances for protecting trains automatically. Electricity and compressed air are the favorite means of accomplishing this end. One method already described at considerable length is based on an electrical circuit, by which all the rails in a section of road are connected by a current of electricity. At each end of the section the rails are separated from those of the adjacent section. Weights, with clockwork attachments, are so arranged that when a train enters a block the danger signal is set, and stands thus until the train has passed on to the next block, when the signal changes to safety. Under the operation of the circuit system, the first wheel of a train entering a block, by electrical means sets the signal at the beginning of the section at danger. When the section is cleared, a contrivance restores the circuit, and the signal guarding the entrance to the section assumes the safety position, or "go ahead, the block is clear." One of the most popular, if not the most popular system of signaling, is the electric pneumatic method, in which the force used is compressed air and the controlling power electricity. It contemplates air-compressing plants at convenient distances so arranged or provided that when one plant gives out there will be another to take its place.

Of the many quaint safety devices invented, none, perhaps, is more ingenious, in the thought that lies back of it, than that designed to throw the signal to danger, in the event a car on a siding should be so close as to endanger the safety of passing trains. Another ingenious electrical contrivance that has been invented is intended, by means of the contraction of a brass cylinder placed within a signal lamp, to call the attention of the watchman to the fact by means of an alarm signal in the event the light goes out. Still another is designed to call the attention of the train dispatcher to the fact if a train runs past a station where another train is discharging or taking on passengers. Another device is intended to announce the approach of trains by ringing a bell at crossings while the train is yet distant. Only those whose duties lie in this particular field can keep track of the new appliances that are constantly being put upon the market. No one can demonstrate their value except by exhaustive practical tests. Speaking generally, however, it may be said that safety devices are one and all incomplete, one and all leave something to be desired, one and all leave trains subject to the watchfulness and intelligence of employes, whereas there should be devices that will protect trains whether or no. That such devices will be perfected as fast as railroad companies are able to afford them is more than probable.

CHAPTER XVII.

GROWTH AND VALUE OF TRAIN RULES.

In considering the subject of train rules, one of the first questions that suggests itself is, Are uniform regulations practicable? The answer is that among men trained under particular systems, who possess the strong individuality that characterizes railroad officers, difficulty will always be experienced in securing acceptance of the ideas of others. Where the methods of a railroad are peculiar and such peculiarity possesses no advantages, but, on the contrary, invites disaster, they should give place to uniformity. The desirability of this in connection with train rules has been a subject of discussion for many years, and a code has been adopted in conformity therewith which railroads have been asked to subscribe to as far as practicable. Many companies have done this, partially, at least, reserving the right, however, to make any change they think fit at any time, without reference to others. Many valuable rules have been left out of the code because of the indisposition of particular companies to adopt them. This indisposition is the result, partly of dissimilar needs and partly of an indisposition to make sacrifices to gain something not esteemed essential.

The same necessity does not exist on every railroad for particular rules. Moreover, a rule that may be desirable in one case may not be so in another. Hence the difficulty of prevailing upon railroads to conform to a particular code in its entirety. It is not probable that the difficulty will ever be entirely surmounted. Perfect uniformity is impracticable, and therefore improbable. But that which is best and generally valuable will be adopted. Possibility of accidents growing out of diversity of practice will be guarded against, while enough freedom will be left to individuals to stimulate further thought.

While practical people do not believe in the desirability of uniform methods of business, any more than they believe in uniformity of experience and intelligence, nevertheless they believe that in merely mechanical matters uniformity may oftentimes be adopted without sacrificing anything of value. This is true in regard to many details having no special significance. Thus, it is true of a feature of the time table of railroads that has no local bearing, namely, the signs that are used. These should mean the same thing everywhere. Thus, * the train runs daily; † the train runs daily, except Sunday; ‡ daily, except Saturday; ¶ daily, except Monday; § Sundays only; ‖ the train stops for meals.

In promulgating train rules no sufficient effort is made in many cases to explain the reasons underlying them; no attempt is made to place the trainman who has to carry them out on a plane with the official who made them. This is a mistake, as it will never be possible to operate trains with the highest possible efficiency so long as those in charge do not have as full a comprehension of the rules as the person making them. The subject is an important one and growing more so each day, as the service grows in needs and complications. In some of my books I have referred to the financial affairs of railroads and the rules and regulations governing the collection, care and disbursement of money and the economical purchase, care and use of material. These references are in every case accompanied with explanations that enable the reader to look at the subject from the standpoint of the manager. He can thus not only understand clearly a particular matter, but questions collateral thereto. A similar practice can be observed to advantage in many things connected with the rules and regulations governing the movement of trains. Much that I have to say in this book has this object in view. Such explanatory matter appears unnecessary to experts, but it must be remembered that rules and regulations are most valuable to beginners. To such persons explanatory matter, even of the most simple and rudimentary character, is of the greatest possible value. Rules are not promulgated for the few, but for the great multitude who require guidance.

The disposition of those connected with the train service to give the rules governing them more thoughtful consideration is apparent with each year's experience. But this is not esteemed enough by some managers, and accordingly they require that all connected with the train service shall be examined periodically, as to general fitness and specific knowledge. This examination is not confined to new men, but applies to all. It is based upon a belief that it is necessary, and moreover, if not voluntarily carried out by the railroad companies that it will be arbitrarily enforced by the government; that one great railroad accident brought about through the manifest ignorance of trainmen in regard to necessary rules and regulations will precipitate action by the government.

In the absence of specific examinations of this nature, it has been suggested that a particular person shall be designated by each company whose duty it shall be to answer questions propounded to him by trainmen in regard to rules and regulations. Thoughtlessness and indifference on the part of some and timidity and pride upon the part of others, it is believed, will prevent a general understanding of the rules unless adequate provision is made to overcome the difficulty. If explanation could be vouchsafed the proud and the timid without shocking their sensibilities, they would gladly accept it.* With the

* Quite a number of railroad companies place at convenient points on their lines what they call a "question box." Anyone wishing to ask a question writes it out and drops it into the box without signing his name. The reply is posted on the bulletin

careless and indifferent more forcible measures are necessary.

Not only must rules be adequate and thoroughly understood by those they govern, but they must be obeyed. The emergency suggests inspection and supervision. Many of the departments of the service provide supervisors, whose duty it is to see that needed rules and regulations are adopted and carried out. The same practice will be found to work well in connection with the train service. High efficiency is impossible otherwise. Men will not confess their ignorance unasked; indeed, may not know that they are ignorant. There must consequently be someone whose duty it is to seek them out.

The rules and regulations governing the movement of trains are printed and supplied to every person interested. They are simply and clearly stated. If a rule is transgressed, it should be assumed that the offense was conscious. Ignorance cannot be assumed in so vital a matter. To do so is to destroy the force of a code and weaken the discipline of the force.

Moreover, if a rule is embodied in the manual, attention should not be called to it outside of or apart from the manual itself. To do so is to weaken all other rules.* The manual should be enforced in its entirety.

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board, where all, including, of course, the person who made the inquiry, can see it.

* It has not been a startling nor unusual thing in railway practice to see circulars issued calling attention to a rule in the manual and asking its enforcement.

Employes do not always attach the same significance to specific rules. This is also true of signals. Acquaintance with the everyday working of trains teaches that allowance must be made for ignorance, stupidity and thoughtlessness, and trainmen strive constantly to protect themselves and their trains from the fatal effects thereof. Thus, the engineer does not depend implicitly upon the protection the time card affords him. Will the rules be carried out? he constantly asks himself. Doubtless; anyway he ventures no comments. Outwardly, he is unconcerned, but as he proceeds on his way he scrutinizes the road before him with an intensity that never wearies. His anxiety is not occasioned by fear for his own safety, though that has its influence, but is the result of knowledge, born of experience, that blind adherence may cost him his life and the lives of the people in his care, and who are as unconscious of danger as they are helpless to avert it. Oftentimes his watchfulness is of no avail; a sharp curve brings him face to face with an obstruction, an open switch, or may be a track torn up for repairs. Some necessary rule upon which his safety depends has been disregarded. A train perhaps that should have waited has gone on its way, confident of making a desired siding, but high winds, a slippery track, or an engine that will not make steam have prevented, and so, suddenly, from out the obscurity it emerges to meet the train that is proceeding on its way under the rights accorded it by the schedule.

That disasters of this character are not of more frequent occurrence is largely attributable to the watchfulness of trainmen. They know that lack of care may not only cost the offender his life but involve many innocent lives. And so there grows up in their minds an intense conservatism. They strive literally to comply with every rule, risking nothing, but their obedience is attended with unceasing watchfulness. To this latter and their desire to adhere to established rules, travelers owe their safety.

The more we scrutinize the rules of different roads, the more we are surprised at their lack of uniformity. Many of the differences appear material; others, again, are manifestly differences of form only. Oftentimes we can trace, or think we can, in the regulations the peculiar traits of those who formulated them. Thus, the rules of one company are minute and exacting, while those of another trust more to the discretion of employes. Much is said in favor of each system; under one it is claimed employes act automatically; under the other more zealously, but less effectively. The first named system, a critic may point out, is the best for the company for the time being, the last named most advantageous to the growth of the men.

We must be familiar with properties to enable us to understand the reason for many differences that exist. Thus, upon one line trains going south are entitled to the road for a certain number of minutes after the time fixed in the table for meeting opposite trains, the trains going north being required to keep out of their way meanwhile. Upon a neighboring road trains going north will be the ones that are favored. The distinction is based on the importance of trains, but it does not require a vivid imagination to picture the possible consequences that would follow a mistake as to the rights possessed by the respective trains. Such a mistake, however unlikely, is rendered barely possible, it has been claimed, by the transfer of employes that is all the time going on between railroads.

A noticeable difference in rules is that affecting construction and other working trains. Thus, one company will require such trains to keep ten minutes out of the way of freight trains. These trains require many men in their operation, and the loss to a company through enforced idleness of this kind amounts yearly to a large sum. A neighboring company, keeping this fact in mind, gives its working trains permission to continue at work (protected by signals) until the approaching freight train is in sight. Upon the last named road its practice might be practicable while upon the other it might not be. Business situations in the main govern such matters, though not always.

The margin of time allowed trains of a superior class (which time must not be used by inferior trains) is not uniform upon different roads. One company will require freight trains to be upon a siding twenty minutes in advance of the time a train of superior grade is due; another line, fifteen minutes; another line, ten minutes. The object of each is to strike a safe mean. Different conditions render differences possible and necessary.

A study of the rules and regulations of railways discloses strenuous efforts to make the most of every circumstance. That these efforts are sometimes ill directed is true, but such failures teach a lesson and are, therefore, in the end not wholly lost. On one road, to illustrate, detached engines are required to precede regular trains. Another company, with an eye to the saving that may be effected, requires such engines, when accompanying freight trains, to follow rather than precede, the object being to make them assist the loaded train. However, it may be said in connection with such differences that assistance may be valuable in one instance and not in the other.

Not the least surprising of the variations that exist are those having reference to the manner of conducting business upon double track roads. While it seems apparent to Americans that vehicles on the public highway should turn to the left in passing, it seems equally clear to them that upon a railway where danger of collision does not exist, trains should take the right-hand track. However, the regulations of many lines require trains to run on the left-hand track; others require them to take the right-hand track. There are reasons for these differences at the present time (though perhaps not in the beginning), one of the most weighty of which is the fact that custom has made current practices the best to follow. Not only is the force schooled in such practice, but many of the physical features of the line have been based on it and cannot be easily or cheaply adapted to any other.

A diversity somewhat similar to that existing in train rules is found in the telegraph service. Thus, upon the lines of one company the signal "7" flying along the wire closes every key and silences every operator. It is a magic number and hushes all disputes. It may mean life and death. At any rate, it is a warning to clear the line, a signal that the waiting message must take precedence of everything else. On another line the signal in question possesses no significance whatever, and its repetition would never still the struggle that is forever going on among operators for the circuit. Upon another line the cabalistic sign "9" hushes everyone. It is the signal of the executive, and woe to the unfortunate who ventures to break in upon its prerogatives. Elsewhere this number has no meaning, and its repetition would only excite profanity. Upon every line ingenious means are adopted to save time and labor. Thus, letters are made to convey special information or lengthy interrogatories. When letters have been exhausted, numerals are resorted to.

While the rules of no two railroad companies were alike at the start, no code contained every rule that possessed practical value. But the code of every company contained valuable hints and suggestions that might be profitably studied by others. It has been my aim to embrace in this book the valuable features of all of these codes. The work was an herculean one, and one in which I have been only partially successful. But in pursuing these studies I have never ceased to admire the practical wisdom and adaptability railway managers evinced in forming their train rules and regulations. Each brought to the subject his quota of knowledge, sometimes wholly original, sometimes adaptive merely.* This last peculiarity was especially striking. Thus, one manager, who had given particular attention to claims, directed his subordinates in case of accident to report, with other facts, the names of witnesses; other companies noted the provision and adopted it. Another manager, taking advantage of every doubt, warned employes that the company would not be responsible for accidents to them while coupling cars! Another manager would take a common rule and, by adding a clause, gave it a completeness it did not before possess. By and by the change would be generally noticed and adopted. One practical manager ordered his engineers not to exceed fifteen miles an hour, and pointed out that, running at that rate, they would pass seven telegraph poles a minute. Another manager invented a system

* I speak in the past tense because the methods that govern trains were, in the main, formulated in the early history of railroads, and the men who instituted them and put them in force have long since passed away, with but few exceptions.

peculiarly his own, whereby trainmen could signal each other in the event a train should break into more than two parts. Still another manager defined the rights possessed by extra trains in the absence of special orders, if they could not reach the meeting point without trespassing upon the time of trains going in the opposite direction. The instances I have cited are merely intended as illustrative of the originality of knowledge and diversity of experience evinced by managers (acting apart) in framing codes of rules governing the movement of trains. A volume would hardly be sufficient to point out the special regulations in force to-day suggested by the experiences and environment of different managers. Out of such experiences and conditions an effective code of train rules is being evolved. It is not yet complete. The way seems long and prosaic, but all the beneficent laws in existence that make life worth living have grown in the same simple, cumulative way.

CHAPTER XVIII.

TRAIN PHRASEOLOGY.

The nomenclature of trains is well understood by men in the service, in the localities where the peculiar idioms it takes on happen to be current, but to novices and the world at large it is an enigma, and, like all enigmas, must be explained in order to be understood.

Many of the phrases used by trainmen are adaptations. Many are evolved from the peculiarities of the service. While the vocabulary of trainmen is not as copious as that of sailors, many of their phrases are quite as enigmatical. Thus, when American trainmen speak of "flying switches" foreigners are puzzled. Nor are they more enlightened in regard to such things as "running switches," "shooting stations," "wild trains," "whistling posts," "taking side tracks," "making time," "clearing trains," "slipping engines," "setting switches," and so on.

The phraseology of the English roads is quite different from that of America, but not more intelligible to us than our form of speech is to Englishmen. How many railway men in America are there who know the meaning of "scotch block,"* "sprag,"† "trolley,"‡ "lay bye,"§ "lorry,"‖ "ganger,"¶ or "train staff"?** In England, as in the United States, the names of many things connected with railways had a significance half a century ago that they no longer possess.††

The great bulk of the phrases now used by trainmen in a country are well understood by its people, but many are intelligible only to those familiar with the peculiar vernacular of railway men. It is desirable that they should be understood at least by everyone in the service of railways. The list I give might be enlarged. It is constantly receiving new accessions. It is as follows:

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* A movable block laid across the track to prevent the movement of cars.

† A block fastened to a pivot near the end of a siding and laid across the siding when cars have been left in it, to prevent their being moved out accidentally.

‡ Car used by trackmen.

§ A side track.

‖ A flat car.

¶ The foreman in charge of sectionmen.

** A staff used upon a single track road to indicate that a train has been granted the right to run over a particular section of line, as explained elsewhere herein.

†† "At the 'booking office' of an English road, no booking is done. You merely say, to an unseen if not invisible person, through a small hole, 'First (or second) class, single (or return)' put down your money, receive your ticket, and depart. But as there were booking offices for the stage coaches which used to run between all the towns and through nearly all of the villages of England, the term had become fixed in the minds and upon the lips of this nation of travelers. So it was with the guard and his name; and when the railway carriage supplanted, or rather drove out, the stage coach, the old names were given to the new things, and the continuity of life was not completely broken."—*Richard Grant White.*

Ahead of Time.—When a train reaches a place before it is due at such place, according to the schedule or special order under which it is running, it is said to be ahead of time.*

Behind Time.—When a train fails to reach a point at the time specified in the schedule or special order under which it is operated, it is said to be behind time.

Block System.—A system devised to facilitate business and protect trains. Under the block system the track of a road is divided into convenient sections called blocks.

Brake.—An apparatus attached to engines and cars for the purpose of bringing them under control, when occasion requires to lessen their speed or stop them when in motion. "A piece of mechanism for retarding or stopping motion by friction, as of a carriage or railway car, by the pressure of rubbers against the wheels."—*Webster.* The application of this power or friction to the wheels is described by the phrase "setting the brakes."

Cars.—Freight cars are called wagons in Great Britain; passenger cars are called coaches or carriages. In Europe the passenger car is quite generally divided into compartments, with entrances on the sides of the car. The compartments of first and second class carriages usually contain seats for eight, four on each side. The third class car is occupied in common and is

* It is a most imperative and obviously necessary rule that no train shall *leave* a station ahead of its schedule time.

extremely plain. Formerly, there were no toilet facilities for any of the classes. They are now provided in many instances for the first class. While the compartments of this class are luxuriantly furnished, the facilities do not compare in comfort with the drawing room or chair car of America.

Classes of Trains.—" Regular," "Extra," "Special" and "Wild."*

Clearing a Train.—Keeping out of the way of a train; arriving at a meeting or passing point before the train to be cleared is due.

Closed Switch.—When a switch is "closed" the main track is then uninterrupted, i. e., not diverted.

Construction Train.—A train employed in the transportation of material used in connection with the improvement of the property of a railroad or the building of new lines. It is usually understood to mean trains engaged in hauling ballast, dirt, gravel, stone and timber, or engaged in removing earth from ditches and cuts. Trains occupied in the work last described are called ditching trains.

Drop off Flagman.—A man who gets off a train for the purpose of protecting its rear.

Extra Train—A train not expressly provided for in the schedule.†

* As a matter of fact there are only two classes—regular and special. The last is, however, differently designated on different railroads.

† The term is not as common as formerly. It is now quite generally the practice when extra trains are run to incorporate them with trains provided for by the time table, as the first,

Flying Switch.—The disconnecting of a portion of a train while in motion, just before reaching a switch. The forward part of the disconnected train is then accelerating in speed so that it will reach and pass the switch in time for the person in charge thereof to divert the detached cars to another track.

Grade of Trains.—The grade of trains varies upon different roads, but it may be stated generally as follows: the four classes of passenger trains, limited, express, local and suburban; the three classes of freight trains, live stock, through and way; trains operated under special or telegraphic orders.

Holding a Train.—Holding a train by special order or under the provisions of the schedule, say until another train arrives or passes it.

Interlocking.—Tracks controlled from a common point, by means of levers, each switch and signal being locked so as to protect the track over which the train is passing. The term is fully explained elsewhere herein.

Keeping off the Time of a Train.—An order to a train not to obstruct the track nor attempt to occupy it as against another train.

Lost its Rights.—When a train has lost its rights under the schedule.

Lost Time.—The time that a train has lost according to its schedule. If a train is behind time it has "lost time."

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second or third section, as the case may be. Extra passenger trains are more frequently called "specials" than "extras."

Main Track.—The principal track or tracks of a road upon which trains are run.

Making Time.—A train running in accordance with the time allotted it in the schedule. When a train is recovering time it has lost, it is said to be "making up time."

Meeting Point.—A point at which trains moving in opposite directions meet.

Movement of Trains by Telegraph.—The manipulation of trains from a central office through the medium of the telegraph. The substitution of special orders for the rights allotted under the schedule.

On Time.—A train conforming to the time specified in the schedule.

Open Switch.—When a switch is "open," the main track is connected with a subsidiary or collateral track.

Overshooting.—Running past a point or station.

Passing Place.—The place where a train is overtaken and passed by another train going in the same direction.*

Regular Train.—A train specifically named in the schedule.

Right to the Road.—The right of a train to occupy the main track at a particular time and place, to the exclusion of all other trains. In the absence of orders to the contrary, trains of an inferior grade are required to keep out of the way of trains of a superior grade. Thus, when a

*If the trains are proceeding from opposite directions, the point where they pass each other is called the meeting place.

superior train is due according to the schedule, inferior trains must not occupy the main track.

Rights of a Train.—Rights that a train possesses as defined by the schedule, or special orders.

Running Against a Train.—When two trains are to meet at a certain point they are said to be running against each other.

Run Regardless.—The right a train has to run regardless of other trains, as "you will run from Fort Edward to Glens Falls regardless of train No. 9, keeping out of the way of all other regular trains."

Schedule.—See "Time Table."

Semaphore.—An apparatus or signal for conveying information to trainmen.

Setting a Switch.—Arranging a switch so as to connect certain tracks. When a switch is adjusted so as not to disconnect the main stem, it is said to be "set for the main track." The directions to trainmen and others, so often to be met with, to see that "switches are set right," means that they are to see that switches are adjusted so as not to disconnect the main track.

Shunting.—The English term for switching.

Side Track.—A track varying in length and running parallel with the main track, and connected with it at one or both ends. With unimportant exceptions, freight cars are loaded and unloaded on these tracks. The tracks vary in number and length with the business that requires accommodation. For the purpose of enabling trains to meet and pass each other, suitable side tracks are required to be located at convenient points. The terms familiar to railway men, "will take a side track," "will side track," mean that the train referred to will occupy a side track.

Signals.—The mediums by which intelligence is conveyed quickly, and at a distance between employes at night and by day, through the agency of the senses.

Sliding Wheels.—In England this is called skidding wheels.

Special Train.—A train provided for a special purpose and not named in the schedule.

Spur Track.—A track connected at one end only with the main track.

Station.—A place where the traffic of a railroad is received and discharged. The depot and its immediate vicinity. In the movement of trains a side track located at an isolated point on the line possesses the same significance as a station—a place where trains meet or pass.

Switch.—A mechanical apparatus constructed at the junction of two or more tracks. It is operated with a lever and cross bar, and by its aid diverging lines are connected or disconnected at pleasure. In England a switch is spoken of as "the points." What we call a switchman is there termed a pointsman.*

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* It is an interesting fact that when the switch was first used the two movable rails composing it were not connected by a cross bar, nor was it operated by a lever, as described. The operator was compelled to move first one and then the

Switching is called "shunting" on English roads. It means the transfer of a car from one track to another; the manipulation of cars in yards; arranging and rearranging cars in trains, etc.

Third Track.—A third track placed between the main tracks of a double track road for the purpose of enabling trains to pass each other with facility; a track occupied by trains of an inferior grade for the purpose of allowing trains of a superior grade to pass.

Through or Limited Train.—A train designed to accommodate through traffic.

Time.—The time allotted to trains in the schedule by which their movements are governed.

Time Table.—The schedule fixing the grade of each and every regular train, providing where trains shall meet or pass each other; fixing the maximum speed of trains and giving each regular train a definite number, and specifying the time of its arrival at and departure from stations. Rules and regulations governing the movement of trains from a part of the time table.

Train Dispatcher.—The official who directs the movement of trains. An expert.

Turn a Switch. To disconnect one track to connect with another.

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other rail into position. The connection of the two rails was, in its day, esteemed a great invention, as indeed it was, paving the way for the use of the elaborate interlocking devices now in vogue.

Way Train.—A train that stops at the various stations and is occupied in doing the local business of a company; an accommodation train.*

When a Train Has Lost Its Rights.—A regular train, when twelve hours behind time, loses its right to the road against all regular trains; is no longer provided for by the schedule; ceases to be a regular train. A train may lose its rights as against a particular train or trains, and still possess rights over other trains. Upon a single track road a train is not allowed to leave a station where it should meet a train of its own grade until, say, thirty minutes after its leaving time. Thereafter it proceeds on its course, keeping thirty minutes behind its time, the opposing train keeping out of its way. Trains of inferior grade cannot proceed until trains of superior grade have arrived, unless the latter are twelve or more hours behind time.

Whistling Post.—A post erected in the vicinity of stations, crossings and bridges to signal the engineman to sound the whistle.

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*The duties of employes on way freight trains in America are multifarious. In addition to the duties of trainmen they handle much of the freight hauled in their trains. For instance, a freight car will contain small parcels of freight for many different points. It is the duty of the trainmen to unload this freight. When the freight to be shipped from a station is not sufficient to warrant the exclusive use of a car, it is piled upon the depot platform, to be loaded by the trainmen into some empty or partially loaded car in the train. The engines of way freight trains do the switching at the small stations.

Wild Train.—An irregular train for which no provision is made in the schedule. It is operated under special orders.

Wood or Fuel Train.—A train engaged in hauling the fuel of a company.

Y—A track of this shape; a convenient means of turning engines.

Many words used to express things in connection with the operations of railroads are readaptations from old forms, as I have intimated. Thus, in the days of stage coaches the place where passengers engaged their seats was called the "Booking Office." When railroads were introduced the offices in which tickets were sold were called "Booking Offices." The man who Guarded the stage coach in the troublesome times of Dick Turpin continued to be called a Guard when put in charge of a railroad train. Inter-communication has made some of the words of the respective countries familiar to the people of each, but in many cases, this is not so and never will be. I append below a few of the words that differ whose significance must be known in order to understand the nomenclature of railroads in the respective countries. Thus, what Americans call a baggage car, the English call a luggage van; what the former call a fireman, the latter call a stoker; similarly a ticket office is a booking office; a station agent, a station clerk; a baggage room, a cloak room; a passenger car, a carriage; baggage is luggage; a mail car is a post van; a conductor is a guard; an engineer is a driver; a freight car is a goods van; section foreman is a ganger; sectionmen are plate layers. These are the more important differences in addition to those already noticed.

CHAPTER XIX.

RULES AND REGULATIONS GOVERNING THE MOVEMENTS OF TRAINS.

The rules and regulations embodied herein governing the movements of trains were selected from those of all the railroad companies of America.* The workings of the principal railroads of Great Britain were also studied, and such of their rules as were applicable, given a place. In many cases old regulations have been inserted as foot notes for purposes of information and illustration. They are exceedingly interesting. Many of the rules embodied herein are necessarily original. In some instances I have found it necessary to decide between conflicting rules. In such cases I have chosen those that seemed the best, the object being to form a practicable working code, or one from which such a code might be selected.

I do not publish these rules and regulations with the expectation that railroads will adopt them. A uniform code is impracticable, but every rule that is valuable, either wholly or in part, will in time be accepted, or the suggestion it conveys, used. Those that have no relevancy, if there are any, will not be used.

*In appendix C will be found the Single Track Train Rules contained in the Standard Code of the American Railway Association.

While it has been the aim to make the regulations general, I know that many rules that are necessary upon one line possess little relevancy upon another. A double track road, for instance, does not require such elaborate rules as a single track road, still it is necessary for such roads to provide regulations sufficiently comprehensive to govern operations on a single track in the event circumstances should temporarily restrict the company to one track.

Again, a company that can allow twenty minutes between its trains will possess rules that would be impracticable upon a line where business requirements restrict intervals between trains to five minutes.

The object I had in view in forming these rules originally (in 1878) was to aid in bringing something like uniformity out of the medley that existed. The rules have since been changed in many respects and greatly added to. This will continue to be the case as railways are more and more efficiently organized and operated, and they are, through such better methods, able to throw additional safeguards around life and property. The object I have in view now, as in the past, is to place within the reach of railway men ample facilities for acquiring knowledge of the needs of trains under the American system. These needs, for reasons I have explained, are not fully set forth in the rules and regulations of any particular road.

On examining the rules of many great companies, I found, when pursuing my inquiries, that many important rules were omitted entirely from the code they used on the theory that they were well known to railroad men. Those practically familiar with the working of trains doubtless did possess such knowledge, but the novice found the omission not to be overcome except by diligent inquiry, which, as a rule, he was unable to prosecute successfully. I therefore embraced every rule or procedure I believed to be necessary or valuable to a complete code.

In reference to old rules, I altered their phraseology and scope wherever greater clearness could be attained thereby, the object being to frame a code everyone could understand.

The more minute regulations of the English block system having no general significance in the United States, I did not embody herein, but the general regulations of the system will be found in the chapter I have devoted to the operation of trains in Great Britain.

In preparing the accompanying code, I have availed myself freely of the standard regulations of the American Railway Association (an association made up of men of the highest talent and railway experience) but the code, as a matter of fact, has its basis in the rules and regulations prepared by me in 1878. That was the first attempt ever made to secure fullness or uniformity in such matters. It formed at once the basis and initiative of all subsequent action. The rules of the railway association, referred to above, include only a small percentage of those I embody, for the reason (as already intimated) that only a very small percentage of rules apply to every company, or if they may be made to apply, all railroads cannot be brought to agree upon them. The rules formulated here are such as general railway practice requires, but not essential in the practice of each and every company. Every rule is, however, valuable as throwing added light on the general subject.

The object of train rules is to facilitate business and throw necessary safeguards around life and property, but all rules are not equally important. For this reason, it will never be possible to prevail upon railroads as a whole to accept a code in its entirety. They can only agree on essentials.

With these explanations I proceed to point out the rules and regulations that will be found essential at one time or another, in moving trains, leaving it to the reader to avail himself of such as may be required to meet his practical needs.

GENERAL RULES.*

Instructions governing the movements of trains will be found in printed manuals; in instructions issued in connection with time tables; and in such special orders as circumstances may from time to time require.

* Many of these rules, it will be observed, aptly apply to all departments of the service, officers and employes alike, and in so far as this is so, properly have such general application.

Every employe should have a copy in his possession, at all times, of the rules, regulations and orders he is expected to obey.

Officials in charge are required to see that instructions relating to trains are fully understood, and that proper measures are taken to secure obedience.

The fact that a person enters, or remains in, the service of a company is assurance of willingness to obey the rules. No one can be excused for their violation, even though not included in those strictly appertaining to his branch of the service.

If doubt exists as to the meaning of a rule or order, application should be made at once, to the proper authority, for enlightenment. Ignorance cannot be accepted as an excuse for failure to comply with the letter and spirit of the rules.

Every employe, while on duty connected with trains on a division, is under the authority and must conform to the orders of the officials of such division.

All persons engaged in performing service on a train, no matter what the nature of the service may be, are subject to the rules governing employes of the company.

The custom requiring trainmen and telegraph operators to pass an examination in regard to the rules and regulations before being assigned to duty, should be strictly observed.

Due and proper notice must be taken of disobedience of orders, neglect of duty, or inefficiency.

Employes who are liable to be called upon for duty at any time, must keep the proper official advised of their place of residence.

Employes are expected to be on the alert to protect the interests of the company in all things, and to this end should report at once anything coming under their notice detrimental to its best interests; full particulars, in writing, should be made of cases of damage to persons or property.

Persons who are garnished, are required to repay the company any outlay it is put to in consequence.

The use of intoxicating liquors on the part of employes, while on duty, is strictly forbidden.

Employes discharged from one department cannot be re-employed by another without permission.

Minors cannot be employed in the train service except under special arrangements covering the contingencies of such cases.

Communications concerning the safety of trains, track or buildings, should, if possible, be made in writing.

An employe cannot become familiar with his duties unless he is familiar with the duties of those about him. This knowledge can be acquired by studying the rules and regulations. Matters of interest will be found under all the headings and sub-headings, as it is impossible to classify the duties of various employes without endless reiteration. All rules and regulations should therefore be studied.

A test of fitness is accuracy of information as to train and station service. This is particularly the case with train and station employes. Each must be familiar with the duties of the other, so that in the event of accident he may be prepared to perform his functions. The same rule holds good in regard to employes at stations.

Employes must be temperate men.* They cannot accept gratuities.† They must attend diligently to their duties during prescribed hours and reside where the interests of the company require.‡

Lost property coming into the hands of employes must be turned over to authorized officers of the company.‖

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* "Smoking while on duty is forbidden, and the use of intoxicating liquors as a beverage will be considered just cause of dismissal from the service of the company."—*A Western Road.* "The proprietors of refreshment rooms are forbidden to supply spirits to any engineman, fireman, guard or other servant of the company while on duty."—*Great Northern Railway, England.* "No instance of intoxication while on duty will be overlooked." —*Old Regulation.*

† "No person is allowed to receive any gratuity from the public, on pain of dismissal, and the compensation paid will cover all risks incurred or liability to accident from any cause on the road."—*Old Regulation.*

‡ "Each officer and man shall devote himself to the company's service, and he must serve when and wherever he is required, including Sunday, if necessary, he being allowed for any extra work at his usual daily rate of compensation. If a guard or other servant should have two residences, he must make them both known at each station from whence he works." —*English Road.*

‖ "All property which may be found on the line or premises of the company, by any man in their employ, shall be imme-

Instructions issued by those in authority must be promptly obeyed.

Disobedience, negligence, incompetency or immorality renders a person unfit for service and should be sufficient cause for dismissal but suspension from duty can be substituted, at the discretion of the proper officer, in lieu of more severe disciplinary measures.*

Employes should not absent themselves from duty without permission. Permission should be asked through intermediate heads, when employes are not directly responsible to the chief officer of the department.†

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diately handed to his superior officer, and by him to the agent at Blank street station, and entered by him in a book kept for that purpose. But should it be known that the property found had fallen from any particular train, it should be forwarded by the next train, or as soon thereafter as possible, to the station to which the train was proceeding, and notice thereof sent to the office at Blank street. Any man known to keep any property so found will be severely punished."—*Old Regulation.* "All property found by any servant of the company on any of the premises must be immediately taken to the clerk in charge, in order that a proper entry may be made of the article in case of inquiry."—*Great Northern Railway, England.*

* "Persons who disapprove of the regulations adopted, or are not disposed to aid in their enforcement, are requested not to remain in the employment of the company."—*Old Regulation.* "And they will inquire into and punish instances of immoral or loose conduct on the part of any of their servants."—*English Road.*

† "Men absenting themselves without leave, and prevailing on others to supply their places, will subject themselves and all parties concerned to a heavy fine. Any man absenting himself without having a proper 'leave of absence ticket' will be fined $1.25 as though he were absent without leave. In case of extra business, of sickness, or unavoidable cause of absence of any

Orders or instructions received should be filed for future reference.

Wise discretion and economy should be used in the use of material.*

Those entrusted with keys to switches, cars, etc., should receipt for them, and see that no improper use is made of them.

Employes are held responsible for injuries to persons or property occasioned by their negligence or misconduct; also for moneys coming into their possession belonging to others.

Any expense the company is put to in consesequence of the negligence, misconduct or improper action of an employe is deducted from the pay of the employe in fault.†

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servants (excepting clerks), the clerk in charge is immediately to provide for the proper performance of the duty by appointing some temporary substitutes, but he is responsible for selecting men of good character, sober, honest and intelligent, and capable of undertaking the office. With a view to such temporary appointments, it is desirable that the character and eligibility of some proper persons from time to time be previously ascertained."—*Great Northern Railway, England.*

* The duties of employes in connection with the use of a company's supplies and the rules and regulations governing the same will be found in the book "Economical Purchase, Care and Use of Material."

† "In the event of any misconduct or suspicion of irregularity of the servants, it is competent to the district agents or clerks in charge to suspend them, reporting the circumstances immediately. The pay of all clerks, guards, policemen, porters and others will be stopped from the moment of their being suspended; and the pay will not be allowed except in the event of entire acquittal of the charge for which the man was suspended. The company reserves the right to deduct from pay any fine imposed for neglect of duty, or otherwise, which (in the event

Employes, while on duty, should not enter into any altercation with others, no matter what the provocation.

No employe will be paid, while absent from duty, except upon the order of the proper officer.*

When instructions are not fully understood, or when the course to be pursued admits of doubt, employes should so act as not to compromise the safety of property or endanger life, seeking, on the first opportunity, the explanations they require.

Employes connected with the train service should have in their possession a copy of the time table.

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of pecuniary loss to the company not being entailed thereby) will be appropriated to a benevolent fund."—*Great Northern Railway, England.*

* "A clerk, in case of continued absence on account of illness, is not entitled to pay for more than a fortnight during such absence, except under the special sanction of the board, to whom application must be made through the superintendent of the line, who will decide whether the case be one he can properly recommend for consideration; but as a sick fund is now established to which all persons in the service are eligible, and which, for a small weekly payment, provides medical attendance for the contributors, their wives and families, a weekly allowance in sickness, and funeral allowance in case of death, clerks are recommended to subscribe to it, and thus render themselves, in a much greater degree, independent in case of sickness or other unavoidable calamity befalling themselves or their wives or families. Every guard, policeman and porter is required to become a member of the sick fund established by the company, and to pay his subscriptions regularly out of the wages he receives by deduction from the pay bill, or otherwise."—*Great Northern Railway, England.*

STANDARD TIME.*

Observatory time is the recognized standard of railroads, and will be transmitted from the observatory to designated offices daily, at the hour agreed upon.

[NOTE.—In order to detect possible errors at junction points and to secure uniformity, it is recommended by the committee of the railway association that the time be disseminated to all points at the same hour. They also consider it of great importance that the time be obtained from some observatory of recognized standing.]

Certain clocks to be named will be designated as standard clocks.

Conductors and enginemen must not take time from any clock unless it is designated as a standard clock.

Each conductor and engineman† must have a reliable watch, which has been examined and certified to on a prescribed form by a designated inspector, and must file such certificate with the proper officer before he is allowed to go on duty.

Watches must be examined and certificates renewed as often as the rules require. The certificate should be in form as follows:

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* The United States is divided into four divisions—Eastern, Central, Mountain and Pacific. Thus, when it is eight o'clock in the morning in New York, it is five o'clock in the morning in San Francisco. In reference to the rules that follow, the reader will be able to distinguish those that may aptly be applied to all railroad companies from those that are less general.

† The term "Engineman" embraces locomotive engineers and firemen.

This is to certify that on............................, 18....
the watch of..
employed as..
on the...R..........
was examined and found to be a reliable and accurate timepiece, and in such repair as will, in my judgment, with proper usage, enable it to run within a variation not to exceed thirty seconds per week.
Name of Maker..
Brand..
Number of Movement.................................
Gold or Silver..
Open or Hunting Case...............................
Stem or Key Winding.................................
(Signed) ....*Inspector.*
Address....................................

[NOTE.—Where this system of examining watches has been adopted the result of the examination has developed the fact that a large percentage of the watches previously in use were unfit to run trains by.]

To insure uniform time being kept at stations to which time is not telegraphed, the following regulations should be observed:

Each conductor and engineman must compare his watch with the designated standard clock before starting on each trip, and register his name and the time he compared his watch on a prescribed form.

Conductors and enginemen whose duties prevent them from having access to a standard clock must compare their watches daily with those of conductors and enginemen who have standard time, and have registered as above provided.

The conductor in charge of the first passenger train stopping at stations, should, on his arrival at each station at which there is no telegraph office, give the person in charge the precise time, in order that the station clock may be regulated accordingly.

Agents are held responsible for keeping their clocks properly regulated in accordance with the provision indicated. They should at once report to the proper officer if anything is wrong with their clock, so that necessary steps may be taken for its immediate repair.

The minimum standard of excellence for watches in America should be of a grade equal to what is generally known as the "fifteen jeweled patent regulator, adjusted to heat and cold." All watches should be duly protected from magnetism and electric influence.*

When a watch examined does not fill the required standard, it should be replaced by one that will. A watch rejected by one examiner cannot be repassed upon, except by the chief examiner.

When watches need cleaning or repairing they should be left with the company's examiner for that purpose. But if an employe prefers to take his watch to his own watchmaker he is at liberty to do so. The watch he carries during the time his own is being cleaned or repaired, however,

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*This last requirement is considered by experts to be of more importance than adjustment, as railway employes are so continually coming in contact with magnetism and electricity that any employe is in danger of having his watch ruined or rendered unreliable by its becoming magnetized.

must be examined by the company's examiner, and for this examination the employe should pay the fee, if any.

When watches are left with the company's examiner to be cleaned or repaired, a watch may be lent the employe to be used by him during the time his watch is undergoing repairs, free of charge.

Any variations in watches, as compared with the standard time of the road, should be noted on a blank provided for that purpose at least once a week, and oftener if necessary.

THE TIME TABLE.*

A time table is the general law governing the arrangement, class and time of all regular trains.

The times allotted each train is the schedule for such train.

A time table, from the moment it takes effect, supersedes the preceding time table, and all special instructions relating thereto.

A train of the preceding time table, unless otherwise directed, takes the time and rights of the train of the same number on the new time table.

A train of the new time table which has no corresponding number on the preceding time table shall not run until it is due to start from its initial point on any division after the time table takes effect.

Each time table, from the moment it takes effect, supersedes the preceding time table, and

* For form of time table, see appendix B.

all special instructions relating thereto. A train of the preceding time table loses its rights, and can thereafter proceed only by special orders.

A train of the new time table is one which is due to start from its initial point, on any division, after the time table takes effect.

[NOTE.—The committee of the railway association recommends three forms of above rule, leaving it discretionary with each road to adopt any one of these, as best suits its requirements.]

Upon the time table not more than two sets of figures are shown for a train at any point. When two times are shown, the earlier is the arriving time, and the later the leaving time. When one time is shown it is the leaving time, unless otherwise indicated.

Regular meeting or passing points are indicated on the time table by figures in full faced type.

Both the arriving and leaving time of a train are in full faced type when both are meeting or passing times, or when one or more trains are to meet or pass it between those times.

Where there are more trains than one to meet or pass a train at any point attention will be called to it by a sign indicating the fact.

[NOTE.—The railway committee recommends that each company adopt such sign as it may prefer.]

In all cases trains are required to clear and follow as provided.

On the time table the words "daily," "daily, except Sunday," etc., printed at the head and foot of the schedule of a train, indicate when it shall be run. The following signs placed before the figures indicate:

"s"—regular stop (or the same may be designated by the different styles of type used):

"f"—stop on signal to receive or discharge passengers or freight;

"¶"—stop for meals.

Trains are designated by numbers and their class indicated on the time tables.

[NOTE.—The railway committee recommends that odd numbers shall be given to west or south-bound trains, and even numbers to east or north-bound trains.]

SIGNAL RULES.

Employes whose duties may require them to give signals, must provide themselves with the necessary appliances, and keep them in good order and ready for immediate use.

If in an emergency proper signals are not at hand, warning should be given by the best means at command.

Flags of the proper color must be used by day.

Lamps of the proper color must be used by night, or whenever from fog or other cause day signals cannot be clearly seen.

Red signifies danger, and is a signal to stop.

Green signifies caution, and is a signal to go slowly.

White signifies safety, and is a signal to go on.*

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* At some large stations, where there are lamps showing white lights for other purposes than signaling, which come in the line of the signals, a green light is substituted for a white

[NOTE.—The three colors referred to were at one time generally used for the purposes indicated. However, as I have already said, there has never been any such thing as uniformity either in signals or rules. The tendency at this time is steadily in the direction of substituting green for white as a signal of safety. The reason for this is obvious. A red lamp, the glass of which is broken, shows white, and when thus broken (as is not unfrequently the case), signals the engineer to go ahead, (that everything is right) when a contrary order is intended. It is likely that red will still be used as a signal of danger, notwithstanding the objection referred to. Red and green combined are a desirable caution signal. White, it is probable, will in time be abandoned except as a hand light, thus, if a red lamp should be broken, the white light that would shine in its place, would have no significance and the train would be brought to a stop to ascertain the absence of a red or green signal. The signals that are embodied in this section, and in general throughout these rules and regulations are those agreed upon by the American railway association. They are not, however, binding on any company, and may be changed, as they have been in numerous cases.—M. M. K.]

Green and white is a signal to be used to stop trains at flag stations for passengers or freight.*

Blue is a signal to be placed on a car or an engine to forbid its being moved.

A torpedo placed on the top of the rail is a signal to be used in addition to the regular signals.

The explosion of one torpedo is a signal to stop immediately; the explosion of two torpedoes, not more than 200 feet apart, is a signal to reduce

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light on the signal post; but in all such cases trains are to approach and pass through such stations with caution.—*Great Western Railway, England.*

*When a train does not stop at a station unless signaled, such station becomes a signal station, so far as that particular train is concerned, but generally speaking, we understand a signal station to mean a small and unimportant place where trains do not stop unless signaled.

speed immediately, and look out for a danger signal.*

A fusee may be used in addition to torpedoes or other danger signals.

A flag or lamp swung across the track, or a hat or object of any kind waved violently by a person on the track, signifies danger, and is a signal to stop.

Those giving signals should locate themselves so as to be plainly seen, and should make the signals in such a manner as to be readily understood.

The utmost care should be exercised by trainmen to avoid accepting the wrong signal, when two or more trains are passing each other at stations or yards. Unless both the conductor and engineer are positive that the signal given is for them, they should not move until communication is made by word of mouth.

Engineers, conductors and brakemen of trains, also station, track, bridge, signal and switchmen, should carefully observe passing trains by day and night to see if they flag following trains, and in case they do, govern themselves accordingly.

"Every guard, signalman, engine driver, gateman, foreman of work, and ganger of plate layers, will be provided with packets of detonators, which they are always to have ready for use while on duty, and every person in charge of a

* It is easy to understand that with effective air brakes a train may be brought to a standstill before the second signal referred to here is reached.

station must keep a supply of these signals in a suitable place, known by, and easy of access at all times to, every person connected with the station. All the persons above named will be held responsible for keeping up the proper supply of detonators. These signals must be placed on the rail (label upward) by bending the clasp around the upper flange of the rail to prevent their falling off. When an engine passes over a detonator it explodes with a loud report, and the engine driver must instantly shut off steam, and bring his engine to a stand, and then proceed cautiously to the place of obstruction, or until he receives an 'all right' signal. Detonators must be carefully handled, as they are liable to explode if roughly treated. It is necessary to keep them well protected from the damp. At intervals of not more than two months, one from each person's stock must be tested, to insure that they are in good condition."*

A third torpedo exploded six hundred yards from the two referred to above, is a signal to stop at once.†

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* English Standard.

† Exposure to rain or wet for thirty minutes destroys or impairs the explosive qualities of torpedoes, and, in such cases, too much reliance should not be placed upon them. "When in snowy weather there is any probability of the detonators being swept from the rails by the brooms attached to the guard irons of the engines, these signals must not be depended on alone. The guard must not rejoin his train, even though it may be able to proceed, unless some qualified servant of the company can be found."—*Great Northern Railway, England.*

TRAIN SIGNALS.

A train, while running, must display two green flags by day and two green lights by night, one on each side of the rear of the train, as markers, to indicate the rear of the train. Yard engines will not display markers.*

A train running after sunset, or when obscured by fog or other cause, must display the headlight in front, and two or more red lights in the rear. Yard engines must display two green lights instead of red, except when provided with a headlight on both front and rear.†

Each car on a passenger train while running must be in communication with the engine by a bell-cord or an equivalent appliance.

Two green flags by day and night, and, in addition, two green lights by night, displayed in the places provided for that purpose on the front of an engine, denote that the train is followed by another train, running on the same schedule and

* "Every train traveling on the line must have a signal lamp attached to the last vehicle, by day as well as by night, except when assisted by an engine in the rear, when such engine must carry the signal."—*Foreign Road.* Some single track railroads have abolished the use of green lamps for the rear of trains, on the ground that they are not of especial value, while they give engineers an excuse for carelessness at meeting points. They claim that the use of such signals is valuable only on double track roads.

† "The engines carry a white light in front of the passenger trains, and a green light in front of the goods, cattle, mineral, and ballast trains, but north of Doncaster they carry two white or two green lights, to distinguish between goods and passenger trains."—*Great Northern Railway, England.*

entitled to the same time-table rights as the train carrying the signals.*

Two white flags by day and night, and, in addition, two white lights by night, displayed in the places provided for that purpose on the front of an engine, denote that the train is an extra. These signals must be displayed by all extra trains, but not by yard engines.

A blue flag by day and a blue light by night, placed on or at the end of a car, engine or train, denote that workmen are at work under or about the car, engine or train. The car, engine or train thus protected must not be coupled to or moved until the blue signal is removed by the person who placed it.

When a car, engine or train is protected by a blue signal, other cars must not be placed in front of it so the blue signal will be obscured, without first notifying the workman that he may protect himself.

Two green and two white flags (one of each kind on each side) by day and two green and two white lights by night indicate that the engine or train carrying the same is followed by another which is irregular and will keep out of the way of all regular trains.

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* "A special train to follow is indicated by the preceding train carrying on the last vehicle a red board or a red flag by day and an additional red tail lamp by night, but as special trains or engines have frequently to be run without previous notice of any kind, it is necessary for the staff along the line to be at all times prepared for such extra trains or engines."—*English Standard.*

A yellow flag or lantern carried in front of an engine denotes that the telegraph line is out of order, and the trackmen of the various sections of road over which the signal is carried should at once examine the telegraph lines, for the whole length of their several sections, carefully and promptly repairing any defects they may discover.

When signals are carried on the front of an engine, two flags by day or two lights by night should be invariably used; if from any cause but one should appear, it will be taken to have the same meaning as two.

WHISTLE SIGNALS.

One long blast of the whistle (thus, ——) is the signal for approaching stations, railroad crossings and junctions.

One short blast of the whistle (thus, —) is the signal to apply the brakes to stop.

Two long blasts of the whistle (thus, —— ——) is the signal to throw off the brakes.

Two short blasts of the whistle (thus, — —) is an answer to any signal, except "train parted."

Three long blasts of the whistle (thus, —— —— ——), when the train is standing (to be repeated until answered, as provided), is a signal that the train has parted.

Three short blasts of the whistle (thus, — — —,) when the train is standing (to be repeated until answered, as provided), is a signal that the train will back.

Four long blasts of the whistle (thus, —— —— —— ——) is the signal to call in a flagman from the west or south.

Four long, followed by one short, blast of the whistle (thus, —— —— —— —— —) is the signal to call in a flagman from the east or north.

Four short blasts of the whistle (thus, — — — —) is the engineman's call for signals from switch tenders, watchmen, trainmen and others.

Five short blasts of the whistle (thus, — — — — —) is a signal to the flagman to go back and protect the rear of the train.

One long, followed by two short, blasts of the whistle (thus, —— — —) is a signal to be given by trains on single track, when displaying signals for a following train, to call the attention of trains of the same or inferior class to the signals displayed.

Two long, followed by two short, blasts of the whistle (thus, —— —— — —) is the signal for approaching road crossing at grade.

A succession of short blasts of the whistle is an alarm for persons or cattle on the track, and calls the attention of trainmen to danger ahead.

The whistle should not be used as a stopping signal, except in case of danger, if it can be avoided. It should never be used as a signal for starting a passenger train.

BELL CORD SIGNALS.

One tap of the signal bell, when the train is standing, is the signal to start.

Two taps of the signal bell, when the train is running, is the signal to stop at once.*

Two taps of the signal bell, when the train is standing, is the signal to call in the flagman.

Three taps of the signal bell, when the train is running, is the signal to stop at the next station.

Three taps of the signal bell, when the train is standing, is the signal to back the train.

Four taps of the signal bell, when the train is running, is the signal to reduce speed.

When one tap of the signal bell is heard while a train is running, the engineman must immediately ascertain if the train is parted and, if so, be governed accordingly.

Signals of the same number of sounds shall have the same significance when given by other appliances than bell cords and signal bells.

HAND LAMP SIGNALS.

A lamp swung across the track is the signal to stop.†

* "Every guard, when traveling, must keep a good look out, and should he see any reason to apprehend danger, he must use his best endeavors to give notice thereof to the engine driver. Should a guard wish to attract the attention of the engine driver, he must, in addition to using the communication, where such exists, apply his brake, sharply, and release it suddenly. This operation repeated several times is almost certain, from the check it occasions, to attract the notice of the engine driver, to whom the necessary 'caution' or 'danger' signal, as the case may require, must be exhibited."—*Old English Standard.*

† "The danger signal 'to stop' is shown by a red flag, or, in the absence of the flag, by both arms held up. 'Caution,' 'to slacken,' is shown . . . by one arm being held up. 'All

A lamp raised and lowered vertically is the signal to go ahead.

A lamp swung vertically in a circle across the track, when the train is standing, is the signal to back.

A lamp swung vertically in a circle at arm's length across the track, when the train is running, is a signal that the train has parted.

A flag, or the hand, moved in any of the directions given above, will indicate the same signal as given by a lamp.

Signal lamps should be lighted at dusk, and during the interval between daylight and darkness both day and night signals should be used.*

Hand lamps and flags, when used as signals, should be held in the hand.

FIXED SIGNALS.

Fixed signals are placed at junctions, railroad crossings, stations and other points required. Special instructions are issued indicating their position and use.

A semaphore arm extended in horizontal position by day, or a red light by night, signifies danger,† and trains should come to a stop, and not proceed until the signal indicates that all is

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right' is shown . . . by holding the right arm in a horizontal position pointing across the line of rails."—*Great Northern Railway, England.*

* English Clearing House Standard.

† "The danger signal is shown by the arm on the left-hand side of the semaphore post standing out from the post."—*Great Western Railway, England.*

right. When the line is clear, the arm will not be seen by day,* and by night a white light will indicate that all is right. During storms and foggy weather, great caution should be observed. If semaphore arms or signal lights cannot be plainly seen, trains should be brought to a stop, and not be allowed to proceed until all is known to be right.

Switch signals should be arranged so as to show white† when the switch is set for the main track, and red when set for a siding, crossing or junction.

RULES GOVERNING THE USE OF SIGNALS.

A signal imperfectly displayed, or the absence of a signal at a place where a signal is usually shown, must be regarded as a danger signal, and the fact reported to the superintendent.

The unnecessary use of either the whistle or the bell is prohibited. They will be used only when required by rule or law, or when necessary to prevent accident.

When a danger signal (except a fixed signal) is displayed to stop a train, it must be duly recognized.

The engine bell must be rung before an engine is moved.

The engine bell must be rung before reaching a public road crossing at grade, and until it is

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* "The 'all right' signal is shown by the arm hanging down to the side of the post."—*Great Western Railway, England.*

† Green may be used if thought more desirable.

passed. The whistle must be sounded at all whistling posts.

When two or more engines are coupled to a train, the leading engine only shall display signals.

One flag or light displayed, as provided, will be regarded the same as if two were displayed, but conductors and enginemen are held responsible for the display of all train signals.

When a train turns out to meet or pass another train the red lights must be removed and green displayed as soon as the track is clear; but the red must again be displayed before returning to its own track.

Headlights on engines, when on side tracks, must be covered as soon as the train has stopped; also, when standing at the end of double track.

The combined green and white signal is to be used to stop a train only at the flag stations designated by the schedule for that train; when it is necessary to stop a train at a point that is not a flag station a red signal must be used.

Signals must be used by watchmen at public crossings to warn persons when trains are approaching. Danger signals must be used only when necessary to stop trains.

[NOTE.—In connection with the subject of signals the railway committee recommends that no cross arms or telegraph poles placed along the line shall be premitted to be painted red or green.]

A red lantern should be kept lighted, ready for use at night or in foggy weather, in the rear car of trains; also, upon engines.

Should an engineman observe a train or engine at a stand, on the opposite line to that on which he is traveling, obscured by steam or smoke, he should sound his whistle and approach very cautiously, so as to be able to stop if necessary.

Cylinder cocks should be closed when trains are waiting on turnouts, clear of the main track.

When on duty trainmen should carry three torpedoes in their pockets. Trains should also be supplied with fusees.

No new signal should be brought into use, nor alteration made in the position or use of a signal, without authority from the proper officer.

TRAIN RULES.

CLASSIFICATION OF TRAINS.

Whenever the word train is used, it is understood to include an engine in service, with or without cars, equipped with signals as provided.

Regular trains are those named on the time table, and may consist of one or more sections.

All sections of a train, except the last, must display signals as provided.

Extra trains are those not represented on the time table.

Regular trains are classified on the time table with regard to their priority of right to the track, trains of the first class being superior to those of all succeeding classes; trains of the second class being superior to those of all succeeding classes, and so on.

Extra trains may be distinguished as extra passenger; extra freight; extra work. Extra trains are inferior to regular trains of whatever class, unless otherwise specifically ordered.

MOVEMENT OF TRAINS.

A train of inferior class must keep out of the way of a train of superior class.

On a single track, all trains in one direction, specified in the time table, have the right of track over trains of the same class running in the opposite direction.

When trains of the same class meet on single track, the train not having right of track must take the siding and clear the main track before the leaving time of the opposing train, but such train must not pass the switch to back in on a siding until after the arrival of the opposing train unless otherwise directed by special instructions. When necessary to back in on the siding, before passing the switch, a flagman must be sent ahead in the direction of the opposing train.

When a train of inferior class meets a train of superior class on a single track, the train of inferior class must take the siding and clear the train of superior class five minutes; a train of inferior class must keep five minutes off the time of a train of superior class following it.

A first class train must not arrive at a station where only the leaving time is shown more than the number of minutes specified in the time table in advance of its schedule leaving time.

[**NOTE.—The railway committee recommends ten minutes if grades are heavy or other conditions render it necessary.**]

A train must not leave a station to follow a passenger train until five minutes after the departure of such train, unless the block signal is used.

Passenger trains following each other must keep not less than five minutes apart, unless the block signal is in use on the line.

Freight trains following each other must keep not less than five minutes apart (except in closing up at stations or at meeting and passing points) unless protected by the block system.

A train must not leave a station expecting to meet or to be passed at the next station by a train having the right of track, unless it has ample time to reach such station and clear the track as provided.

[**NOTE.—The railway committee recommends, in case grades or other conditions are such that on any line or parts of a line greater protection is necessary, the two preceding rules should allow a clearance of ten minutes or more.**]

A train not having the right of track must be clear of the main track by the time required by rule to clear an opposing train. Failing to do so it must be protected by signals.

Except at meeting or passing points, as may be provided, a train must not arrive at a station in advance of its schedule arriving time, when such time is shown.

A train must not leave a station in advance of its schedule time.

Trains must stop at schedule meeting or passing points on a single track, if the train to be met or passed is of the same class, unless the switches are plainly seen to be right and the track clear.

When the expected train of the same class is not found at the schedule meeting or passing point, the train having right of track must approach sidings prepared to stop, until the expected train is met or passed.

Trains must approach the end of a double track, junctions, railroad grade crossings and drawbridges, prepared to stop, and must not proceed until switches or signals are seen to be right, or the track is plainly clear. When required by law, all trains must stop.

A train must not leave its initial station or a junction, or pass from a double to a single track, until it is ascertained that all trains, which have the right of track, have arrived or left.

When it is necessary for the flagman to go back to protect the rear of the train, the next brakeman must immediately take the flagman's position on the train and remain there until relieved. On passenger trains the baggageman must take the place of the front brakeman when necessary.

When a train stops or is delayed, under circumstances which render it possible, it may be overtaken by a following train, the flagman must go back immediately with proper signals, a sufficient distance to insure full protection. When recalled he must first place two torpedoes on the rail if the conditions require it.

The front of a train must similarly be protected by the fireman.

When a train on a double track crosses to the opposite track, a flagman must be sent with danger signals, as provided by the previous rule.

When a train parts, trainmen must use care to prevent the detached parts from coming into collision. Enginemen must give the signal provided, and keep the front part of the train out of the way until the detached portion is stopped.

The forward part has the right to go back (regardless of all trains) to recover the detached portion, first sending a flagman with danger signals in the direction in which the train is to be backed. In thus backing the speed must not exceed the limits of safety. On a single track the precautions required by the rules must be taken to protect the broken train from opposing trains. The detached portion must not be moved or passed until the front portion comes back.

When it is known the detached portion has been stopped, and the situation is in plain view, the conductor and engineman may arrange for recoupling the train, using the greatest caution.

[NOTE.—The railway committee, finding the distance necessary for flagmen to go back to differ so much on account of grades, amount of traffic, and other local circumstances, has left blanks for each company to determine what distance and time is necessary, either for its road as a whole or for each division.]

If the engineman of a train cannot make sure that the rear portion of his train has stopped, he should proceed to the first siding, where he should leave his train, and after waiting a reasonable time signal his engine back to the rear portion of the train, taking care not to collide with it.

If a train breaks into more than two parts, the rear part should be stopped first, then the part next forward of it, and so on, using great care.*

A train starting from its initial station, or leaving a junction, when a train of the same class running in the same direction is overdue, will proceed on its own time and rights.

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* "Should any part of the train become detached when in motion, care must be taken not to stop the front part of the train before the rear portion has either been stopped or is running slowly, and the rear guard must promptly apply his brake to prevent a collision with the front portion. There may be cases requiring the train to be stopped, owing to the failure of or accident to, some part of it, when the prompt exercise of judgment and skill is necessary to decide whether to stop quickly or otherwise. If the engine be defective, the sooner the train can be stopped the better. If any of the vehicles be off the rails, the brakes in the rear must be instantly applied, in order that by keeping the couplings tight, the disabled vehicle may be kept up and out of the way of the vehicles behind, until the force of the latter is exhausted, it being desirable in such cases that the front portion of the train should be brought slowly to a stand. The application of the front brakes might, in such cases, result in further damage, and they should only be applied when the disabled vehicles are in the rear of the train. In all cases the application of brakes behind a disabled vehicle will be attended with advantage."—*English Standard.*

Trains twelve hours or more behind their schedule time lose their rights.*

A train overtaking a disabled train of the same or superior class, will pass it, and, if necessary, will take the rights and orders of the disabled train, and proceed to the first open telegraph office, where the occurrence will be reported to the Superintendent. The disabled train will take the rights and orders of the train passing it (with which it has exchanged rights or orders), and proceed until the first telegraph office is reached.

Messages or orders respecting the movement of trains or the condition of the track must be in writing.

Trains must not display signals for a following train without proper authority.

Extra trains must not be run on single track without proper authority.

When signals displayed for a following train on a single track are taken down before the following train arrives, the conductor must inform the proper official promptly by telegraph; also the operator or switchtender. The latter (unless there is other provision) must notify all opposing trains leaving before the train arrives for which signals were displayed.

If signals are taken down at a point where there is no operator, switchtender, or other provision, the conductor must notify opposing trains

* Until, therefore, a regular train is twelve hours or more late on a single track line it is only necessary for it, as it proceeds, to keep off the time of regular trains, of the same or superior grade. Extra trains must keep out of its way.

until he reaches the next telegraph office, when he must inform the proper official. Meanwhile the operator at such point must notify all opposing trains.

If the train for which signals were displayed leaves the main line at a point where there is no operator, switchtender, or other provision, a flagman must be left to notify opposing trains that it has arrived.

Work trains are run as extras under special orders, and are assigned working limits.

Conductors will be held responsible for the proper adjustment of the switches used by their trains, except where switchtenders are stationed.

Whoever opens a switch must remain at it until it is closed, unless relieved.

When there is more than one train to use a switch it must not be left open, unless a trainman of the following train is at the switch and takes charge of it.

Conductors and enginemen are held equally responsible for the violation of any rule governing the safety of their trains. They must take every precaution, even if not provided for by the rules.

In cases of doubt or uncertainty trainmen must take the safe course and run no risk.

Should a train having the right to the road be directed not to leave a station until a specified time, unless another train has arrived, the train so held should wait five minutes, to allow for possible variation of watches, before proceeding.

When a train has orders to run regardless of a specified train the train under such orders has no rights over any other train.

In the event fusees are used in addition to torpedoes to protect trains, the signalman should place a fusee the prescribed distance from the train. The fusee should not be lighted until the signalman is recalled.*

When a mixed gauge is used the signals should be placed on the rail used in common.

When, from any cause, a train is unable to proceed at a greater speed than four miles an hour, the rear brakeman should go back twelve hundred yards, and follow the train at that distance, using the proper danger signals to stop any following train.

When a train is stopped on the main track by the signals referred to its conductor should in turn protect his train from any train that may be following, thus relieving the signalman previously on duty.†

Should anything occur to cause an engine, not attached to a train, to occupy the main track, it

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* This distance will vary according to the topography of the road, condition of business, etc.

† "He (the signalman that is relieved) must tell the guard of such train as he stops, what has happened, and ride on the engine, so as to point out to the driver where he left his own train, and tell him the particulars under which he had been obliged to stop the following train."—*Great Northern Railway, England.*

should be protected by signals, the same as a train.*

In the event of obstruction of the line, not expressly provided for in the rules, signals should be placed in both directions to warn approaching trains.

In the event of obstruction of the track, notice of the same should at once be sent to the proper officer from the next telegraph station; also to the nearest agents or flagmen in each direction, but the first duty is to protect approaching trains.†

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* While the instructions contained herein provide specifically for *trains*, they are also, in many cases, intended to cover engines running without trains; in many instances the rules are so worded as to cover both trains and engines; but whether both are mentioned or not, those cases where both are intended will be obvious to the reader. When it is desired to apply a rule to engines that refers, herein, only to trains, but may be made to apply to both trains and engines, the word conductor, wherever used, should give place to engineman (unless there is a conductor in charge), and engine should be substituted for train.

† "When an accident or obstruction of any kind occurs on any part of the line, it must be immediately reported by telegraph, or by the most expeditious means, to the next station or signal box on each side of the place where the accident has occurred, so that notice may be given to the engine drivers and guards of approaching trains; also to the heads of departments, to the locomotive station where the breakdown vans for the district are kept; to the district superintendent and the traffic inspector for the district, and to the inspector of permanent way. It must also be reported, by telegraph, to those stations where the starting of other trains is liable to be affected by the delay caused by the obstruction. In conveying intelligence of, or in summoning assistance to, any accident or failure, a platelayer (section man) must be sent as quickly as

In the event of any obstruction occurring dangerously near the track, the usual precautions necessary to protect approaching trains must be observed.

Should a train or engine stop at any unusual point on the road, it must be protected.

If inferior trains are obliged to keep the main track in passing superior trains, a signal should be sent twelve hundred yards, in the direction of the expected train, to give suitable warning. The conductor of the inferior train should see that switches are right for the passage of the approaching train.

Those in charge of switching engines are required to exercise care to prevent accident from the obstruction of the track.* Engines or cars should not be permitted to stand upon the main track, except when switching within the limits of the yard. If it is necessary to use the main

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possible to the next gang in each direction, from which a platelayer must in like manner be sent to the next more distant gang, until information of the accident has by this means reached the nearest station in each direction, and the necessary assistance has been obtained, the platelayers of each gang proceeding, without loss of time, to the place at which their services are required."—*English Standard.*

* "When any train or engine is shunting from one line to another after sunset and in foggy weather, the head and side lights of the engine must be reversed so as to show red against any other train or engine traveling on the line of rails obstructed by the train or engine so shunting. Shunting engines employed exclusively in station yards and sidings must, after sunset and in foggy weather, carry both head and tail lamps showing a red light."—*English Standard.*

track at any other point, signals should be placed for the protection of approaching trains.*

Should a vehicle in a train be on fire, the train should be stopped, and the brakeman or fireman should detach the cars in the rear of the fire. The burning car should then be drawn forward to a safe distance and uncoupled, and left until the fire can be extinguished.

In the event of accident to trains, the persons in charge thereof have the right to call upon sectionmen and others for such assistance as they may require.†

When it is necessary to leave a car or portion of a train on a grade upon the main track or elsewhere, the brakes must be set and the wheels blocked.‡

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* "No train may shunt on the main line unless absolutely necessary; and a train must be detained at a station where there is a long siding, so as to allow the following train to pass, rather than send it on with a chance of having to shunt on the main line." — *Great Northern Railway, England.* "Guards performing shunting operations at sidings must, in all cases, take care that the vehicles are left clear of the main line, and within the safety points and scotchblocks, and that the points fall properly, and the scotchblocks are replaced across the rails after the operation is completed."—*English Standard.*

† "In cases of accidents or emergencies requiring such exercise of authority, the conductor or engineer is empowered to summon any person or persons in the employ of the company, by night or day, to render assistance to a disabled train or engine, and any person neglecting or refusing to obey such summons will be discharged."—*Old Regulation.*

‡ "When, from any cause, a goods train has been brought to a stand on the main line, where the line is not level, and it is necessary for the engine to be detached from the train, for the

When it is necessary to back up on a single track road, or to run in the opposite direction from that contemplated on a double track road, the necessary precautions must be observed to prevent accident. The train should be preceded by a signalman and should not exceed four miles per hour, or such rate of speed as will enable him to keep the required distance in advance.*

Trainmen must take into consideration the state of the weather, the condition of the track and the weight of the train.

Trains should run with care during and after severe rains, and at reduced speed when the track is in bad order, or when crossing long bridges or piling.

Trains should carefully approach yards where engines use the main track in switching. Stations

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purpose of attaching or detaching wagons, the guard must, before the engine is uncoupled, satisfy himself that the van brakes have been put on securely, and as an additional precaution, must pin down a sufficient number of wagon brakes, and place one or more sprags in the wheels of the wagons next to the rear brake in the case of an ascending gradient, and of the foremost wagons in the case of a descending gradient, so as to prevent the possibility of the wagons moving away. The number of sprags must be regulated by the steepness of the gradient, the number of wagons, their loads and the state of the weather and rails."—*English Standard.*

* This rule, like all rules, is intended to facilitate business and not to obstruct or retard it, and is subject to change when circumstances require it. Thus, if a train is backing up in the day time over a perfectly level and straight track in clear weather, where the line can be seen for miles in advance, it would be farcical for it to be preceded by a signalman in the manner stated. When backing up, the engine whistle should be sounded as often as circumstances may require.

and switches should also be approached with vigilance.

When an order is given a train to proceed with caution, keeping a lookout for a particular train, it is the duty of the conductor to send signals in advance as the train approaches curves and obscure places in the track, unless otherwise ordered.

Upon arriving at a place where a particular train is to be met, care should be taken by trainmen to identify such train; in other words they should not proceed until the right train has arrived.

When a train is not required to stop at a meeting or passing point it must, at night or in foggy weather, approach such point with caution, and at reduced speed, and under control until the opposing train is found to be clear of the main track, and the switches set.

The conductor of a slow train should report to the proper authority immediately on arrival at a station, where, by the schedule, he should be overtaken by a faster train of the same class, in the event the latter does not arrive on time.

When a train is passed by a train carrying signals for other trains (having the same rights as the train carrying the signals), it should wait until all the sections of such train have passed, unless otherwise directed by special order. Trains of an inferior grade should be governed by this rule in starting from terminal stations, and in its application terminal stations are the same as other stations.

If an inferior train falls behind its time, as fixed by the schedule, it will not yield the road to a following train of the same class with which it has no designated passing point, until overtaken by it, but the first train should be protected by signals from rear collision, and yield the road at the first station after the following train has overtaken it.

When approaching stations and sidings, enginemen should carefully observe the switches and be on the lookout for signals.

An engineer approaching a place where a signal should be shown and failing to observe it, should stop until he learns the cause of its absence. Absence of signals where they should be shown indicates danger. Omissions of this kind should be reported to the proper officer.*

Enginemen of delayed trains, or trains moved by special order, should approach stations with extreme caution upon the supposition that another train will be overtaken or met, or that the track will be obstructed.

Enginemen should carefully approach stations at which they ought to meet or pass trains.

Trains approaching stations where a passenger train is receiving or discharging passengers

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* "Should a guard find any signal exhibited which ought not to be, or observe any irregularity in the working of signals, or should he see any cattle or any other obstruction on the line or any defect in the signals, works, permanent way or telegraph. he must report the same at the first station at which the train stops and also on his journal."—*English Standard.*

should stop, and not go forward until the other moves forward or a signal is given.*

A train following another train should proceed with caution and approach stations and fuel places with care, expecting to find the preceding train, whether it may be a stopping place for such train or not.†

When a train is followed it should not be stopped between stations (if practicable to avoid it) where the view is not clear for a distance sufficiently great to stop the following train.

Enginemen, when following a train, should

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* "Permanent danger signals are erected in both directions from stations, by many roads in this country. They are in common use in Europe. These signals are displayed when a train is at a station receiving or discharging passengers, or whenever the track is for any reason obstructed, or the switches are turned. When these signals are displayed, enginemen of approaching trains are required to advance cautiously until otherwise ordered. For the purpose of protecting a train from trains that may be following it, these station signals (or semaphore arms or lights) are not lowered until a specified time after the departure of the train. The wisdom of protecting trains with permanent or stationary signals, where the business of a line warrants it or its receipts will permit of it, cannot be too highly commended. 'Should a train be approaching, stopping at, or leaving a station, on the opposite line, or should shunting operations be going on, he must, on approaching and whilst passing, sound the engine whistle. The whistle must also be sounded on entering a tunnel.' "—*English Standard.* It should be remembered whenever reference is made to the engine whistle in the regulations of the English roads quoted herein, that it is a very small affair compared with that on the American locomotive.

† This is in a certain sense supplementary to the rules directing how many minutes shall elapse between trains of various grades moving in the same direction.

keep a sharp lookout, especially when rounding curves.

In the event one or more trains are united and run as one, notice of the fact should be given agents, and also conductors and enginemen of trains met or passed. The proper officer should also be advised at the first telegraph station of the consolidation of the trains.

A train of inferior grade, running ahead of a train of superior grade, should keep ten minutes off the time of such train.

Except when otherwise provided, extra trains should keep ten minutes off the time of all trains.

Upon a single track road, in the event a train is delayed between stations and loses its rights, the conductor should, when ready to move, send the necessary signals in advance. He should only run to the next siding, and the engineman, meanwhile, should frequently sound the whistle. The speed may not exceed four miles per hour, to enable the signalman to keep the required distance in advance.*

In the event a train is delayed between stations, and another train having the right to the road approaches, the former must proceed to the first siding carrying signals for the following train.

In extreme cases, in which enginemen find it impossible to make time in running to a station

* In the event a delayed regular train has time to reach the first telegraph station ahead without trespassing upon the time of another regular train, then it has not lost its rights (unless it is twelve hours late), and it may proceed directly to such telegraph station without being signaled, as directed above.

at which they should, by schedule, meet another train, they may disconnect their engine, leaving the train under proper danger signals, and run to the station and notify the approaching train, and then return for their train.* But before doing this the engineman should have the authority of the conductor.

When a train is delayed agents and switchmen should report the fact to such trains that follow as stop at their stations.

If a train is more than fifteen minutes late, the conductor should report the cause of the detention to the proper officer at the first telegraph station.

A train that follows and is properly signaled is to be taken to have the rights of the first train.

A train should not carry a signal for a train not of its own grade, unless ordered to do so.

If it becomes necessary for a train of inferior grade to follow a train of superior grade, under signals, then the following train should for the time be taken to be of the same grade as the preceding train.

When a train is ordered to carry signals for a following train, the conductor and enginemen of each of the trains should be notified. It is also the duty of conductors of trains carrying signals to notify conductors whom they meet or pass of

* This rule is provided for those extreme cases where, from some sudden and wholly unexpected cause, a train becomes stalled or is unable to make the meeting point, or back up to the station it has left.

the fact; also agents and switchmen at places where they stop.

Care must always be taken to observe whether signals are carried by passing engines.

It is the duty of conductors to assure themselves that signals for extra trains are properly placed and secured.

When a train is following another train, under signal, it should be kept near the same on approaching a station where a train is to be met, in order that the opposite train may not be detained longer than necessary, but in no case should the distance between the two trains be less than one mile.*

When two or more trains of the same grade are running in company, upon the time of one train, and the forward train cannot make time, it should run upon a sidetrack, and let the following train go ahead. Conductors and enginemen should, in such cases, see that the train which goes ahead carries the proper signals. Orders affecting the movement of the trains must be exchanged. Conductors should report the occurrence to the proper officer at the first telegraph station, and also notify trainmen they meet and agents at stations as well.

A train will not carry signals for an extra engine or train without orders from the proper officer, except as follows: Should a train be held

* The distance will not be the same for every road, nor for every occasion. The rule is intended to expedite business, and at the same time impress upon trainmen the necessity of care in such cases.

by another between telegraph stations, the conductor of the train thus detained may require the first regular train passing him, bound in the same direction, to carry signals for him to the next telegraph station, on his arrival at which he shall report to the proper officer for orders. A freight train will not have the right to have signals carried by a passenger train, in case at the next telegraph station or at some intervening place said passenger train should pass a train of its own class; nor in any case unless the freight train is in readiness to follow immediately. A train following another, in accordance with this rule, possesses the same rights as the second section of a train.*

When it is necessary to send an engine over the road, it should precede and run on the time of a regular train. It is entitled to the rights thereof, and should carry signals therefor. In such cases the regular train should run five minutes behind its time.†

* "When a train is held between telegraph stations and cannot proceed, except under the protection of some other train, and there is no train passing (without great delay), by which it may be signaled, except a wild train, the train held may proceed immediately in advance of such wild train to the first telegraph station, at which place it must get out of the way. But those in charge of the delayed train should notify agents and signal men, also the trainmen they meet, that they are running irregularly in advance of a wild train."—*Old Rule.*

† When it is desired that the engine running over the road should assist the accompanying train (assuming it to be a freight train) at the various grades, it can be instructed to follow rather than precede. But an engine should never be allowed to follow a passenger train.

CONSTRUCTION TRAINS.

A construction train in going to or coming from work should proceed with caution.* It should not be on the road within ten minutes of the running time of other trains.†

When permission is given, the conductor may keep at work, in respect to freight trains, until the arrival of such trains, but he should station signals, twelve hundred yards in each direction, when upon a single track, or in the rear when upon a double track. The signal man should continue on the watch until the freight train arrives. On its arrival the construction train should proceed to the siding in advance.

When freight trains are thirty minutes late, construction trains may temporarily occupy the main track, but should keep signals not less than twelve hundred yards in the direction of the expected train. Upon its arrival the construction train should proceed to the siding.

A construction train will not run beyond its defined limits without orders, except in cases of emergency. In such cases it should not only keep off the time of regular trains, but the conductor should signal the curves in advance and keep a sharp look out for special or extra trains. He should also report the fact of being off the limits of his train and the reason therefor at the

* It should know, before starting, that all trains that are due have arrived.

† In some instances this is five minutes; in some cases twenty minutes.

first telegraph station. If there is no telegraph station, a report should be sent to a telegraph office by the first train, or by special messenger if necessary.

Two construction trains should not work within the same limits, except in an emergency. In such case special orders should be given to that effect.

An order allowing two construction trains to occupy the same limits does not relieve either from signaling curves carefully while running, and otherwise protecting the trains properly when at work on the main track.

Before leaving for the day's work, conductors of construction trains should report to the proper officer the location where they intend to work. They should not leave until they have received a permit from him.

Conductors of construction trains should leave with the agent at the starting point a memorandum stating where their trains will be during the day. This memorandum should be entered in a book kept for that purpose. It should at all times be open to the inspection of trainmen.

Conductors of construction trains should stop at telegraph stations and register time of arrival and departure and direction of their trains. They should at the same time ascertain if any extra trains are on the road; also the limits of other construction trains that may be at work on the same division.

They should also keep themselves informed as to where the company's fuel trains are at work.

In the same way conductors of fuel trains should keep themselves advised of the location of construction trains.*

When a limit is given a construction train, it will only embrace stated hours, and the train will not occupy the main track before or after the hours specified.†

Upon a single track road, signals should be placed at a distance of not less than twelve hundred yards on either side of the place where the construction train is at work. A man should remain with the signals in each direction. Upon double track roads, signals need only be placed in the direction from which trains arrive, but if the opposite track is obstructed, then signals should be placed in both directions.

Conductors of construction trains are held responsible for the due observance of rules governing signals, and they should use every additional precaution necessary.

Construction trains should not have signals carried for them by regular trains; nor will they carry signals for other trains. If circumstances

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* In the early history of railroads in America and in many parts of the country at this time wood was burned by locomotives. It was corded up along the line and fuel trains gathered it up and carried it to the fuel supply depots. Where this practice is observed the fuel trains may be governed by the rules laid down herein for construction trains.

† "Ballast trains must not work on the main line in a fog, except when authorized under special circumstances."—*English Standard.* Americans sometimes call these ballast trains, sometimes construction. The latter word is the more comprehensive.

compel them to follow a train carrying signals for another train, they should (if sandwiched between them) carry signals for the train following.

Conductors of trains unloading ballast or material along the line, should see that it is so arranged as to be out of the way of passing trains. This should be attended to as each car is unloaded.

THIRD TRACK OR MIDDLE SIDINGS.*

The middle sidings, or third track, should be used by trains (in either direction) whenever it is necessary to turn out to allow trains of a superior class running in the same direction to pass.

A half-way post is placed in the center of each middle siding. Trains in either direction may run to this post at a speed not exceeding six miles per hour, but may not run beyond it, except under the protection of danger signals.

When trains pass the half-way post, they should run at a speed not exceeding four miles per hour, to enable the signalman to keep not less than six hundred yards in advance of the train.

When two trains meet on a middle siding, the train nearest the switch should be backed, keeping a flagman not less than six hundred yards in advance; but when there are crossing switches in the center of a middle siding, they should be used when the backing of either train from the siding onto the main track can be avoided.

* These regulations express generally the practices of a great railroad. M. M. K.

Trains should use the middle sidings with care. They should run expecting to meet an opposing train, whether such trains are due or not.

MISCELLANEOUS TRAIN ORDERS.

When trains are delayed, the lost time should, so far as possible, be made up by shortening the stops at stations. No risk should be incurred for the purpose of making up lost time.*

Mail trains should not run at such speed as to prevent the mails being exchanged as provided for.

Upon a double track road, a train that is delayed and falls back on the time of another train of the same grade, does not lose its rights, and will not take the time or assume the rights of another train, except as provided by rule, without orders.

Upon a double track road, no conductor will assume the rights nor take the time of another train without orders, except as provided by rule.

Should a train, which has been telegraphed as having entered a tunnel, not emerge therefrom within a reasonable time, the signalman toward whom the train is approaching should prevent

* "When passenger trains are behind time, the engineer is at liberty to make it up, in whole or in part, with the consent of the conductor, when he can do so with safety."—*Old Regulation.* "Their trains should be so run as to leave at stations only the necessary time for doing the business of the train, that as much time may be used in running and as little in stops as possible. They will, after attending to their passengers, see that what remains to be done to enable them to leave the station is done in the shortest possible time."—*Old Regulation.*

any train in the opposite direction entering the tunnel (through which there is a double track) until he has ascertained that the line is clear.

Should an engineman observe anything wrong on the line of rails opposite that on which his train is running, he should sound the whistle and exhibit a danger signal to any train he may meet, stopping, if necessary, to notify the train. He should also stop at the first station and report to the person in charge what he has observed.

If, upon a double track road, a portion of a train is left behind with the conductor, the engineman should not back up for it unless ordered to do so in writing by the conductor, but should go back on the proper line and cross at the nearest point behind the part left, unless there is a crossing in its immediate front. He should push the severed part before him till convenient to go in front again with the engine. It is the duty of the conductor, in cases such as those referred to, to see that every precaution is adopted to prevent accident of any kind.*

* "In the event of an accident occurring, whereby one of the main lines is obstructed, the traffic in both directions must be carried on by the other line; but this must not be done until the following rule is rigidly put in force: A pilot engine must at once be procured, and in the event of there not being a pilot at hand, the engine of a goods or coal train must be taken temporarily for the purpose, and written orders having been given at both ends of the single line by the chief officer on the spot, that no engine or train be allowed to go onto it without the pilot engine is at the end from which the train is about to start, the district agent, clerk in charge of the principal station near which the obstruction has taken place, or other officer, will proceed to pass the traffic on one line, accompanying the pilot

A train should not pass a junction of two lines nor pass from a double track to a single track until the conductor has examined the register (kept at such places) for the purpose of ascertaining particulars of trains due or past due.

Regular trains must be run in accordance with the schedule, unless otherwise ordered.

No passenger train can be stopped at a station where it is not timed to stop for the purpose of receiving or discharging passengers without special authority.*

Trains should be run uniformly and steadily and delayed as little as possible for fuel, water, and the transaction of business.

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engine backward and forward, and directing the arrangements at both ends of the single line. If no pilot engine can be procured, one man, whose name must be given to the person in charge of such contiguous stations or crossings, must be appointed, in writing, to act as pilotman, and he must ride on every train or engine in both directions, and no train or engine must move from the said stations or crossings unless this man is riding with it; and this one man must continue riding to and fro between the aforesaid places until relieved, and a successor, named in writing, at the two ends of the single line then being worked."—*Great Northern Railway, England.* "In case of accident blocking or breaking one track and requiring a train to pass along the wrong track, the utmost caution must be exercised, and no train or engine must be permitted to proceed on the wrong line without a memorandum in writing from the person in authority at the spot where the accident had happened, and station agents must be satisfied that such orders have been given and received, that all trains have been stopped until the arrival of the one they dispatched on the wrong track."—*Old Regulation.*

* "All passenger trains are to stop at the stations mentioned on the time bills, whether there be passengers to alight from the carriages or not."—*Great Northern Railway, England.*

Passenger trains should be drawn, not pushed, except in case of accident or other emergency, and in case such trains are pushed the speed should not exceed ten miles per hour.*

When express or freight cars are hauled in a passenger train, they should be placed where the regulations require.

A train should not start without a signal from the conductor, and conductors should not give the signal until they know that the cars have been properly coupled, and other details looked after.†

At junctions and other points where registers are kept, or train boards or indicators are located, it is the duty of those in charge to see that the

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* "No engine must be allowed to push a train of carriages or wagons on the main lines, unless within station limits, but must, in all cases, draw it, except under special regulations when assisting up inclines, or when required to start a train from a station. In case of an engine being disabled on the road, the succeeding engine may push the train slowly to the next siding, or crossover road, at which place the pushing engine must take the lead."—*English Standard.*

† "When a passenger train is about to start from the station or ticket platform, the signal to start given by the guard merely indicates that the station duty or the collection of tickets is completed; and previous to starting the train, the engine driver must satisfy himself that the line before him is clear, either by observation, or by obtaining, by means of his whistle, the exhibition of the necessary signal, as the circumstances of the case may require, and, when starting, the fireman must look back on the platform side until the last vehicle has drawn clear of the platform, to see that the whole of the train is following in a safe and proper manner, and to receive any signal from the stationmaster or guard that may be necessary."—*English Standard.*

arrival and departure of trains are accurately and promptly noted thereon, the grade of the train being given in each instance. It is the duty of trainmen to carefully examine this record before proceeding.

Objects should not be thrown from an engine or train when in motion, lest section men or others be injured thereby.

Flying switches must not be made, except at places and by persons authorized. In the absence of authority, a switch rope must be used.*

No person is permitted to ride on an engine without an order, except employes in the discharge of their duties upon their respective divisions, and trainmen, when necessary.

Trainmen are under the authority and must conform to the orders of the superintendent of the division upon which they work, unless otherwise directed.

At night conductors of freight trains will make and sign duplicate memorandum cards stating the time of leaving, and give same to the telegraph operator, or, in case there is no operator, to the watchman. When the next train going in the same direction arrives, the operator or watchman will hand a copy to the engineman of such train. Enginemen should be on the lookout to

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*** "Double shunting is strictly prohibited, except when done by engines specially used for the purpose of shunting, and attended by experienced shunters. Fly shunting of empty vehicles against loaded passenger trains, and of vehicles containing passengers or live stock, is strictly prohibited."—*English Standard.***

receive these notices as they pass stations. At stations where train registers are kept, this rule need not be observed.

All accidents, detention of trains, failure of engines or defects in the road, should be reported to the proper officer by telegraph from the next station.

When making repairs that obstruct the track, or jeopardize the safety of trains, sectionmen should place danger signals upon the track, being careful to see that no risk is run.*

If the track is in bad order, or, if, for any other reason, it is desired that trains should run slowly, proper signals should be displayed by trackmen.†

In case of accident to a train the nearest section foreman should take his whole force to the

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* "When repairing, lifting the line or performing any operation so as to make it necessary for a train to proceed cautiously, the foreman or ganger must send a man back at least half a mile, and as much farther as the circumstances of the case render necessary, who must exhibit the 'caution' signal so as to be plainly visible to the engine driver of the approaching train. Each gang of platelayers or laborers must be supplied by the inspector of permanent way for the district with two sets of day signals, two hand signal lamps, if working after dark, and a proper number of detonators. Each ganger will be held responsible for having his signals constantly in proper order and ready for use."—*English Standard.*

† "A green flag, or a green light, exhibited by platelayers, indicates that trains and engines must reduce speed to fifteen miles an hour over the portion of line protected by such green signal. The 'caution' signal must always be exhibited at a distance of at least half a mile from the point where it is required that the speed of trains and engines should be reduced and as much farther as the circumstances of the case render necessary."—*English Standard.*

assistance of the train, even if not on his own section.

In case of a wreck the track foremen should appoint watchmen to prevent property from being stolen.

On receiving notice of a wreck the roadmaster, or such person as may be assigned the duty, should at once proceed to the place and take charge of the track forces and proceed to put the track in condition for the passage of trains and to remove the wreck with the least possible delay.

No notice is given trackmen of the passage of trains, and they must therefore govern themselves accordingly.*

Section foremen should report to the proper officer any neglect upon the part of trainmen to properly regard danger or caution signals.

"Whenever a crane is in use whereby the jib, or any other portion of it, obstructs or fouls any line of rails in use for traffic purposes, or whenever, by any possibility, during the loading of

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* "On no occasion, except in cases of emergency or of accident, and never at night, or in a fog, or when a train is due, must a trolley be run in the wrong direction, and in such cases the trolley must be preceded at a distance of not less than a mile by a man with a red flag and detonators. In tunnels a red light must always be used."—*Great Western Railway, England.* "In the case of a single line, the trolley must be so protected in both directions. No trolley must, in any case, be placed on the line, except by the platelayers and with the knowledge of the ganger, who is responsible for seeing it properly protected and used. No trolley must, under any circumstances, be attached to a train, and all trolleys when not in use must be taken off the rails, placed well clear of the line, and the wheels secured with chain and padlock."—*English Standard.*

round timber, long timber, angle iron, or other articles of great length, the main line may be obstructed, it is incumbent on the person in charge of the loading to place danger signals, as required by rule."*

MOVEMENT OF TRAINS BY TELEGRAPH.†

Special orders, directing movements different from those specified by the time table are only issued by authorized officials, and they are not to be used for movements that can be provided for by rule or by the time table. Nor must they contain information or instructions not essential. They should be brief and clear, and the prescribed forms should be used when applicable. There must be no erasures, alterations or interlineations.

[NOTE.—On roads whose organization provides that any other officer than the superintendent shall direct train movements, the official title of such officer is used. The railway

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* English road.

† The following rules and regulations are similar, substantially, to those adopted by the railway committee. In connection with this subject it is interesting to remember that the idea that a train could be moved by telegraphic orders from station to station against an opposing, but delayed, train, first occurred to Charles Minot, superintendent of the Erie Railway, in 1850. The practice had but a narrow application at first, but has widened greatly since until it has become the prevailing custom upon every American railroad when business can be accelerated thereby, as it can be in nearly every instance where trains are delayed. I acted as a train dispatcher in 1860–61, at which period the method of moving trains by telegraphic order had reached quite a high state of perfection. M. M. K.

committee consider it essential, however, that but one person's signature should be used in directing train movements on any dispatching division.]

Each order must be given in the same words to all persons or trains directly affected by it, so that each shall have a duplicate of what is given to the others.

Orders should be numbered consecutively for each day as issued, beginning with No. 1 at midnight.

Orders should be addressed to those who are to execute them, naming the place at which each is to receive his copy. Those for a train must be addressed to the conductor and engineman, and also to a person acting as pilot.* A copy for each person addressed must be supplied by the operator.

Each order must be written in full in a book provided for the purpose at the dispatcher's office. In connection with it must be recorded the names of trainmen and others who have signed for the order; the time and signals, showing when and from what offices the order and responses were transmitted; also the train dispatcher's initials. These records must be made at the time on the original copy.

The terms "superior right" and "inferior right" herein refer to rights of trains under the time table and train rules, and not to rights under special orders.

*** When an engine is run over the road without a train or conductor the engineman acts as conductor, and one copy of the order is of course sufficient for him in both capacities.**

When an order is to be transmitted, the signal 31 (or whatever it may be, meaning a train order) will be given to each office to be addressed, followed by the word "copy" and the figure indicating the number of copies to be made.

An order to be sent to two or more offices must be transmitted simultaneously to as many as practicable. The several addresses must be in the order of superiority of rights of trains, but each office will take only its proper address. When not sent simultaneously to all, the order must be sent first for the train having the superior right of track.

[NOTE.—On roads which desire the operator, at a meeting point, to have copies of the order, the several addresses will be, first, the operator at whose station the trains are to meet and next in the order of superiority of the rights of trains.]

Operators receiving orders must write them in manifold during transmission and make the requisite number of copies at one writing, or trace others from one of the copies first made.

When an order has been transmitted, preceded by the signal 31, as indicated above, operators receiving it must (unless otherwise directed) repeat it back at once from the manifold copy, and in the succession in which their several offices have been addressed. Each operator repeating must observe whether the others repeat correctly. After the order has been repeated correctly by the operators required at the time to repeat it, the response "O K," authorized by the train dispatcher, will be sent, simultaneously, to as many as practicable, naming each office. Each operator must write this on the order with the time, and then reply "i, i, O K," with his office signal.

Those to whom the order is addressed, except enginemen, must then sign their names to the copy of the order to be retained by the operator, and he will send their signatures to the dispatcher. The response "complete," with the dispatcher's initials, will then be given, when authorized by the latter. Each operator receiving this response will then write on each copy the word "complete," the time, and his last name in full, and will then deliver a copy to each person included in the address, and each must read his copy aloud to the operator. The copies for the enginemen must be delivered to them personally by the person designated to perform that duty, and the engineman must read it aloud to such person, and understand it before acting upon it.

[NOTE.—Individual operator's signals may be used, when desired, in addition to office signals, as here and elsewhere provided for.]

For an order preceded by the signal "31," the answer "complete" must not be given to the order for delivery to a train of inferior right until "O K" has been given to and acknowledged by the operator who receives the order for the train of superior right. Whenever practicable, the signature of the conductor of the train of superior right must be taken to the order and "complete" given before the train of inferior right is allowed to act on it. After "O K" has been given and acknowledged, and before "complete" has been given, the order must be treated as a holding order for the train addressed, but must not be otherwise acted on until "complete" has been given.

If the line fails before an office has received and acknowledged "O K" to an order preceded by the signal "31" the order, at that office, is of no effect, and must be there treated as if it had not been sent.

[NOTE.—On roads where the signature of the engineman and pilot is desired, the words "engineman and pilot" may be added after the word "conductor" in the second preceding paragraph.]

When an order has been transmitted, preceded by the signal 19, as provided by regulations, operators receiving it must (unless otherwise directed) repeat it back at once from the manifold copy, and in the succession in which the several offices have been addressed. Each operator repeating must observe whether the others repeat correctly. After the order has been repeated correctly, the response "complete," with the dispatcher's initials, will be given, when authorized by him. Each operator receiving this response must write on each copy the word "complete," the time, and his last name in full, and reply "i, i, complete" with his office signal, and will personally deliver the order to the persons addressed without taking their signatures.

[NOTE.—On roads where it is desired, the signatures of the conductors (or conductors, enginemen and pilots) may be taken by the operator on the delivery of the order. The railway committee has recommended two forms of train orders—the "31" order and the "19" order (as will be noticed above), leaving it discretionary with the roads to adopt one or both of these forms.]

For an order preceded by the signal "19," "complete" must be given and acknowledged for the train of superior right before it is given for the train of inferior right. If the line fails before an office has received and acknowledged the "complete" to an order, preceded by the signal "19," the order at that office is of no effect, and must be treated as if it had not been sent.

The order, the "O K," and the "complete" must each, in transmitting, be preceded by "31" or "19," as the case may be, and the number of the order, thus, "31, No. 10," or "19, No. 10." In transmitting the signature of a conductor it must be preceded by "31," the number of the order, and the train number, thus, "31, No. 10, Train No. 5." After each transmission and response the sending operator must give his office signal.

The operator who receives and delivers an order must preserve the lowest copy. On this must appear the signatures of those who sign for the order, and on it he must record the time when he receives it; the responses; the time when they are received; his own name; the date, and the train number, for which places are provided in the blanks. These copies must be sent to the dispatcher.

For orders delivered at the dispatcher's office the requirements as to record and delivery will be the same as at other points.

Orders to persons in charge of work requiring the use of track in yards or at other points authorizing such use when trains are late, must be delivered in the same way as to conductors of trains.

An order to be delivered to a train at a point not a telegraph station, or while the office is closed, must be addressed as follows, to "*C. and E., No.*———(*at*———) *care of*———," and forwarded and delivered by the conductor or other person in whose care it is addressed. "Complete" will be given upon the signature of the person by whom the order is to be delivered, who must be supplied with copies for the conductor and engineman addressed, and a copy upon which he shall take their signatures. This copy must be delivered to the first operator accessible, who must preserve it, and at once advise the train dispatcher of its having been received. Orders so delivered to a train must be compared by those receiving them with the copy held by the person delivering and acted on as if "complete" had been given in the ordinary way. Orders must not be sent in the manner herein provided, to trains the rights of which are thereby restricted.

When a train is named in an order, all its sections are included, unless particular sections are specified. Each section included must have copies addressed and delivered to it.

Meeting orders must not be sent for delivery to trains at the meeting point if it can be avoided. Special precautions must be taken by the train dispatchers and operators to insure safety. There should be, if possible, at least one telegraph office between those at which opposing trains receive meeting orders. An operator must not acknowledge the receipt of an order for a train that is at his station, the engine of which has passed his train order signal, until he has personally notified the conductor and engineman that he has orders for them. Orders should not be sent an unnecessarily long time before delivery, or to points unnecessarily distant from where they are to be executed. No orders (except those affecting the train at that point) should be delivered to a freight train at a station where it has much work, until after the work is done.

A train, or any section of a train, must be governed strictly by the terms of orders addressed to it, and must not assume rights not conferred by such orders. In all other respects it must be governed by the train rules and time table.

Orders once in effect continue so until fulfilled, superseded or annulled. When more than one movement is included in an order, any part of the order specifying a particular movement may be be superseded. Orders held by or issued for a regular train are annulled when such train has lost its rights, as provided by the rules, and other trains will be governed accordingly.

A fixed signal must be used at each train order office, which shall display red at all times when there is an operator on duty, except when changed to white to allow a train to pass after getting orders, or for which there are no orders. When red is displayed, all trains must come to a full stop and not proceed as long as red is displayed. The signal must be returned to red as soon as a train has passed. It must only be fastened at white when no operator is on duty. This signal must also display red to hold trains running in the same direction the required time apart.

Operators must be prepared with other signals to use promptly if the fixed signal should fail to work properly.

If a signal is not displayed at a night office, trains which have not been previously notified must stop and inquire the cause, and report the facts to the dispatcher from the next open telegraph office.

When a semaphore is used, the arm means red when horizontal, and white when in an inclined position.

Operators will promptly record and report to the dispatcher the time of departure of all trains and the direction in which extra trains are moving. They will record the time of arrival of trains and report it when so directed.

Regular trains will be designated in orders by their schedule numbers, as "No. 10," or "2d No. 10," adding engine numbers if desired; extra trains by engine numbers, as "Extra 798," and all other numbers by figures. The direction of the movement of extras will be added when necessary, as "East" or "West." Time will be stated in figures only.

[NOTE.—In case any roads desire to state time in words as well as figures, the railway committee sees no objection to their doing so.]

The following signs and abbreviations may be used: Initials for dispatcher's signature; such office and other signals as are arranged by the superintendent; C & E—for conductor and engineman; O K—as provided in these rules; Min—for minutes; Junc—for junction; Frt—for freight; No—for number; Eng—for engine; Sec—for section; Opr—for operator; 9—to clear the line for train orders, and for operators to ask for train orders; 31 or 19—for train order as provided in the rules. Also the usual abbreviations for the names of months and stations.

OTHER SUGGESTIONS RELATING TO TRAINS.

When a train is abandoned the order directing its abandonment should be sent by telegraph to all agents, conductors and enginemen upon the division, and no train should leave a station to run upon the time of an abandoned train, which, by the regulations, would have the right of road, unless the conductor and engineman of such train possess a copy of the order of abandonment, properly signed and certified. Orders for the abandonment of trains should be repeated and approved by the dispatcher.

Before an order is given by telegraph for two or more trains to meet at a station other than that directed by the time table, the order to hold both trains should first be given to the operator at such meeting point, and until this is done no order should be sent to either train.*

When a meeting or passing point is to be made by two or more trains, the order should be definite and conclusive, and be first sent to the conductor having the right to the road.

If it is desired to give a train of lower grade the right to run against a passenger train, the order should first be sent to the latter, and no order be given the opposing train until the receipt of a reply from the passenger train. In the same way, before giving a passenger train the right to the road over a train possessing such

* This regulation requiring that the operator at the station where the trains are to meet shall be notified, is not deemed necessary by many experts in such matters. Indeed, many dispatchers only send the order to the train that would not otherwise move. Thus, if a dispatcher desires a train moving under special directions to meet a regular train at a time and place where such regular train is due by the schedule, he would only send the order to the special, being particular simply to see that abundance of time was given such train to be at the meeting point. This method reduces the labor and expense of the telegraphic service to the minimum, but it has always seemed to me that where two or more trains are to meet at a specific point not designated as their meeting point in the time table, both trains should be notified. I do not know that it is imperative that the operator at the meeting point should be notified; it is an additional precaution, however. Its observance would, of course, require that only telegraphic stations should be selected as meeting points, and this is desirable as far as possible, but is not always practicable. M. M. K.

right, the order should first be sent to the latter. When a satisfactory reply has been received from such train the order may be transmitted to the other train.

A train of inferior grade should not be directed to move ahead of a regular train of a superior grade (when such regular train is on time) unless the train of inferior grade shall have full schedule time (according to the regulation for trains of that grade) to reach the point to which it is ordered, in advance of the time at which the train of a higher grade is due at such point. And in the event a train of an inferior grade running ahead of a regular train of superior grade, as directed in this rule, cannot make schedule time, its conductor, as soon as he discovers such to be the case, should leave a signalman to warn the approaching train, ahead of which he has been directed to run, and report to the proper officer for orders at the next telegraph station. The conductor and engineman of the train of superior grade that is following should be notified in writing of the order directing the train of inferior grade to proceed, but it should be distinctly understood that such conductor and engineman will not be held responsible for any accident that may occur in consequence of the slow train getting in its way, unless such accident shall have been caused by a disregard of signals or of the rules and regulations.

To enable trains to move with promptness and regularity, such expedition as is consistent with safety is enjoined upon trainmen and telegraph operators in the transmission of and response to telegraph orders.

Train orders should have precedence over all other business.

Should a train be held at night at a telegraph station where there is no night operator, the conductor should call the day operator for the purpose of receiving orders.

Conductors and engineers should not go to meals, or delay their trains from any cause, after receiving an order to proceed, without obtaining permission. If a train has work to do, after receiving an order, the conductor should notify the dispatcher of the probable length of time before he will be ready to leave. He should report when ready to go, and ask for further orders.

A record of the movement of regular and special trains, showing hour and minute of leaving each station, as reported by operators, is kept by the dispatcher.

Safety demands that persons connected with the movement of trains by telegraph should use the utmost prudence and watchfulness.

Orders should be written in a clear and legible manner, and conductors and engineers should not receive an order they cannot understand.

In the transmission of orders by telegraph no abbreviation should be used except those provided for by the regulations. Figures should be written with especial care. When there is any possibility of mistaking one train for another the engine number should be given as well as the number of the train.

Train order signals, or signals to stop, should be promptly removed when the object for which displayed has been accomplished.*

Operators should, upon receiving telegraphic orders for a train, immediately exhibit the proper signal. The signal should not, however, be relied upon exclusively. Operators must watch for it and use necessary means to stop trains.

When there is a signal to stop, the approaching train should come to a full stop and the conductor should go to the telegraph office to receive and acknowledge such orders as there may be. Should the signal have been displayed for some other train, the conductor must, before proceeding, receive from the operator a written release; also a copy for the engineer, stating for what train the signal was displayed. Such release will be authority for the train to proceed, provided it can do so on its time table rights or such rights as it may have derived from previous orders.

When a train order is received at a station, and the receipt acknowledged by the operator, it holds the train until the order is approved and delivered. A train order is not complete and a

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* Upon some lines each station is provided with a fixed signal, the normal or ordinary position of which is at danger, and no train is permitted to pass the station unless the signal is positively set so as to indicate that the track is clear and that trains may proceed.

train cannot move under its direction until it is approved by the dispatcher.

Operators should not receive or receipt for an order unless they know that the trains named in it have not passed their station; or, if at their station, that they are not beyond their reach.

An order may be repeated by the operator before the train for which it is intended arrives at the station, but in no case should the signature of the conductor be transmitted by the operator until such conductor has personally signed the same, after it has been carefully read to him. as directed.*

In cases of threatened storm, or probable failure of the wires, orders may be corrected by the dispatcher without waiting for the signature of the conductor. In such cases the signature should be sent as soon afterward as practicable.

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* The regulations of railroads in regard to repeating train orders are not uniform. In many cases the order is not repeated by the operator until the conductor has arrived and his signature has been obtained. On some lines it is the practice (though perhaps not in strict accordance with regulations) for the operator to repeat the order as soon as received, with the names of the conductor and engineer, though the latter has not read nor signed it. It is desirable that the body of the order should be repeated at once. It affords opportunity to correct any mistake that may have occurred, and expedites the movement of trains. Every moment is of value, and a gain of a few seconds will oftentimes permit trains to move forward that might otherwise be delayed. However, preparatory work should never go further than verifying the copy of the order in the hands of the operator. It should remain incomplete until the signatures have been obtained and transmitted to the dispatcher and the approval of the latter received. M. M. K.

When the order that a conductor receives has been approved, he (or some other person to be designated) should personally deliver the engineer his copy. The conductor and engineer should compare their copies before proceeding, and they should also be certain that they understand the subject alike. An engineman will not go forward without a copy of the order in his possession.*

Night telegraph stations should exhibit signals all night; day telegraph stations should exhibit them from dark until the offices are closed.

Operators should keep on hand a red flag by day and a lighted red lantern by night; also a supply of torpedoes.

No train shall pass a telegraph station where the schedule requires it to stop until the conductor has gone to the telegraph office and asked if there are orders for him. If there are none the operator will deliver him a blank, duly signed, stating that he has no orders. This does not relieve operators from the duty of displaying signals when they have orders for trains. Conductors should also inquire for orders at the starting point.†

* The rules of many roads require that the engineman, as well as the conductor, shall go to the telegraph office and sign the understanding in person. The engineman can do more for the protection of his train, it is believed by many, by remaining at his post, than by accompanying the conductor. M. M. K.

† In reference to this rule I know of several companies whose regulations require that freight and working trains must stop at *all* telegraph offices to inquire for orders, while passenger conductors are only required to inquire for orders at such telegraph offices as are regular stopping places for their trains.

Trains running upon special orders should approach, with care, stations where there may be another train, expecting that the main track may be occupied. This, however, does not relieve a train from compliance with the rules and regulations governing signals, etc.

Orders should only be used by the trains they refer to, and only against such trains as are named. An order to run on the time of one train is not to be taken to run on the time of another. In the absence of explicit orders, trainmen and others will be governed by the time table, wherein the time of arrival of trains at different stations is printed; also the time of their departure from different stations; also the rights of different trains and the rules and regulations governing them.

If an order is sent to a train carrying a signal for another train, such order will not, unless so stated, cover the train following. The latter will not avail itself of any privileges without a written order to that effect. When orders are duplicated to trains, the understanding of each

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The rule requiring conductors to go to the telegraph office at each stopping place is in some respects exceedingly inconvenient, and is much complained of by trainmen. It is claimed by conductors in such instances that it takes them away from their trains at the moment when it is important they should be observing the movement of passengers getting aboard their trains, and performing other duties incident to their position. The rules for operating a single track so as to handle the maximum traffic over it are exceedingly complex and require the utmost expedition upon the part of every one, and also the utmost docility. M. M. K.

conductor should be separately signed and separately responded to by the dispatcher.

Under the system of moving trains by telegraph, trains may be expected upon any part of a road at any time. This fact should be kept in mind.

In the event the wire gives out, or if for any reason it is not desired to move trains by telegraph, trainmen will conform to the schedule and the rules and regulations governing the movement of trains as directed above.

If conductors or enginemen change off before the completion of their trips, they should also exchange the orders they have. Each should know that the other perfectly understands the orders of the other, but change of this kind cannot be made without the consent of the proper officer.

[NOTE.—In appendix C will be found the Single Track Train Rules contained in the Standard Code of the American Railway Association.]

TRAINMEN.

The duties of employes engaged about trains, like those about stations, I desire to say here in parenthesis, are explained incidentally throughout this work in connection with other matters relating to the science of railways. Very little can be said about railroad operations under individual headings—on any subject. To know what the duties of a particular trainman are, we must understand the organization and government of trains generally; to understand the duties of the conductor or brakeman we must study the handling of trains in its entirety.

We cannot divide up a branch of railway service under the names of different officials. Baggageman, news agent and expressman are not referred to specifically, in this book, yet they must be familiar with the matter contained in it in order to perform the duties that the emergencies of daily life will frequently require of them.

The book on Baggage refers particularly to the duties of baggagemen, but incompletely, for the reason, as stated, that to thoroughly understand their duties (directly and indirectly) the train service as a whole must be more or less perfectly understood by them. The reader may not, therefore, expect to find any subject completely or exhaustively discussed in any particular part of this work.

The science of railways is homogeneous and a man to understand any part of it well must know a great deal about other parts. I do not write for "specialists," or men of One Idea, but for those who wisely know that in order to intelligently comprehend their own sphere of usefulness in railway life, they must possess something more definite than a vague, shadowy knowledge of the duties of those about them.

Many of the rules and regulations that follow in the succeeding sections of this book, it will be noticed, refer to details of business connected only incidentally with the technicalities of trains. They are a part of the ritual of the service, however, and must be understood and their requirements fulfilled if due order and efficiency are expected. In compiling them originally, I examined personally the rules and regulations of all the great railroads of the world. Like the rules immediately relating to trains, I do not embody them here with the desire or expectation of their being adopted by any company, but by way of reminder and suggestion.

The management of the train from the time it is made up until it arrives at its destination is vested in the conductor. He is held responsible for its movements and safety and it is his duty to see that all orders, rules and regulations affecting it are observed.*

* "The duty of passenger, goods, cattle, mineral, and other guards consists in the general charge and management of the trains when they are moving on the line. They have general control over the enginemen, ordering them when to stop or to proceed at a different speed, as they may deem right, or to shunt or move wagons or other vehicles."—*Great Northern Railway, England.*

He is responsible for the conduct of trainmen and their due observance of the rules and regulations.*

He is required to see that they are supplied with time tables, signals, lamps, tools and other paraphernalia required in the operations of trains, and that they are properly instructed in their duties.

He is particularly required to see that the train force is familiar with the use of the signals and brakes. If air brakes are used, he must see that they are tested according to the rules and regulations and at the times prescribed by the regulations.

The property making up the equipment of the train is under his charge and it is his duty to report to the officer or employe (as the case may be) any defects connected in any way with such equipment.

It is his duty to see that the signals are duly displayed on his train, and in the event a vehicle is attached to, or detached from, the rear of his train, he must see that the signals are rearranged to conform thereto.

Every train must be supplied with signaling apparatus; not less than six fusees, twenty-four

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* "When there are two guards with a train, the under guard must obey the orders of the head guard. Each train is under the control of the head guard, who must instruct the engine driver as to the stopping, starting, and general working of the train. Whilst trains are within station limits, the guards are under the orders of the stationmaster or person in charge."—*English Standard.*

torpedoes, and such lanterns and flags as the operations of the line require; also with switch rope, axes, saws, crowbars, chains, links, pins, buckets, oil, and other tools and supplies necessary for current use, or use in the event of accident or delay to train.*

If compelled, by accident or other cause, to obstruct the main track, the conductor is expected to adopt every needed precaution, keeping in mind the fact that nothing can justify a collision, and that due diligence and a proper use of signals will, as a rule, prevent it.

Conductors must give personal attention to switches used by their trains, except where switchmen are stationed. When more than one train uses a switch, the forward conductor should not leave the switch open unless he has assured himself that the conductor of the following train has some one at the switch to take charge of it.

Conductors must see that road crossings are not unnecessarily obstructed by their trains.

No part of their train should be allowed to stand on the crossing of another railroad.

The rules in regard to visiting telegraph offices at terminal stations and elsewhere, for orders, must be observed.†

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* Each passenger car is required to be supplied with tools and apparatus for the putting out of fires, and one of the most important duties of trainmen is to see that these requirements are not overlooked or incompletely fulfilled.

† Terminal stations are at the ends of divisions and subdivisions. "Every guard, before starting with his train, must examine the notices to see whether there is anything requiring

As the safety of the train is dependent upon cars being in good order, no car should be allowed in a train, that is unfit for use, that in any way jeopardizes the train. If a car is damaged during a trip, or found to be defective, it must be reported by the conductor to the car repairer at the end of the journey. If the condition of a car is such as to require it, it must be removed from the train en route. No risk must be incurred, and conductors will embody in their report to headquarters a statement of cars put into their train in bad order, or that are damaged en route. They must also report any car that does not run smoothly; also, any neglect of the car repairer to inspect cars en route, or failure upon his part to make necessary repairs to the running gear or appurtenances of cars.*

If a wheel breaks, the conductor must report to the proper official the date and number of the wheel and the name of the manufacturer.†

The number of each car in the train, its initials, the point from which taken, place where left, whether loaded or empty, its class and any other

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his special attention on those parts of the line over which he has to work, and he must, before going off duty, ascertain from the notices posted for his guidance, the time at which he is required to be on duty the following day."—*English Standard.*

* "All plated reflectors in lamps are to be wiped with clean wash leathers, kept solely for that purpose, and not rubbed with powder; when, however, they are much tarnished, they are to be cleaned with a little whitening."—*Great Northern Railway, England.*

† "They will also report all the interior defects of their cars, like the rattling of doors, windows, etc."—*1864.*

matters of interest connected therewith must be embraced in the report of the conductor made at the end of his run.

In the event any defect or break in the telegraph is discovered, it must be reported to the operator at the next station.

Any dilatoriness or lack of attention upon the part of agents or others, in connection with the movement of trains, should be reported forthwith to the proper officer.

Conductors are not allowed to undertake to carry packages, or collect money for private parties.*

Letters, waybills, dispatches, returns, accounts and property of the company carried by trains must be carefully guarded and promptly delivered.

Employes of the company riding on trains, whether employed on such trains, or not, must in an emergency render every assistance in their power, if called upon by the conductor.

Passenger conductors must be familiar with the requirements of passenger traffic, including the

* "Conductors will not be concerned in any freight or express matter over the road by the passenger train, and will permit none to be taken by any person, except the agent of the express having contracts with the road, and will see that the express agents confine themselves strictly within the limits of their contract."—*Old Regulation.* "Guards are forbidden to carry any description of package, either for themselves, their friends or the public, without proper authority, in writing, for the free transit thereof, or unless such package be properly entered on the way bill."—*English Standard.*

ticketing and disposition of passengers. They must possess practical knowledge of the duties of the brakemen and baggagemen and be able to direct them, if necessary, in the details of their duty.*

The duties of conductors are referred to quite fully in the books on Baggage, Passenger business and Freight business.

They must also be familiar with the duties of sleeping car conductors, porters, news agents and other train men so that they may be able to

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* "When there are more conductors than the number of trains running, those in waiting at either end of the road will be at the depots on the arrival and departure of all trains, as far as practicable, to aid in making up the departing trains, or discharging those arriving. They will see that extra cars are kept at the proper places upon the line for use in case of accident or other necessity. They will consider themselves to be, and act as, brakemen, when necessary."—*Old Regulation.*

"When on duty, conductors must be respectably dressed. Every man on passenger trains and at stations must appear on duty clean and neat."—*Old Regulation.*

"Every passenger guard must have with him his watch, whistle and carriage key, and take in his van a red, a green and a white flag, a box of detonators (not less than twelve), and a hand signal lamp."—*Great Western Railway, England.*

"The guard must see that platelayers and other workmen of the company holding third class passes are kept as separate as possible from the passengers. When a large number of workmen travel by the same train, carriages must be specially provided for their use, and they must ride in these carriages only."—*English Standard.*

"All guards are to enter their time in the time book every Friday or Saturday night at King's Cross; if this be not done, they will be liable each to a fine of twenty-five cents, and no money will be paid till the following week."—*Great Northern Railway, England.*

enforce the rules and regulations applicable to them, noting in their returns any wilful act of insubordination, neglect of duty, or misconduct they may observe.

"When a deficiency of room occurs in a train while on a journey, guards (conductors) must telegraph to the next station where carriages are kept, to have one or more in readiness to attach, on the arrival of the train.*

The rules of business forbid that drunken or disorderly persons should be allowed on a train or if thus allowed they must be kept apart so as not to disturb the passengers.

Doors of cars must be kept closed, and in case of accident, order must be preserved and the fears of passengers allayed so far as possible.†

Smoking except in cars set apart for that purpose, is not tolerated on American roads.

Nor are beggars, peddlers and gamblers allowed to ply their vocation on trains.

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* English Standard.

† "In all cases of detention or stoppage, it is the duty of the guards to explain to passengers the cause thereof, and if there is no danger to them, to satisfy them of that fact, and endeavor to pacify those that may be annoyed. When a train overshoots a station, the guard is to order the engineman to put back to the platform, and not to allow the passengers to get out until the train has been stopped at the platform."—*Great Northern Railway, England.*

"The guard must not allow any person to ride outside the carriages, nor must he permit any unauthorized person to ride in his van, or in any compartment or vehicle in which parcels or luggage may be placed. No carriage door must be opened to allow a passenger to alight from, or enter a train before it has come to a stand or after it has started."—*English Standard.*

Care in the handling of passengers is a fundamental duty of trainmen and in pursuance thereof trains must not be signaled to start while passengers are getting on or off the cars.*

When signaling to start, the conductor must stand near the front end of the forward passenger car where he has a good view of the whole train.†

If uniforms are prescribed for trainmen, they must not appear on duty without them.

Upon the arrival of a train at its destination the cars must be examined and all articles lost or left behind by passengers, collected and deposited with the custodian to await the call of owners or the disposition of the company.‡

"The guard (freight conductor‖) in charge of the train must satisfy himself before starting,

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* "They will always bring their train to a dead stop to take up or leave passengers."—*Old Regulation.*

† "The signal for starting the train must be given by the guard blowing his whistle and showing a hand signal."—*English Standard.*

"The guards and other servants of the company must take their seats in the trains before they are in motion, so as to avoid the dangerous practice of jumping on the steps, or getting into the carriages after the trains leave the platform." —*Great Northern Railway, England.*

‡ "Every first class carriage is to be searched at the end of each journey by the head guard, and every second and third class carriage by the second guard."—*Great Northern Railway, England.*

‖ "Every head goods guard must have with him his watch and whistle, a red, a green, and a white flag, a box of detonators (not less than twelve), a hand signal lamp, a full set of tail and

and during the journey, that the train is properly loaded, marshaled, coupled, lamped and greased; that the brakes are in good working order; and that the train is in a state of efficiency for traveling, and has the proper signals attached to it. The guard must see that the chains on timber trucks and on boiler wagons are secured in order to prevent their getting loose whilst traveling. Foremen, guards, and shunters must take care that no timber truck or boiler wagon is allowed to leave a station or siding without the chains being first carefully examined and made perfectly secure and safe, and guards will be held responsible for seeing that they remain so during the journey. Before starting from a station, the guard must see that the wagons are properly greased, the coupling chains and doors securely fastened, and carefully examine the loading and sheeting of the wagons, seeing that the goods are protected from rain and sparks from the engine; also that no load is too high or wide, or in any way unsafe to travel. It is not sufficient for the guard, on commencing his journey, to see that all the wagons and their loads in his train are in

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side lamps, two or more spare coupling chains, a brake stick, two sprags, and two hand scotches."—*Great Western Railway, England.*

"They will at all times render all the service in their power to forward the private business of the company (as well as its business for the public), in the hauling of wood and materials for use upon the road, and in bringing to the repair shops cars and parts thereof which may be out of order and left upon any part of the line."—*Old Regulation.*

a secure state for transit, but he must see that all these conditions are continued throughout the journey, especially with wagons that are taken on at intermediate stations, and those loaded with timber, cotton, wool, castings, machinery, and articles of great length and bulky construction." These precautions are as applicable in the main to American roads as to those of Great Britain.

Freight conductors must, in the absence of inspectors, see that the couplings, wheels, journals and brakes of cars in their trains are in good order before starting.*

Freight conductors must assign brakemen their posts† on the train and must see that they keep their positions and use the brakes with good

* "They will frequently examine the cars of their trains to see that all nuts and screws are up to their bearings and the cars in order; that they are properly oiled—not oiling them at random, but when needed; and for this purpose will see that their trains are supplied with such tools as may be wanted, as well as oil for the bearings. They will not allow repairers to attach their repair cars to their trains, unless it shall be necessary in order to forward some very urgent piece of work."—*Old Regulation.*

"They must examine carefully and minutely every wagon, whether loaded or not, and its covering, the axle boxes, the fastenings of its doors and side flaps, etc., and the way in which the goods are placed in the trucks, so that large loads may not overhang, or be too high; they must compare the road bills with the wagons; see that they are placed in the proper position in the train; that they are entered correctly, and properly labeled."—*Great Northern Railway, England*

† "No goods, cattle or coal train may start without one brake van at the least, which must be placed behind the train, and, in case of two brake vans in one train, one of the guards must ride in each, so as to work both the brakes."—*Great Northern Railway, England.* In England the style of the car used prevents

judgment—particularly when descending heavy grades.*

On approaching stations trainmen should be on top of the cars when, at least, one mile distant from the station, and remain thus, looking for signals, observing the switches, and otherwise being prepared to respond to any requirement of the situation.

When freight trains are in motion, at least one brakeman should be on top of the cars or occupy such place of common observation as the needs of the service require.

The conductor of the freight train, or in his absence, a brakeman, must be stationed on the rear car of the train.

Conductors of freight trains must report to the proper person, before starting, the number of the engine and the number of empty and loaded cars in their trains. A similar report must be made by them upon their arrival at destination.†

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brakemen from traveling backward and forward upon the top of the train, as in this country. "The freight conductors must ride on the tender facing train, or else on the rear car."—1854. "The guard must ride in his brake van, and not upon the engine or in any part of the train; he is forbidden to pass over the tops of the carriages [passenger cars] when in motion."—*English Standard.*

* "A rear brakeman, by leaving his post for a short time to have a friendly chat with his next brakeman, has been the immediate cause of much mischief."—*Trainmaster's Assistant.* The use of the air brake simplifies the service greatly in this respect.

† Very elaborate reports are now required by railway companies in regard to the cars in trains. This subject is frequently referred to throughout the work.

Cars supposed to be empty should be known by the conductor to be so in fact.

Loaded cars are required to be kept locked.

The windows of freight cars must also be kept securely fastened.

Loaded cars ready to go forward must be taken, though the train may be behind time, unless some circumstance intervenes to prevent it.*

Those in charge of live stock must be rendered every assistance possible in taking care of their property.

Both loaded and empty cars must, when practicable, be left at the most convenient place for handling, as designated by the agent or person in charge.

Way freight should be left on the platform, if possible, or the most convenient place for the agent that is practicable, expedition being used in unloading, so as to delay the train as little as possible.†

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* "The object of running freight trains being to do the business of the road, and not altogether to make time."—*Western Road.* "In passing over the road, they will attach to their trains all the loaded cars which may be ready for them, in the order in which they come, whether at regular stations or side tracks, till they have a full train; but a loaded car is not deemed ready for the train until the agent has the doors locked and fastened, and the conductor will call for a way bill in all cases, that he may be sure of the proper distribution of all the cars or freight in his train. They will take all empty cars from side tracks where they are not wanted, and draw them where they are required, if in the direction in which they are running." —*Old Regulation.*

† "They, with the brakemen, will render all aid in their power, on the arrival of their train at a station, to enable them

Freight trains are required to stop at the places specified in the schedule, unless on approaching such places, a signal is given to go on. When thus signaled, the train may run past without stopping, unless there is freight to leave. If a train is scheduled to stop at a station "when required" the engineman should stop unless he receives a signal to proceed.*

Unauthorized persons should not be allowed on freight trains.†

Confusion or want of method in loading freight should be noticed by conductors and reported to the proper official.

Watchfulness must be exercised by the conductors of freight trains to prevent cars from being broken open or goods stolen while en route.

The duty of looking after the switches used by a train should be delegated to some particular person.

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to leave in the shortest space of time; that as much time may be used in running and as little in stops as possible."—*Old Regulation.*

* "In order to prevent the unnecessary stoppage of the train if the engine has a full load and cannot take more wagons on, and has nothing to leave at the station, the guard must give a green signal, to indicate to the clerk in charge that he has his full load, and cannot take more. And it will be the duty of the clerk in charge to count the wagons in the train signaled as fully loaded, in order that inquiry may be made, in case of any improper refusal to stop on the part of the engineman."—*Great Northern Railway, England.*

† In some instances freight trains carry passengers. This is generally the case in new countries and in other instances where traffic is very light.

While waiting at stations, such switching as circumstances permit is required to be performed by the engine and crew.*

Conductors are expected to exercise care to see that freight cars are not detached or left on the main track.

Cars left on sidings must have the brakes set and the wheels blocked.

Detentions to trains and accidents of all kinds, whether resulting in damage or loss of property, must be reported to the proper official.†

The initials and number of each car taken on or left must be embraced in the return of the conductor; also whether car is loaded or not.

The brakeman is under the direction of the conductor.‡

He is charged with the management of the brakes, the use of signals, and the care of lights,

*"They, with the brakeman, when not otherwise employed, will render what aid they can in wooding and watering to shorten their stops."—*Old Regulation.* This rule is as appropriate, in many instances now, as it ever was. M. M. K.

† The claim departments of railroads require the most minute reports to be made of accidents to persons or injury to property. It is only by the most intelligent, prompt and thorough systemization of such work that they are able to, measurably, prevent frauds being practiced upon them or keep track of rightful claims upon them.

‡ "At stations it is their duty to assist in taking on wood and water, and, when not on running duty, must assist at the station in whatever work may be required of them."—*Old Regulation.*

stoves, water, gas and other appurtenances of the train.

He is required to supply himself with the train signals he may be called upon to use. These he should keep in good order, and at hand, ready for use when required.

The rear car of every train should have a hand brake attached thereto, and a brakeman detailed to look after the same. However, when stopping a train, he should, if necessary, set the brakes upon the forward cars after having set the brake on the rear car.

[NOTE.—The use of the air brake modifies the brake regulations, without wholly annulling them, for the reason that if for any cause it becomes inoperative, recourse must be had to the hand brake.]

Brakemen are required to stop trains at stations, and control them when descending grades without the whistle signal.*

In damp or frosty weather the brakes must be applied earlier than would otherwise be the case.

* "They are not allowed to slip the wheels except in cases of danger, and never upon the ordinary occasion of stopping at a station; observing strictly when the engineman shuts off steam on approaching a station that it is a signal, without waiting for the sound of the whistle to apply the brakes, using judgment in order to stop at the proper place at the station, without allowing the train to press hard upon the tender or engine, allowing the engineman to stop the engine and tender without causing them to draw or press upon the train."—*Old Regulation.* "In traveling down steep inclines, guards must, in order to steady the trains and assist the engine driver, apply the rear brake, care being taken not to skid the wheels except when a train is approaching at too great speed a station at which it is timed to stop, or when the brakes are specially whistled for by the engine drivers."—*English Standard.*

Signals to apply brakes should be obeyed instantly without waiting to ascertain the reason therefor.

The post of the rear brakeman is on the last car, and he should not leave his place while the train is in motion except to protect it, or apply the brakes on connecting cars. It is his duty to see that the signals are displayed on the rear car and otherwise when necessary for the protection of the train, as prescribed by the rules. In case of detention on the main track, he must go back, as directed by the rules, for the protection of the train, without waiting for a signal from the engineman or other instructions.

The forward brakeman is charged with the duty of protecting the train ahead with signals, when, from any cause, the fireman is unable to perform such duty.

When an assisting engine is attached to the rear of a train, it is a part of the train, and in case of detention, the brakeman should go back as in other cases.

Brakemen (as well as conductors) must examine the running gear of cars at stopping places, reporting any defects they notice as directed.

They are held responsible by the conductor for the brakes and couplings being in good order before the train starts, and afterward en route.*

* The position of brakeman is such as to afford the person filling it a fine knowledge of the train service and because of this is by many esteemed the most fitting place to enter the railway service.

The passenger brakeman is expected to report for duty at the time prescribed, open the doors of the cars when necessary and otherwise assist the conductor in the care and disposition of passengers.

It is his duty to render prompt and intelligent assistance in all matters relating to the movement of the train and the reasonable requirements of passengers.

As the train comes to a stop at a station the name thereof must be twice distinctly called from each end of every car. Similarly when the train is leaving a station, the name of the next station at which it stops must be twice distinctly announced from each end of every car.*

It is the duty of the brakeman to assist the conductor in preserving order, and in preventing passengers from standing on the platforms of the cars while the train is in motion, or otherwise violating the rules.

He is expected to be respectful to passengers, and give polite attention to their wishes, avoiding, however, unnecessary conversation.†

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* "The policeman, porter or other person on duty at a station must, on the arrival of a train, walk the length of the train, and call out in a clear and audible voice the name of that station when opposite the window of each carriage, so as to make every passenger in the train aware of the name of the station; and particular care must be taken by the clerk in charge, policemen and porters to observe the indication of any passengers that they desire to alight, by their knocking at the windows, or otherwise."—*Great Northern Railway, England.*

† "Brakemen on passenger trains will be required to wear coats or overalls when on duty."—*Old Regulation.*

When necessary to pass through the cars, he must do so quietly and unostentatiously, so as to avoid disturbing passengers.

When not otherwise engaged he should remain near the door of the car, ready to respond to the signal of the engineman, or perform such other services as the needs of the train may require at his hands.

It falls to the lot of the passenger brakeman to look after the water supply. The toilet rooms and appurtenances connected therewith are also under his immediate charge.* The heating, lighting and ventilating of the car belong to him as well.

His duties, it will thus be seen, are multifarious and such as to keep him constantly occupied. He is in all things the active assistant of the conductor, carrying out his orders promptly and

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* "There is no water closet in the train, no passage through the cars, and no means of communicating with the conductors. Robberies have often been committed in the carriages. Each compartment is lighted at night by a lamp in the roof and warmed in winter by flat tubes of metal filled with hot water and placed under the feet of the passengers on the floor."—*Hon. Geo. P. Marsh describing passenger cars in Italy.*

"The guards must immediately open the door of any carriage from which passengers may require to alight for the purposes of nature, etc., particularly at those stations where the engines take in water. The guards must, on all occasions, represent to passengers the necessity for their resuming their seats quickly for the prevention of delay, and they must avoid all loss of time on the journey."—*Regulations, English Road.*

"Guards, porters, policemen, etc., are forbidden to use the water closets provided for the public, and will be fined for so doing."—*Great Northern Railway, England.*

effectively, whether the duty assigned to him be that of ejecting an unruly passenger, or guarding the train from collision.

The freight brakeman is required to report for duty at the time appointed, and assist, if necessary, in making up the train.

He cannot leave his post while the train is in motion, nor take any position other than that assigned to him by the conductor.

He assists in loading and unloading way freight when necessary, and performs such other duties as may be asked of him by the conductor.

His duty, as his title implies, is (or was) to control the train by the use of the brakes on approaching stations and when descending grades, and at such other times as may be necessary; this without slipping the wheels or the signaling of the engineman. He is, like the passenger brakeman, the conductor's assistant — faithful, active, vigilant and hardy; ready and willing to do anything asked of him.

The engineer, as the lookout and pilot of the train, is its custodian and guardian on the road. Both life and property are in his keeping, and dependent upon his prudence and good judgment. The importance, therefore, of his understanding his duties and being vigilant and cautious in the discharge thereof, cannot be over estimated. No one appreciates this fact so fully as he.

"The engineer must keep a good lookout all the time the engine is in motion, and the fireman must also do so, when he is not otherwise engaged."*

The engineer, when passing over the road with an empty locomotive, acts also as conductor and is held responsible for the faithful observance of the precautions adopted for the protection and government of trains. He must, therefore, familiarize himself with all needed rules and regulations. This he does thoroughly.

While observing the signals of the line as he proceeds, he must also keep a sharp lookout to see that no portion of his train is detached without its being instantly observed.†

The engineer is under the general direction of the conductor when on the road, except in things that conflict with the rules established for his government.

He is also required to observe the orders of inspectors and supervisors in regard to the working of his machine and the due and effective use of fuel and other materials.

He is also subject to the directions of the yard master in regard to switching cars and making up trains.‡

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* English Standard.

† "With the firemen, they will often alternately look around to see that all is right with the train while passing over the road, or standing with their train at stations, and to attend to signals from the conductor, for starting forward or backward."—*Old Regulation.*

‡ "The engine driver must afford such assistance with his engine as may be required for the formation, arrangement and dispatch of his train."—*English Standard.*

His duties are thus regulated from many different directions. They affect in everything the traffic of the line, and are throughout of a co-operative nature. Before he goes to work in the morning, he consults the bulletin board for any orders there may be that affect him; from thence he goes to his engine. In its care and direction he is supreme; in everything else he works under the direction of others.*

Where time and opportunity have been afforded to regulate the train service with a view to the comfort of travelers and the preservation of property, engineers start and stop the train so uniformly that it is difficult for passengers to tell when it starts or stops.

Engineers should not apply the brake so suddenly (except in case of danger) as to cause abrupt concussion of the cars.

In stopping trains, engineers are compelled to pay attention to the weather and the condition of the rails, as well as the weight of the train; many circumstances govern in determining when to shut off steam, how to apply the brakes, etc.

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* The duties of engineer in connection with the hauling of trains cannot be defined under a specific heading any more than the duties of a conductor or superintendent can be thus defined. They embrace incidentally the train service in its entirety, switching, marshalling cars, etc. What I have to say, therefore, relative to them, is incidental merely. The technical duties of the engineer in connection with the management of his machine, I do not refer to at all in this chapter. That is a vast and interesting theme in itself.

Terminal stations require to be approached and entered with caution.

Particular care is required to be exercised in starting and stopping stock trains.

Engineers are not justified in starting from a station, even though signaled to that effect, if they have good reason to believe they cannot safely do so or cannot reach the next station without trespassing upon the rights of other trains.

It is the duty of those in charge of such matters to see that the locomotive is in good working order and supplied with the necessary apparatus, namely, lights, signal lamps, flags, oils and other stores including fuel and water, screw jacks, extra spring hangers and such other implements as are required to operate the machine or meet the contingencies of accidents. Engineers on taking charge must see that due provision has been made in these respects, and in the event it has not, report the circumstance to the proper officer.*

Engineers are required to familiarize themselves fully with the practical and scientific operation of the air brake.† Good judgment is needed

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* "They will be particular to see that the chimney is kept in order, so as not to throw fire. They will not empty their sparks between the extreme switches at any station, unless a proper place be provided for them. Where no place is provided, select the most suitable beyond the switches, putting them down an embankment, if possible, so as not to disfigure the line."—*Old Regulations.*

† The subject of air brakes is exhaustively discussed in another part of this work.

in its working. It should be applied (tested) before starting, to make sure it is in working order. On the road it should be used in such manner as to avoid injury or cause discomfort to passengers. Experience and good judgment are required to stop trains at the precise point desired.*

The brake is not to be wholly relied upon when approaching railroad crossings or other obscure and hazardous points, but steam must be shut off, and the train held under due control.

Engineers must see that the bell cord is not obstructed by fuel or otherwise and it should not be unfastened until the end of the trip. If there are two locomotives, it should be attached to the leading one.†

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* "Should a passenger train, in stopping at a station, overrun or stop short of the platform, the engine driver must not move the train back or draw it forward until he receives instructions from the guard in charge to do so. Stationmasters, guards and others must at once take steps to prevent passengers leaving the carriages that are not at the platform; and as soon as the guard in charge has satisfied himself that all carriage doors are closed, and that no passengers are entering or leaving the train, he must instruct the engine driver to put back or draw up to the platform, as may be required. The engine driver must sound his whistle before moving his train."—*English Standard.*

† "When two engines are employed in drawing the same train, the engine driver and fireman of the leading engine are responsible for the observance of signals; the engine driver of the second engine must watch for, and take his signals from, the engine driver of the leading engine, but the engine driver of the second engine is not relieved from the due observance of all signals regulating the safe working of the line. Great caution must be used in starting such a train to prevent the breaking of couplings."—*English Standard.*

In switching cars the engine must not be detached until the vehicles are placed in the position desired, unless there is some one present to control their movements. Nor should more cars be moved at one time in switching than the engine can easily control.

Engineers are required to obey signals instantaneously, even though they may think them unnecessary. If in doubt as to the meaning of a signal, they must take immediate measures to enlighten themselves in regard to the matter. In the event of failure to display signals,* or if improper signals are displayed, the matter should be reported by them to the proper authority† for action. The subject is too grave a one to temporize with or overlook.

It is also the duty of engineers to observe whether watchmen and flagmen are at their posts and to report any neglect of duty they observe in this respect. Here again the situation is too serious to be passed over unnoticed.

In approaching stations where the train does not stop, it should be held well under control.

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* "The absence of a signal at a place where a signal is ordinarily shown, or a signal imperfectly exhibited, must be considered a danger signal, and treated accordingly, and the fact reported to the signalman or stationmaster."—*Great Western Railway, England.*

† "The engine driver and the fireman must pay immediate attention to and obey all signals, whether the cause of the signal being shown is known to them or not. The engine driver must not, however, trust entirely to signals, but on all occasions be vigilant and cautious. He must also obey the instructions of the officers in charge of stations."—*English Standard.*

Care must also be observed during and after storms; this without regard to making time; special caution must be observed in approaching bridges, curves and other obscure places where the track may be washed away.

Care is required to be taken by engineers to prevent injuring or killing livestock, and trains must come to a full stop, if necessary, to avoid such accidents.* In the event they occur, a report thereon must be made to the proper officer.†

Accidents to cattle are much more frequent in new and partially developed countries than elsewhere. Frequently in such cases cattle are allowed to run at large, and to add to the embarrassment, the railroad company has no fences, or they are inadequate.

"Engine drivers, after taking water from tanks or water columns, must be careful to leave the hose or water crane clear of the main line and properly secured."‡

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* "Pass all roads cautiously; be careful not to frighten horses, and at Cary take extra care."—*Old Regulation.*

† "Reports of livestock killed or injured should be forwarded promptly to the proper officer. In case of doubt as to whether animals were injured, or not, a report should be made. If animals are injured by running between the cars, or by being struck by the cars, the engineman should report the fact in the same manner as if the damage had been done by the engine. When the facts are not within his personal knowledge, he should give the name of the person from whom information can be obtained. As claims for stock injured or killed are usually held in abeyance until a report has been received from the engineer, it is important that he should give attention to the matter." This old rule is still a valuable one.

‡ English Standard.

Burning waste or hot cinders must not be ejected from the engine while in motion, and care must be used when crossing wooden bridges and culverts, to prevent their taking fire from the engine.*

Ash pans must not be cleaned nor emptied on the main track, except at designated points.

Engineers must not leave their machines during the trip, except when required by the regulations, or urgent necessity. In case of absence, the fireman or other competent person must be left in charge. In the event it is necessary to leave the locomotive without attendance, the brake must be applied and other necessary precautions taken to prevent mishaps of any kind.

In the event the conductor is disabled, the engineer has full charge of the train.

The condition of the engine must be reported to the inspector at the end of each trip in the event it is out of order in any way.

Engines must not be allowed to stand on the main track.

The headlight of the engine requires to be carefully looked after. It should be kept lighted after dark, and at other times when occasion requires. It must be covered, however, when waiting on sidings.

Engineers cannot refuse to take cars assigned them, but use their best efforts to handle such as are put in their train. Should the capacity of

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*** "Pass all important bridges carefully and at a reduced speed, with the ash pan closed."—*Old Regulation.***

their engine be overtaxed, they will report the matter to the proper official.

Only those authorized are allowed to ride on locomotives.

More fuel should not be allowed to be placed in the receptacles therefor than can be carried without waste.*

In the event any one is injured or killed by the locomotive or train, the facts in the case must be reported to the proper officer by the enginemen.†

Engineers are expected to assist, when called upon, in repairing the engine. When working in the shop, they are subject to the rules and regulations provided therefor.‡

Firemen, when on the road, are under the direction of the engineer.§

They are required to observe the instructions governing the use of fuel and the best method of firing.‖

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* There is great danger to trackmen and others if the tender is piled so high with fuel that pieces thereof fall to the ground.

† The personal injury reports of railroads are exceedingly elaborate and such as to bring out all the facts as well as the names and addresses of those who witnessed the occurrence. These latter are taken on the spot at the time.

‡ "When not on running duty, they will assist in the machine shop, and conform to its rules."—*Old Regulation.*

§ "They will act under the direction of the engineman, and will aid in the small daily repairs and cleaning of the machine."—*Old Regulations.*

‖ "Fires must be regulated so as to prevent undue emission of smoke at stations or the wasteful use of fuel."—*Old Regulations.* This rule is still a valuable one.

They must be on their engines at the prescribed time before starting.*

It is their duty to look after the fuel,† also the water supply,‡ to see that the bell is rung at the proper time; to keep the engine clean;§ to aid in making repairs when called upon; to watch the track when not otherwise engaged, and, finally. to perform such other duties as the engineman may require of them in the discharge of duty.

Firemen are required to be more or less familiar with the train rules, including those relating to the protection of trains. They must be fully acquainted with the signals, and prepared to use them or respond to them promptly when occasion requires.

They have charge of the engine in the absence of the engineman and must not leave it, under such circumstances, without permission.

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* Many duties attach to firemen and enginemen about the roundhouses and stations of small roads that are given to others on big systems where the traffic is great.

† Before arriving at the station where they are to take wood, they will pile up their remaining wood in the front part of the tender, that the wood from the station may be taken in with the greatest dispatch.

‡ "They must see that the boilers are properly filled before firing up; that the fires are kindled in proper time, and that all the working joints of the engine are kept well oiled, together with such other duty as the engineman may require of them."—*Old Regulations.* "They are strictly forbidden to throw fire or sticks of wood upon the road, as also to interfere, in any manner, with the running of the machine."—*Old Regulations.*

§ "During the passage, whenever they have an opportunity, they will wipe the connecting rods and most exposed parts of their machine, keeping it as clean and neat as possible."—1853.

They must not run the engine, in the absence of the engineman, without authorization, unless directed to do so by the conductor.

When at work in shops, they are subject to the rules and regulations governing under such circumstances.

The position of fireman affords one of the most advantageous avenues for entering the service of railroads. It offers the incumbent an opportunity to become familiar with the construction, operation and maintenance of the locomotive. The facilities it affords for learning the details of train service and, incidentally, of traffic, are also good. The position has been a stepping stone to many men who have achieved the most exalted and honorable records in railway life.

Inspectors of engines and instructors of those in charge thereof constitute a part of the working force of most of the railroads of later days, although entirely unknown in the early history of such properties. As locomotives multiplied and those in charge increased in number, the need of systematic inspection of the former and instruction of the latter became more and more apparent. Hence, the office of inspector. He travels much back and forth along the line studying the performances of locomotives and the capacity of those in charge.

He performs his duty under the direction of the master mechanic or shop foreman. These duties are oftentimes of a more or less general nature. They are important in every instance. They include looking after the condition of locomotives and indicating their working capacity.

It is also his duty to examine the statistics that record the performances of locomotives, and indicate whether they are satisfactory. He knows the tonnage each machine can handle; sees that the steam pressure prescribed in each instance is not exceeded; that the boilers are washed and cleaned as often as required; that the locomotive is fully equipped with necessary appurtenances, tools and signal apparatus; that the shop foreman is kept advised as to the condition and wants of each engine, and, finally, that firemen fully understand and properly exercise the art of firing. This last is one of the most important and laborious of his many responsible duties.

The Yardmaster looks after the cars in the yards and on the sidings connected therewith.*

* "The stationmaster must see that all fixed scotch blocks at his station are kept across the rail; that all safety points are closed against the main line, when it is not necessary that they should be open for the purpose of shunting, and that all vehicles are placed within such scotch blocks or safety points. Facing points not worked from a locking frame must, in all cases, be securely fastened or held for the passage of trains. . . . The stationmaster, or person in charge, must take care that, while shunting wagons or other vehicles at stations or other places situated on inclines, in addition to screwing the van brakes tightly down, a sufficient number of wagon brakes

He sifts out the cars that are empty from those that are loaded and makes such disposition of each as circumstances require.

He has charge of the yard and its precincts and preserves order therein.

He is the marshal of trains, making up those that are to go out and dissolving those that come in.*

The prompt and effective handling of cars is dependent upon the efficiency of the yardmaster. If he is energetic, cars to be sent out go forward with as little delay as possible and no time is lost in disposing of cars to be loaded, unloaded or switched. He acts under the immediate supervision of the superintendent or his deputy.

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are pinned down, and sprags or hand scotches used when necessary, to prevent the possibility of the train or any of the vehicles running down the incline. At such stations and other places a supply of sprags and hand scotches must be kept for the purpose. When wagons require to be shunted into incline sidings the trucks to be moved at one shunt must be limited to such a number as the engine can push up without going at a violent or excessive speed."—*English Standard.* This rule is, in the main, as applicable to America as Great Britain.

* "At any terminus, or large station where carriages are kept, the station inspectors are to see that they are always in good order, and, before being formed into a train, that every carriage or other vehicle has its proper supply of roof lamps trimmed; that it is cleaned inside and out, and the glasses and handles made bright. They are also to see to the screwing up of the connections, and that the buffers of the several carriages forming the train press against each other, and recede about an inch when screwed up, and also to take care the doors on the off side of all carriages are locked."—*Great Northern Railway, England.* This regulation applies in some respects to American roads. Our method of coupling is different.

The yardmaster is the Autocrat of the Switches; all the yard forces are subject to his direction.*

The yardmaster is expected to see that the switches and yards are kept in order and that the signals are properly maintained and operated.†

If cars are required for loading, the yardmaster must see that they are selected and placed in position. Afterward he must look to their being forwarded, and when trains are ready to move, see that the force to take charge of the same is on hand.

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* "They (flagmen and switchmen) must be provided with a crowbar, shovel, sledge, spiking mauls, spikes, red and white lanterns, and with a flag staff eight feet long, and have a white flag three feet square at one end and a red flag of the same size at the other end."—*Old Regulation.*

† The care of switches and signals is a work of the utmost delicacy and particularity. Switches must be kept free from snow or other obstructions. The cleaning, trimming, lighting and placing of signal lamps is also a work that cannot be slighted. Similarly, the day signals must be inspected with the utmost faithfulness and maintained in the highest possible state of efficiency.

"He must satisfy himself that the signalmen at or attached to his station perform their duties in a proper manner by night as well as by day, and in order to maintain a proper supervision over the men in this respect, it will be necessary for him frequently to visit the signal boxes."—*English Standard.*

"They will know personally, at least ten minutes before any regular train is due, and before leaving their stations at night, that the switches upon the main track are properly secured and locked, and that the cars upon their side tracks, nearest the switches, have their brakes set, or their wheels well blocked."—*Old Regulation.*

"When any one beat or post is covered for twenty-four hours by a day and night man, who relieve each other, the day will usually comprise thirteen hours, and the night eleven hours."—*Great Western Railway, England.*

All trains are made up by him, and it is his duty to see that they are duly equipped and that those who operate them are qualified and duly instructed.*

It is the duty of the yard master to see that every car is inspected, and if requiring repairs, that the work is properly done, or, if of a serious nature, that the car is sent to the shop. Cars engaged in passenger traffic are cleaned and looked after under his direction and assigned their places in the yard and train.†

One of the most onerous of his duties, where the old fashioned hand couplings are used, is the proper instruction of switchmen in the performance of their dangerous duty. Happily this service is becoming less burdensome with the introduction of automatic couplings.

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*The duties of the yard master, it may readily be supposed, vary on roads according to the extent of the yards and the amount of work to be done therein. In the majority of cases the work is performed at small and unimportant yards by the agent or a subordinate of the latter. In some cases horse power is used. When this is the case, "A man must, in all cases, have hold of its head, whether the horse is drawing vehicles or otherwise."—*English Road.*

†"At stations where carriage examiners are kept, the station master, or person in charge, must, before starting the train, satisfy himself that the examination of it has been completed, and that, so far as the carriage examiner is concerned, the train is all right and fit to proceed. At stations where examiners are not kept, steps must be taken to remedy any defect that may be observed in the running of the vehicles, by supplying oil or grease to the axle boxes of any that may require it, or removing the defective vehicles from the train, as may be found necessary."—*English Standard.*

All vehicles, particularly those used in passenger traffic, require to be carefully searched on their arrival at destination with a view to the due protection of any valuables that may be left therein.

The windows and doors of passenger cars also require to be locked and other needed measures taken to protect them.*

The records of the yardmaster's office embrace a history of every car he handles, its number, initials, class, condition, work performed on it, date of arrival, date of departure, whether loaded or empty, etc. In many instances, the yardmaster, or his assistant, is required to signal trains. Where this is the case, it adds another to his many responsibilities.

In the event of accident occurring in the yards, the yardmaster reports the same to the proper officials on the blanks provided therefor.†

Telegraph operators, under the American system of working trains, constitute a vital feature thereof, and it is not too much to say that upon

* "The windows of all empty compartments must be closed, not only while the carriages are standing at the stations, but also when the trains are running, immediately upon the compartment becoming vacant. The ventilators must be kept open."—*English Standard.*

† The most thoughtful provision is made by railroad companies for keeping themselves accurately informed of any mishaps that occur to their employes while in the performance of duty, such as date of accident, name of employe, occasion of accident, its extent, etc.

their faithfulness and skill depend, in a large measure, the safety of trains. That so few accidents occur through their oversight, or because of their mistakes, is the best possible evidence of their attentiveness and skill.

The details of service connected with the administration of the myriad telegraph offices along the lines of railroads vary according to the circumstances of each case. In some instances the operator acts under the immediate direction of the agent, and constitutes a part of the station traffic force. In other cases he has sole charge of his office and devotes himself wholly to the telegraph branch of the service. In whatever position he is placed, however, he fulfills the duties required of him with intelligence and painstaking particularity. The place is a most important one, and is constantly made the stepping stone to other and, in some cases, higher positions.*

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* The author of this book commenced his railroad experience as a messenger boy in a telegraph office, at seven dollars a month, in a little town on the Mississippi River. This in 1856. When not thus occupied he learned to telegraph. The position of operator paid him twenty-five dollars a month. He worked for this pay for nearly four years. He was never a very good operator. He looked with wonder on the facility of others with greater adaptability. However, he learned, as an operator, certain practical things about railroads that he could never have learned elsewhere. The time he thus spent was worth everything to him afterward. For a part of the period he was telegraphing he also acted as clerk in the freight office. This was also fortunate for him. It not only broadened his knowledge, but increased his desire to learn. This desire is never very strong in young men, and too great care cannot be exercised by those in authority on railroads to cultivate it.

Every reasonable incentive is held out to telegraph operators to look carefully after the administration of their offices and to strive, while filling them, to familiarize themselves with railway operations as a whole, so that they may be fitted for promotion when opportunity offers.

The duties of operators in connection with the movement of trains are described generally and particularly elsewhere in connection with such matters. Details of an incidental or subsidiary nature, vary, according to circumstances, but so far as they are of a general nature, may be briefly and imperfectly summarized as follows: Operators are required to be prompt in their attendance and unremitting in their duties during business hours. If necessarily absent, notice of the fact is given so that untoward complications in connection with the movement of trains may be avoided. Where there are two or more operators they never leave the office simultaneously. When going off duty an operator is required to fully advise the one taking his place of the situation of affairs so far as relates to his office.

In some instances the regulations of railroads require operators to be in their offices every day, including Sundays, twenty minutes before the arrival of trains and to remain there until trains have passed the next station. Night operators are expected to keep in touch with the home office by signaling it every hour. At an hour designated each day (generally one minute before eight o'clock in the morning) the correct time is telegraphed from headquarters and all time-pieces are forthwith regulated to conform therewith. A particular minute is also assigned each day for sending a report to headquarters of particulars of cars arriving, leaving, on hand, needs in this direction, etc.

The files of telegraph offices require to be systematically kept and copies of messages preserved, so that the work may be reviewed or verified if occasion requires.

Everything relating to the office is of a confidential nature.

All interruptions or delays in the discharge of business (including the delivery of messages) should be made a matter of record. The rule requiring the sender of a message to read the same aloud before forwarding is a wise one and should be rigidly observed. If parties for whom messages are received cannot be reached the sender should be notified without delay.

If a line is out of repair, the trouble should forthwith be located and necessary measures taken to have it repaired. To facilitate this, the operator must keep himself supplied with needed supplies and utensils. Similarly he should keep the section foreman supplied and should see that he is fully instructed in regard to looking after the line and making repairs when required.

One of the requirements of the telegraph service is that the paraphernalia of the office shall be kept in a high state of efficiency, that relays shall be kept accurately adjusted, and instruments, batteries, wires, switchboards and other appliances faithfully looked after. Not only are operators expected to maintain their own signals intact, but to see that the trains that pass carry the proper signals, and in the event they do not, to report the fact to headquarters. This duty is not burdensome, as they are expected to report the time of departure or passage of every train. Each telegraph operator is throughout an active lieutenant of the superintendent in handling the traffic of a line. Through his eyes officials at headquarters scrutinize all that is going on as if present on the ground.

As, under the American system, the movement of trains by telegraph is directly dependent upon the line being in good order, telegraph inspectors and repairers having supervision thereof are required to be diligent day and night in the discharge of their duties. Thus they are expected to pass over the road at short intervals, make frequent tests of the wires, see that they are free from obstructions, that they are insulated throughout, that the poles are firm and in good order, and, finally, that all office connections and fixtures are effective and fully maintained.

CHAPTER XX.

PARTICULARS OF SERVICE IN GREAT BRITAIN—INCLUDING AN ACCOUNT OF THE ABSOLUTE BLOCK SYSTEM.

The railroads of Great Britain are, as a rule, operated under the block system, or modifications thereof. In this phase of life as in other things our English cousins are incisive, comprehensive and thorough. The lines of their railroads are like the front of a fortress picketed throughout with signal towers and observant guardsmen.

The bulk of the rules and regulations under which trains are operated in America have no relevance in that country.

While the roads of Great Britain have schedules distinctly defining the time and rights of trains, their movements are greatly facilitated on all double track roads by the signal service; there trains everywhere move or remain stationary, approach or remain away from stations at the beck and nod of signalmen. They may be behind time, or may not be recognized by the schedule at all, but are still able to pursue their way with undiminished speed guided and directed by the signalmen.*

In no case can a train leave a station until signaled to do so. The English guard has in this respect no such prerogative as the American conductor.

Train dispatching by telegraph as practiced in America upon single track lines is very little known in Great Britain, and to that extent our system is superior to theirs.

The duties of the conductor (guard) abroad are much simpler than in America. He is, however, the creature of circumstances. Frequently without an assistant, he is yet expected to protect the train and perform the duties of a brakeman, express messenger and baggageman. Nominally in control on the road, his authority vanishes at the station. While he assists in making up his train, it is started and its fares are collected by others!†

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* "Trains and engines will be run without previous notice. The line-staff must, therefore, be prepared to make provision for them whenever exigency arises, without notice."—*English Regulation.*

† "Should a guard have reason to suppose any person is without a ticket, or not in the right carriage, he is to request the party to show him his ticket, not with a view to receiving it from him, but to satisfy himself that every passenger has a proper one. He is under no circumstances to receive money on account of the company."—*Regulations English Roads.*

The elaborate force we have on passenger trains in America is unknown in England; when they have an assistant guard, he has a box in one of the cars, aids in signaling the train in case of danger, attends to the brake, and performs such other duties as are required of him.

The American train, as is well known, usually has a conductor, express messenger, baggageman and two brakemen. The station service is, however, lighter than in other countries. The apparent extravagance of foreign companies in this last respect is explained by the fact that they insist upon passengers purchasing tickets before entering the cars. This necessitates adequate provision. The rules and regulation governing the procurement of tickets before entering the cars, in many instances sanctioned by law, are exceedingly strict in most of the countries of Europe.

In reference to the spirit of the service in Great Britain and the specific methods practiced there, I can in no way so clearly illustrate their scope and intent as by quoting the regulations themselves. Those that I give refer to various matters connected with admission to the service, promotion therein, wages, disciplinary measures, procedure, benevolence, and finally the great chart created by English minds, constituting the block system, under which vast numbers of trains impossible for Americans to realize, run to and fro without risk to life or property.

The following comprise regulations of a general nature:

Every employe must devote himself exclusively to the service of the company residing at whatever place may be appointed, attending at such hours as may be required, paying prompt obedience to all persons placed in authority over him, and conforming to all the rules and regulations of the company.

The rules and regulations given under different heads are made specially for the observance of the servants employed in doing the work required by such rules and regulations, but every such person must make himself thoroughly acquainted with them as a whole, and will be held responsible for a knowledge of and a compliance with them as a whole.

Everyone is required to assist in carrying out the rules and regulations, and must immediately report to his superior officer any infringement thereof, or any occurrence affecting the safe and proper working of the traffic which may come under his notice.

The address of each person employed in the working of the railway must be registered at the station to which he is attached, or at which he is paid, and must be posted in the stationmaster's office, so that, if required in case of emergency, the men may be readily found. Any change of address must be notified to the stationmaster, in order that the record may be kept perfect.

No servant is allowed, under any circumstances, to absent himself from duty, or alter his appointed hours of attendance, or exchange duty with any other servant, without the special permission of his superior officer. In case of illness, he must immediately report the circumstance to his superior officer.

Every person receiving a uniform is to appear in it, when on duty, clean and neat, with the number and badge perfect, and if any article provided by the company shall be damaged by improper use, he will be required to make it good. No servant is allowed to convert to his own use any article the property of the company, and if guilty of such misconduct he will be severely punished. The conduct of all servants must be prompt, civil and obliging. They must at all times afford every proper facility for the business to be performed, be careful to give correct information, and, when asked, give their names without hesitation.

All officers, clerks, and persons holding situations of trust, will be required to find security for their faithful services, the amount and conditions of which security will be stated upon appointment.

No officer or servant of the company is allowed to travel on the railway, unless provided with a proper ticket, or free pass; nor is he allowed to ride on the engine, or in the brake van, or in any vehicle in which luggage or parcels are conveyed, unless in the execution of his duty, without written permission from the properly authorized officer of the company.

No guard, engine driver, fireman, signalman, policeman, porter, or other servant of the company, while on duty, is allowed to enter a station refreshment room, except by permission of the stationmaster or person in charge of the station.

No money or gratuity in the shape of fee, reward or remuneration is allowed to be taken from passengers, or other persons, by any servant of the company, under any pretense whatever, even although the regular hours of duty shall have expired.

No servant of the company is allowed to trade, either directly or indirectly, for himself or others. The company reserves the right to punish any servant, by immediate dismissal, fine, or suspension from duty, for intoxication, disobedience of orders, negligence, misconduct, or absence from duty without leave, and to deduct from the pay of their servants and retain the sums which may be imposed as fines, and also their wages during the time of their suspension, or absence from duty from any cause.

No servant is allowed to quit the company's service without giving the month's notice required by the terms of his engagement.

When a man leaves the service, he must immediately deliver up his uniform and all other articles belonging to the company, and no money due for wages to any man leaving the service will be paid until his clothing, book of rules, lamps, flags, tools, detonators, and all other articles, the property of the company, which may have been supplied to him, shall have been delivered up in accordance with the company's regulations. If not delivered up, or if any article be missing, or be damaged by improper use, the cost of such articles or of the repair of such damage shall be a debt due from the man to the company, and may be deducted from any pay then due, or, if such pay be found insufficient to meet the claim, it will become a debt recoverable at law.

All testimonials and letters of recommendation will, if required, be returned by the company at the time the person whom they concern leaves the service; except such as are addressed to the company or its officers.

All servants must exercise proper care in getting between vehicles for the purpose of coupling or uncoupling them.

No trespassing upon the railway must be allowed, and no person must be permitted to walk on the line, unless provided with written or printed permission to do so, signed by a properly authorized officer of the company. In the event of any person trespassing, and refusing to quit when requested to do so, the name and address of such person must be obtained, and the circumstances reported to the nearest station-master.

Special trains or engines have frequently to be run without previous notice of any kind; it is therefore necessary for the staff along the line to be at all times prepared for extra trains or engines.

The safety of the public must, under all circumstances, be the chief care of the servants of the company.

Whenever the term "Main Line" is used, it means the running line of any railway, or branch. Whenever the word "Train" is used, it must be understood to include "Light Engine," i. e., engine without a train.

Whenever the words "Goods Train" are used, they must be understood to include "Goods, Mineral, Cattle and Ballast Trains."

The conditions under which persons are admitted to and retained in the service of the English companies are thus set forth by the Great Northern Company:

A candidate as an experienced clerk must possess railway experience or experience in other traffic equivalent thereto.

The salary, not exceeding four hundred dollars per annum, is fixed on appointment.

A candidate as a junior clerk must have attained eighteen and must not exceed twenty-three years of age.*

A junior clerk is eligible for promotion only on a vacancy occurring, and upon the head of the department in which he has been employed and the general manager recommending him as qualified to fill the same.

A candidate as a lad clerk must have attained fifteen and must not exceed eighteen years of age.†

A lad clerk is ineligible for promotion to be a junior clerk until he is eighteen years of age, and then only upon a vacancy occurring, and upon the head of the department in which he has been employed and the general manager recommending him as qualified to fill the same.

All clerks, without reference to their standing in the service, are allowed one dollar a week in addition to their pay, when employed wholly on night duty.

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* The salary on appointment and

For the	1st	year is	$5 25	per week.
"	2d	"	5 50	"
"	3d	"	5 75	"
"	4th	"	6 00	"
"	5th	" and until promoted,	6 25	"

If employed in London, but during such employment only one dollar a week is allowed in addition to the salary.

† The salary on appointment and

For the	1st	year is	$2 50	per week.
"	2d	"	2 75	"
"	3d	"	3 25	"
"	4th	" and until promoted,	4 00	"

Written application at the end of each year of service must be made to the directors through the medium of the superintendent of the line, or chief of the department in which the clerk is engaged for the authorized increase of salary, and failing such application at the proper time, increased pay will be allowed only from the date at which it is eventually made. This rule applies also to the police and porters.

A candidate as a clerk will undergo a strict examination as to his qualifications in proportion to his age; he will be required to show a good handwriting, suited for accounts and correspondence, and that he has a competent knowledge of mercantile arithmetic; and he must be in a good state of health.

The candidate must, on attending at the secretary's office to be examined, produce testimonials of character.

In the case of an experienced clerk, and of a junior clerk who has been before employed, first, from his last employer; second, one from each of two householders of undoubted respectability.

In the case of a lad clerk, and of a junior clerk who has not been before employed, first, from the head master of the school in which he has been educated; second, one from each of two householders of undoubted respectability.

The nomination, with the particulars of the examination and the testimonials, will be submitted to the directors on the candidate appearing before them, and who will decide whether he be qualified and a proper person to be appointed.

The name of a clerk, on appointment, will be added to a list, from which he will be summoned in turn for duty as a vacancy occurs, provided he has in the meantime given security; but should he, on being summoned, refuse or neglect to join, his name will be struck out of the list, and he cannot afterward be readmitted to the service.

A clerk must, immediately on appointment, give security to the amount of two years' salary, or in not less than five hundred dollars through the medium of one of the specified guaranty societies.*

A candidate as a porter must be five feet seven inches in height, without his shoes. He must not be less than than twenty-one and must not exceed thirty-five years of age. He must be able to read and write, and be generally intelligent; free from any bodily complaint, and of a strong constitution, according to the judgment of the surgeon by whom he will be examined, who will report whether he is "fit" or "unfit." The police are selected from this class.

The candidate must produce testimonials of character from his last employer, and one from each of two householders of undoubted respectability, and if he has been in any public service, also a certificate of good conduct during such

* The railway company pays the premium in the case of a clerk whose salary does not exceed $5.25 per week or $6.25 per week without allowances.

employment; these, with the nomination, will be submitted to the directors on the candidate appearing before them, and who will decide whether he be a proper person to be appointed.*

A candidate as a lad porter must not be less than fourteen or exceed seventeen years of age. He must be able to read and write, and be generally intelligent, free from any bodily complaint, and of strong constitution, according to the judgment of the surgeon by whom he will be examined, who will report whether he is "fit" or "unfit."

The candidate must produce testimonials of character from the school at which he has been educated, and one from each of two householders of undoubted respectability. These, with the nomination, will be submitted to the directors on the candidate appearing before them, and who will decide whether he be a proper person to be appointed.†

* The pay of a porter is,

	In London.	In Country.
For 1st year	$4 25 per week.	$4 00 per week.
" 2d "	4 50 " "	4 25 " "
" 3d " and until promoted,	4 75 " "	4 50 " "

provided a fine be not incurred in the interim, in which case increased pay is allowed only after twelve months' service from the date of such fine.

† The pay of a lad porter is,

For the 1st year	$1 75 per week.
" 2d "	2 00 "
" 3d "	2 25 "
" 4th "	2 50 "
" 5th "	2 75 "
" 6th "	3 00 "
" 7th " and until promoted	3 50 "

A lad porter on attaining twenty-one years of age, and not before, is eligible for promotion to be a porter, but he can then become a porter only after being passed by the surgeon and directors, as in the case of a new appointment, want of height (under five feet seven inches) not being, however, a disqualification.

All appointments are made on the distinct understanding that the parties hold themselves in readiness to proceed to duty immediately on being summoned, their pay being allowed from the date of employment, that they reside wherever required, and that they will join and become members, on being so required, of any provident or benevolent society established or to be established in connection with the company, and abide by all rules and regulations made and provided.*

The scale of pay of every employe is based by the company on needs and length of service with painstaking particularity.†

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* The rules of the Sick and Funeral Allowance Fund are furnished to every porter on appointment.

† Thus the wages of station inspectors are $6.25 and $7.50 per week according to the class of station, with house; or an allowance of $1.25 per week in lieu of the house.

Passenger Guards,	1st class,	Chief Guard	$7	50	per week.
" "	1st "	Under Guard	6	87	"
" "	2d "	Chief Guard	6	75	"
" "	2d "	Under Guard	6	25	"
Goods and Cattle Guards,		Chief Guard	7	50	"
" "		Under Guard	6	87	"
Mineral Guards			5	75	"

All guards, when required to sleep away from home, receive twenty-five cents per night additional. The wages of policemen are:

Gatemen provided with a house by the company will have fuel free, and must pay sixty-two cents a week rent, but if they open the gates by night, in addition to the day work, they are to have the house rent free as an equivalent for the night work.*

Police and porters will receive an advance of twenty-five cents per week each year for two years, beginning on the day when they shall have completed a year's service, if not punished in the interval.

Foremen porters, signalmen, or pointsmen, gatemen at level street crossings, shunters and loaders will be advanced under the same rule, twenty-five cents per week each year for two years, from which their only increase will be by promotion to a superior foremanship at six dollars and twenty-five cents, which is a fixed rate of wages, or to the situation of guard or inspector.

Police—Ordinary	$4 25	per week.
" Signalmen at Junctions and Pointsmen in London	5 00	"
" In the Country	4 75	"
" Gatemen at level street crossings	4 75	"
Gatemen at level road station crossings	4 25	"

* Wages of Porters in London	$4 25	per	week.
" " " " the Country	4 00	"	"
" " Foremen Porters in London	5 25	"	"
" " " " " the Country	5 00	"	"
" " Mineral Foremen Porters in the Country	5 25	"	"
" " Shunters in London	4 75	"	"
" " " " the Country	4 50	"	"
" " Luggage Stowers and Loaders	4 75	"	"

Signalmen, at the expiration of every half year of good service, without punishment, will receive a premium of $12.50.

In case of promotion, men who have been advanced under above rule are to carry with them and continue to enjoy their advance, unless the promotion is to a grade paid at a fixed rate of wages, when it will cease.

As soon as any fine or punishment for misconduct shall be registered against any servant of the company, the previous period of the current year's service for increase of pay or premium becomes forfeited, and the year can only be reckoned from the date on which he was punished.

The regulations of the Great Northern Company in regard to the uniforms of its employes are, like all its instructions, exceedingly minute. They are thus stated:

The servants of the company, to whom uniforms are allowed, are required to wear them while on duty. The uniform of servants clothed by the company is as follows, for twelve months:

For station inspectors and guards, a great coat, a frock coat, waistcoat, two pairs of trousers, two red neckerchiefs, and hat or cap; for policemen, a great coat, a dress coat, two pairs of trousers, cape and hat; for porters, a jacket, waistcoat, two pairs of trousers, two red neckerchiefs, and cap.

Foremen, porters and shunters have a cape in addition. Authorized laborers receive two blue "slops," and red neckerchiefs.

Uniforms will be issued as follows: To the inspectors and guards, a top coat once a year, and a frock coat once a year. When a second of either garment is issued the first may be retained, but when a third is served out the first issued is to be given back; when the fourth is issued the second is to be given back, and thus two of each garment will remain in their possession. The trousers and hats or caps may remain in the possession of the men, except that, when they leave the service, two pairs of trousers must be given up, with all other clothing and appointments.

To the police, a great coat and cape every two years; on receipt of new ones, the old ones must be given up. The dress coats in use when the second coats are supplied are allowed to remain in the possession of the policemen until a third is issued.* Hats and trousers remain in possession of the men, except that, when they leave the service, they are required to give up two pairs of trousers, with all the other clothing and appointments.

Porters are subject to the police regulatious as to their jackets and waistcoats. When the second jackets and waistcoats are issued, the first are retained by the men; when the third are issued the first are given back, and so on. The trousers remain in possession of the men, except

* They are then required to give up No. 1, keeping Nos. 2 and 3; when No. 4 is issued No. 2 is to be given up, and so on, two dress coats remaining in possession of the men.

that, when leaving the service, they are required to give up two pairs of trousers and all the other appointments of clothing. The capes are issued once in two years, the caps and neckerchiefs yearly; on receipt of a second cap or cape the first is to be given up.

The general or standard regulations under which the absolute block system of Great Britain is worked on double track roads are explained as follows:

The signaling of trains on the block telegraph system is not intended in any way to dispense with the use of home, distant, starting, hand or fog signals, whenever and wherever such signals may be requisite to protect obstructions on the railway.

The object of the system of electric train signaling is to prevent more than one train or engine being between any two signal stations on the same line at the same time. This is accomplished by not allowing any train or engine to leave a signal station till the previous train or engine has been signaled as having arrived at or left the signal station next in advance.

Block signal instruments and bells are exclusively for the signaling of trains, and must not under any circumstances be used for conversing, nor for any other purpose than block working, in strict accordance with regulations, and they must only be used by the signalman, or other person specially appointed for the duty.

The signal boxes at which the block telegraph working is in operation are furnished with instruments to signal for each line of rails, and the system under which these instruments are to be worked, and the mode of indicating the description of approaching trains, is laid down in the code of regulations supplied to signalmen or exhibited in the signal boxes for the guidance of the persons in charge.

On those portions of the line worked on the absolute block system, a second train or engine cannot be allowed to enter a section until the preceding train or engine has been signaled as having passed out of the section, except under the circumstances specified in rules "A" and "B," further on, to meet cases of train or telegraph failure. The danger signal must be exhibited at both the home and distant signals* to protect trains or engines standing at stations or intermediate signal boxes, and when any train or engine has gone forward into the onward section, the starting and advanced starting signals (where such are provided) which control the entrance of trains and engines into such sections must also be put to and kept at "danger" until telegraphic information has been received from the signal box in advance that the preceding train or engine has passed out of the section. So long as the starting signals stand at "danger," the home and dis-

* The "home" signal or semaphore is located in the immediate vicinity of the station; the "distant" signal is located farther away.

tant signals must also be kept at "danger," except on the near approach of a train which has to stop at the station, when, after the speed of the train has been reduced so as to admit of its stoppage at the platform, the home signal may be taken off to admit the train, but the starting signal must be kept at "danger" until the line is clear to the next signal station ahead.

Unless special instructions are given to the contrary, the line must be considered clear, and the signal "line clear" be given immediately the last car (with rear lamp attached) has passed the home signal post, except during foggy weather or snow storms, when the signal "line clear" must not be sent to the station in the rear until the train or engine that has stopped at the station has passed the home signal and is proceeding on its journey, or has been shunted into a siding clear of the main line.

Should it become necessary to block a section, in consequence of a wreck obstructing the line, or other circumstances taking place rendering it imperative that any approaching train should be stopped, the signalman at the station where the obstruction takes place must use the means authorized by his regulations for preventing any train leaving the post in the rear. Should there be reason to suppose that both lines are obstructed, the signalman must, without any delay, block the lines in both directions.

No obstruction must be allowed outside the home signal until the signalman on duty has carried out the prescribed regulations to prevent any train leaving the signal station in the rear.

If a signalman observes anything unusual in a train during its passage, such as signals of alarm by a passenger, tail lamp missing or out, goods falling off, a car on fire, a hot axle box, or other mishap, he must give the station in advance the signal to "stop and examine train," and the signalman at the station in advance must acknowledge such signal and instantly put on the danger signals to stop the approaching train. Where practicable, the signalman must also telegraph the station in advance the cause of sending the "stop and examine train" signal.

Should the signalman receiving the signal have reason to suppose that there is any danger to a train traveling in the opposite direction, he must also stop that train, and inform the engineer of the circumstances, instructing him to proceed cautiously. Should a train pass a signal station without a tail lamp on the last vehicle, the signalman must not telegraph "line clear" to the station in the rear, but must call the attention of such station in the authorized manner, and on gaining attention, must give the "train passed without a tail lamp" signal. This signal having been acknowledged, the signalman at the rear station will, thereupon, stop any train following, and verbally instruct the engineer to proceed cautiously toward the station in advance, informing him why it is necessary that he should do so. As soon as the train, the engineer of which has been cautioned, has passed the signal station from whence the "train passed without a tail lamp" signal was received, the signalman there will recommence signaling in the ordinary manner.

Should any vehicle or portion of a train be running back in the wrong direction, the signalman must call the attention of the signalman at the next signal box toward which the vehicle or portion of the train may be running, by giving the prescribed signal indicating that vehicles are running back on wrong line.

The signalman who has received this signal must stop any train about to proceed on the same line, and take such protective measures as may be necessary, such as turning the runaway train across to the other line or into a siding, as may be most expedient under the circumstances.

If any car or portion of a train has escaped, and is running away in the proper direction on the right line, the station in advance must be advised of the fact by giving on the bell or gong the signal "vehicles running away on proper line." The signalman receiving this signal must, if necessary, send the signal forward, and take such other measures as he may consider most expedient under the circumstances.

When a train has become divided and is running on a falling gradient, the front portion must not, when the line is clear for it to proceed beyond the signals, be stopped so as to risk its being overtaken by the second portion, but when such train is running on a rising gradient, or where the line is level, the first portion must be stopped and shunted into a siding as expeditiously as circumstances will permit.

The following rules are known under the English system by the letters preceding them:

A. In the event of any failure of the instruments or bells, so that the necessary signals cannot be forwarded and received, no train must, under any circumstances, be allowed to pass a signal station into that section of the line where the failure exists, without having been previously brought to a stand, and the engine driver and guard advised of the circumstances. When this has been done, the engine driver must be instructed to proceed cautiously to the post in advance, so as to be able to stop short of any obstruction there may be on the line. No train must be allowed to follow another within five minutes; nor when a tunnel intervenes in a block section, within ten minutes, unless the signalman on duty can satisfy himself that the tunnel is clear.*

B. To prevent delays to wrecking trains when proceeding to clear the line, they must, in all cases, be signaled as "passenger trains," the signal "shunt for fast train" being given whenever the sections in advance are occupied by trains

* "The engine driver must protect his engine in accordance with the regulations, without reference to any telegraphic communications that may exist between stations or signal boxes, and he is not in any way relieved from this duty by the existence of block or other telegraphic working."—*English Standard.*

which the wrecking gang must pass to reach the scene of accident. The same course is to be adopted in the case of an engine proceeding to take the place of one that has failed, or of an engine with or without a train, when sent forward to render assistance in cases of failure or accident to preceding trains.

Should any obstructions occur necessitating the working of a single line, the person in charge, who gives the necessary instructions for so doing, must at the same time give written instructions for suspending the working of the line by block telegraph, except on inclines or through tunnels, where the block telegraph working may not be suspended on special instructions being given.

On the working of the double line being resumed the order suspending the working of the line by block telegraph is to be canceled by a written notice in the same manner, and at the same time, as the order for working the single line is canceled.

Where the block system is in operation, freight, live stock and ballast trains must be switched out of the way of passenger trains at stations or sidings where there are fixed signals in sufficient time to prevent the passenger train being delayed by the signals either at the station where the train is being switched, or at the block station in the rear.

Where the block system is in operation, and it is necessary to obstruct or occupy any portion of the line outside the home signal, the line must first be blocked back by telegraph to the signal box in rear before such obstruction is permitted, and during a fog or snowstorm, or where, in consequence of the station being approached upon a falling gradient, special instructions for working are issued, no obstructions must be allowed at the station inside the home signal, until the line is so blocked back to the signal box in rear.

The highly favorable conditions under which the railroads of England have grown up have been better calculated to secure abundant facilities and thorough systemization of train forces than has been possible in America. The English, with characteristic bluntness, state frankly in their printed declarations and instructions, as the reader will have noticed, what Americans might say verbally, but would not print. Old civilized communities, accustomed to distinctions and severe disciplinary measures, accept such procedure with equanimity. New communities will not, or do so with reluctance. The tendency in America, however, is all in the direction of more systematic work; of more accurately defining the status and duties of the myriad units that make up the extended and complicated service of railroads. This disposition is to be encouraged, as it is in the interests of both employer and employe. Its effect will be to increase the *esprit de corps* of the force and heighten its co-operative strength.

CHAPTER XXI.

DISPATCHING TRAINS BY TELEGRAPH—FORMS USED.*

In the the early days of railroads no particular form of dispatch or method of procedure was used in telegraphic train dispatching. Messages were written apart as seemed best and sent apart to the conductors whose movements they affected. It followed unavoidably, notwithstanding the care exercised and the alertness of dispatchers, that now and then some necessary order would be omitted, or the name of the meeting point of trains would not be the same in all the dispatches, or some other fatal discrepancy would creep in. This was known as the single order system. As trains multiplied, the risk increased. There was no escape from it. The method itself was fatal. Out of the emergency the double order system grew, namely, the practice of sending the same form of dispatch simultaneously to all those whose movements it concerned. By using carbon sheets as many copies of the dispatch could be made at one writing as circumstances required.

Under the double order system, the dispatcher sends the order simultaneously to all trains affected by it. Thus two or more operators at different points will be copying the same order

*In appendix C will be found the Single Track Train Rules contained in the Standard Code of the American Railway Association.

at the same time. As soon as the dispatch is received by them, it is repeated back to the dispatcher, who approves it if found correctly transcribed. This occurs before the trains the dispatch affects have arrived at the telegraph offices where the order is received.

Under this method every conductor has identically the same dispatch, and if he makes a mistake it must be in conjunction with his engineer, who is also furnished a copy, and who must cooperate with him. Thus the risk is minimized. As a precautionary measure, the order is also sent to the meeting point of the trains (in some cases) so that if through error or omission the information is not conveyed, or is misunderstood in the first instance, the fault will be remedied in time.

As this system of telegraphic dispatching was evolved by the needs of the service, forms necessary to carry it into effect were also invented. These I append below. They are similar to those adopted by the American Railway Association and are used very generally throughout the country. They are the result of much protracted study and discussion by railway superintendents and dispatchers, and are based on fifty years of practical experience. The object they aim at is the absolute safety of trains based on clearness and conciseness of statement.

A great merit of the system is its universality. If an operator or train man has become familiar with it on one road, he does not have to learn something new when he goes to another line. Thus, instead of being a passive agent, or perhaps an incompetent one, he becomes, through his experience and keenness in such matters, a check on what is going on.

The double order system has the merit of avoiding misunderstanding by conveying the information in the same carefully selected words to all concerned.

With this brief explanation I proceed to give the forms of the double order system without further comment.

Form A.

Order fixing meeting point for opposing trains.

This order (like most of those covered by the double order system) is addressed to the conductors and engineers of the trains it affects and signed by the dispatcher. It reads as follows:

"No. 5 and No. 6 will meet at Edwards."

Examples:

No. 7 and 2d No. 4 will meet at Evans.

No. 6 and Extra 63 will meet at Belva.

Extra 522 North and Extra 179 South will meet at Baker.

Trains receiving the above order will, with respect to each other, run to the point designated, and having arrived there, pass in the manner prescribed by the rules.

Form B.

Orders authorizing a train to pass or run ahead of another train running in the same direction.

The orders read as follows:

(1) "No. 5 will pass No. 7 at Evans."

(2) "No. 3 will run ahead of No. 1, Belva to Edwards."

Examples:

When one train is to pass another, both trains run to the point designated, according to the rules, where the rear train passes the other.

FORM C.

Orders giving an inferior train the right of track over an opposing train of superior grade.

(1) "No. 4 has right of track over No. 3, Galt to Hooper."

(2) "Extra 29 has right of track over No. 1, Byron to Snyder."*

These forms are used in giving a train of inferior right the right of track over one of superior right, to a designated point.

If the trains meet at the designated point (under order number one), the train of inferior right must take the siding, unless the rules or orders otherwise indicate.

Under order number one if the train of superior right reaches the designated point before the other arrives, it may proceed, provided it keeps clear of the schedule time of the train of inferior right as many minutes as the inferior train was before required by the train rules to keep clear of the superior train.

If the train of superior right, before meeting, reaches a point beyond that named in the order, the conductor must stop the other train where it is met and inform it of his arrival.

Under order number two the train of superior right cannot go beyond the designated point until the extra train arrives.

When the train of inferior right has reached the designated point, the order is fulfilled, and the train must then be governed by time table and train rules or further orders.

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* A few roads number their extra trains (or wild engines running over the road) the same as the number of the locomotive. Under above order Extra 29 is exactly the same class as regular train 29 under the schedule.

The following modification of this form of order will be applicable for giving a work train the right of track over all other trains, in case of a wreck or break in the track.

"Work train Extra 347 has right of track over all trains between Mecca and Natal from 7 P. M."

This gives the work train in question the exclusive right of the track between the points designated after the time stated.

Form D.

Order giving all regular trains the right of track over a given train.

"All regular trains have right of track over No. 1 between Clark and Bryant."

This order gives to every regular train the right of track over the train named in the order and the latter must keep off the schedule time of such trains, the same as if it were an extra.

Form E.

Time Orders.

Orders changing the schedule time of a train between the points mentioned.

(1) "No. 7 will run 20 minutes late, Salem to Hudson."

(2) "No. 3 will wait at Pittsford until 9 A. M. for No. 6."

Order number one makes the schedule time of the train named, between the points mentioned, as much later as the time stated in the order, and any other train receiving the notice is required to run in conformity therewith, the same as under other circumstances it would be required to run with respect to schedule time. The time in the order should be such as can be easily added (by the person receiving it) to the schedule time.

Under order number two the train of superior right (No. 3) must not pass the designated point before the time given, unless the other train has arrived. The train of inferior right is required to run with respect to the time specified, the same as under other circumstances it would be required to run with respect to the regular schedule time of a train of superior right.

Form F.

Orders regarding sections of regular trains.

"No. 7 will carry signals Buffalo to Rochester for Eng. 903."

Examples.

"Second No. 1 will carry signals Bombay to Bengal for Eng. 70."

This may be modified, as follows:

"Engines 20, 51 and 60 will run as 1st, 2d and 3d sections of No. 1, Bombay to Bengal."

For annulling a section:

"Eng. 21 is annulled as 2d section of No. 6 from Chester." Should there be more sections following, the order should read, "Eng. 21 is annulled as 2d section of No. 6 from Chester, and the sections that follow will change their numbers accordingly."

The character of a train for which signals are carried may also be stated. Each section affected by an order must have copies and must arrange signals accordingly.

Form G.

Order fixing a schedule for an extra train.

"Eng. 61 will run extra, leaving Colo on Saturday, January 14th, on the following schedule, and will have the right of track over all trains:

"Leave Colo 8:30 A. M.
"Leave Evans 10:40 A. M.

"Leave Edwards 2 : 20 P. M.
"Arrive Cecil 6 : 25 P. M."

This order may specify particular trains over which the extra in question shall or shall not have right of track. Any train over which the extra is given the right of track must keep off its time as many minutes as such train is required to clear the schedule time of a first class train.

FORM H.

Order for a train to run or work as an extra train.

"Eng. 37 will run extra, Baker to Genoa."

Example:

(a) "Eng. 37 will run extra, Baker to Genoa."

When the above order is given a train it is not required to guard against other extra trains, but must keep clear of all regular trains as required by rule.

A work train is an extra, for which the above form is used for a direct run in one direction.

Authority to occupy a specified portion of the track, as an extra while working, is given in the following form:

(b) "Eng. 172 will work as an extra, 7 A. M. until 6 P. M., between Cecil and Edwards."

The working limits should be as short as practicable, to be changed as the progress of the work may require. The above may be combined thus:

(c) "Eng. 172 will run extra, Cecil to Edwards, and work extra, 7 A. M. until 6 P. M., between Porter and Edwards"

When an order has been given to work between designated points, no other extra must be authorized to run over that part of the track without provision for passing the work train.

When it is anticipated that a work train may be where it cannot be reached for meeting or passing orders, it may be directed to report for orders at a given time and place, or an order may be given that it shall clear the track for (or protect itself after a certain hour against) a designated extra, by adding to example (b) the following words:

(d) "And will keep clear of (or protect itself against) Extra 149 south, between London and Berlin after 1:40 P. M."

In this case, Extra 149 must not pass the northernmost station before 1:40 P. M., at which time the work train must be out of the way or protecting itself (as the order may require) between those points.

When the movement of an extra train over the working limits cannot be anticipated by these or other orders to the work train, an order must be given to such extra, to protect itself against the work train, in the following form:

(e) "Extra 62 will protect itself against work train Extra 197 between Chester and Columbus."

The above may be added to the order to run extra.

A work train, when met or overtaken by an extra, must allow it to pass without unnecessary detention.

When the conditions are such that it may be considered desirable to require that work trains shall at all times protect themselves while on working limits, this may be done under the following arrangements, viz.: Add the following words to example (b).

(f) "Protecting itself against all trains."

A train receiving this order must, whether standing or moving, protect itself within the working limits (and in both directions on single track) against all trains, in the manner provided by rule.

When an extra receives orders to run over working limits, it must be advised that the work train is within those limits by adding to example (*a*) the words:

(g) "Engine 152 is working as extra between Chester and Cecil."

A train receiving this order must run expecting to find the work train protecting itself within the limits named.

Form J.

Orders to hold a train.

(1) "Hold No. 20 at Berlin."

(2) "Hold all trains east at Berlin."

The above will not be used for holding a train, while orders are given to other trains against it, which are not at the same time given to it in duplicate. The order must be respected by conductors and enginemen of trains directed to be held as if addressed to them personally. Conductors when informed of the order must sign for it, and their signatures must be sent, and "complete" obtained in response, as prescribed by the rules.

When a train has been so held it must not go until the order to hold is annulled, or an order is given in the following form:

"No. 20 may go."

This must be addressed to the person or persons to whom the order to hold was addressed, and must be delivered in the same manner.

[Note.—As any order for which "O K" has been given and acknowledged operates as a holding order for the train to which it is addressed, this form is only to be used in special cases, to hold trains until orders can be given, or for some other emergency. The reason for holding may be added.]

Form K.

Orders annulling a schedule train.

These orders take away all rights of the train annulled and authorize any train or person receiving them to use the track as if the train annulled were not on the time table.

The orders read as follows:

(1) "No. 1 of Jan. 14th is annulled."

(2) "No. 3, due to leave Colo, Saturday, Jan. 14th, is annulled," adding "from Edwards," or "between Edwards and Cecil," when appropriate.

If a train is annulled to a point named, its rights beyond that point remain unaffected.

The train dispatcher may direct any operator to omit repeating back an order annulling a train, until he has occasion to deliver it.

When a train has been annulled it must not be again restored under its original number by special order.

Form L.

Order annulling or superseding an order.

This order must be numbered, transmitted and signed for the same as other orders.

"Order No. 7 is annulled."

When the above order is given to annul an order which has not been delivered, it will be addressed to the operator, who will destroy all copies of the order annulled except his own, and write on that:

"Annulled by order number (giving the number)."

An order superseding another may be given, adding "this supersedes order No. 7," or say,

"No. 1 and No. 2 will meet at Sparta, instead of at Colo."

An order that has been annulled or superseded must not be again restored by special order under its original number.

In the address of an order annulling or supersediag another order, the train first named must be that to which rights were given by the order annulled or superseded, and when the order is not transmitted simultaneously to all concerned. It must be sent to the point at which that train is to receive it and the required response first given, before the order is sent for other trains.

Train order blank Number 19.

The form of blank used by operators for what are known as "19 orders" shall be that indicated on the succeeding page.

Standard train order blank known as Form 19.

Bind Here.

....

Perforated Line.

NEW YORK AND PHILADELPHIA RAILWAY COMPANY.

Telegraphic Train Order No.....

Superintendent's Office. March 27, 1898.

Form 19	For........Station........to........Conductors and Engineers........of........No. 13	Form 19

Four inches space.

(NOTE—The Rules and Regulations require that the Conductor and Engineman shall each be furnished with a copy of this order.)

Rec'd at 2:15 P. M.	Made Complete at 2:16 P. M.	Rec'd by *Jones*, Opr.

The dimensions of the blank space for writing the order shall be 4 inches, with no lines.

The mode of filling the blank is indicated by the small type therein.

The names of Divisions and Offices will be varied to suit each road using it.

The form shall be 6¾ x 6 inches below the perforated line.

The book in which the forms are bound shall be 6¾ inches by 7½ inches.

The book shall contain 300 leaves. It shall be stitched and bound at the top, and shall have a paper cover on the face and top. The back cover shall be made of stiff material.

The paper shall be opaque, green, sized, and of such thickness as to admit of making 7 good copies with a No. 4 Faber pencil.

The book is to be used with Carbon Paper 6¾ x 7 inches, and a stiff tin, of the same size, with rounded corners.

Train order blank known as Form 31.

The form of blank used by operators for these orders shall be that indicated on the succeeding page.

The dimensions of the blank space for writing the order shall be 4 inches with no lines.

The mode of filling the blank is indicated by the small type therein.

The names of divisions and offices will be varied to suit each road using it.

The form shall be 6¾ x 9¼ inches below the perforated line.

The book in which the forms are bound shall be 6¾ x 10½ inches.

The book shall contain 300 leaves. It shall be stitched and bound at the top and shall have a paper cover on the face and top. The back cover shall be made of stiff material.

The paper shall be opaque, green, sized, and of such thickness as to admit of making 7 good copies with a No. 4 Faber pencil.

The book is to be used with carbon paper 6¾ x 9 inches, and a stiff tin, of the same size, with rounded corners.

Standard train order blank known as Form 31.

[NOTE.—This form differs from No. 19, it will be observed, in this, that it provides a place for the Conductor and Engineer to sign an acknowledgment of receipt of order.]

Bind Here.

. . . .

Perforated Line.

NEW YORK AND PHILADELPHIA RAILWAY COMPANY.

Telegraphic Train Order No. ....

Superintendent's Office. March 27, 1898.

Form 31 | For....... (Station) .... to .... and (Conductors / Engineers) .... of .... No. 13 | Form 31

☞ Four inches space. ☜

[NOTE.—The Rules and Regulations require that the Conductor and Engineman shall each be furnished with a copy of this order.]

Time received 2.15 A. M. O. K. given at 2.15 A. M.

Conductor	Engineman	Train	Made	At	Received by
Jones	Brown	13	Complete	2.20	Dennison
	[This column is omitted where Engineman is not required to sign.]				

NEW YORK AND PHILADELPHIA RAILWAY.

CLEARANCE CARD.

Dover, **9:15 A. M.** **March 25,** 188 **8**

Conductor and Engineman No. **12.**

I have no orders for your train. Signal is out for **No. 16.**

John Jones.

Operator.

This does not interfere with or countermand any orders you may have received.

Conductor MUST SEE that the number of HIS TRAIN is entered in the above form correctly.

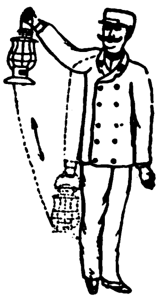
Conductor and Engineman must each have a copy.

CHAPTER XXII.

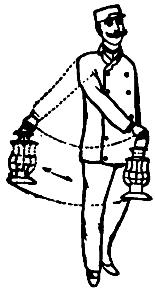
HAND AND LAMP SIGNALS.

The diagrams shown below illustrate the method of signaling trains in America with the hand and lamp.

An explanation accompanies each picture. If a volume were written on the subject, it could not make the matter any clearer.

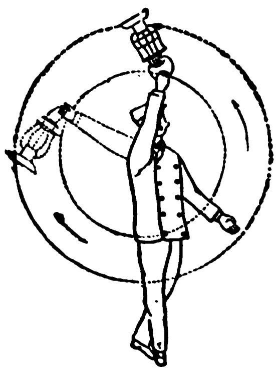


"Go Ahead.
(A motion up and down.)



"Stop."
(A motion crosswise with the track.)

"Back Up."
(A motion in a vertical circle.)



"Train Parted."
(A motion in a vertical circle at arm's length across the track, given continuously until answered by the engineman.)

CHAPTER XXIII.

HOW SIGNALS ARE DISPLAYED ON TRAINS AND LOCOMOTIVES UNDER THE AMERICAN STANDARD.

One of the most interesting, as well as necessary details of train service, is the nature and method of conveying information by the display of signals on locomotives and cars. Appended to this will be found cuts, or colored diagrams, illustrating the manner of using signals according to the American Railway Association's standard code of train rules. Nothing could be clearer. Explanation here can add nothing. Thus the first picture indicates the color of the flag that is used by day on the rear of trains and how it is attached.*

The next picture illustrates the kind of colored lamps that are used on the rear of running trains at night and how they are attached.

The third picture shows the colored lights that are displayed on the rear of trains at night when standing on a side track and so on.

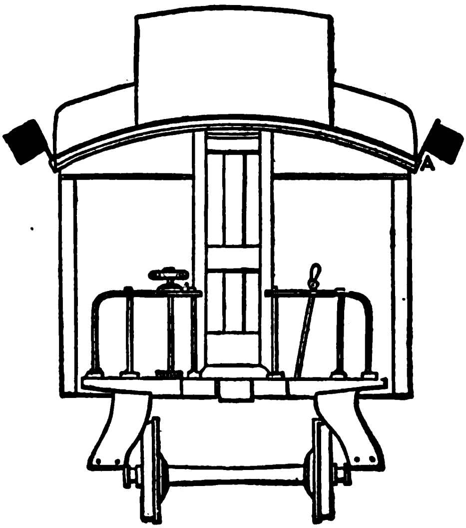
Reference to the pictures themselves will illustrate their extent and object. Naturally the great bulk of the signals are carried by the locomotive. They are made to indicate by their

* This flag is, according to the American Standard, 16x16 inches; the staff to which it is attached being 22½ inches long.

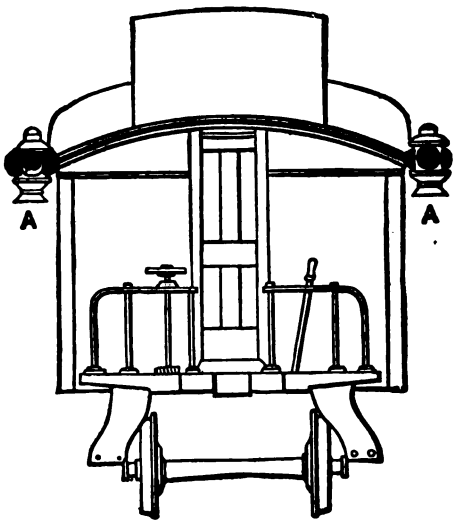
color or arrangement a great variety of things, such as the way the locomotive is going; whether pushing or pulling a train; whether backing up or going forward empty handed; whether a regular or an extra train; whether followed by another train or not, etc.

Practically there is no limit to the extent of the information that may be conveyed in this way. As a matter of fact, however, too great elaboration is not attempted for the reason that such signals are liable to be overlooked or misunderstood. They are therefore confined, as will be seen, to what are esteemed fundamental things. First, as indicating the presence of the train, and second, its direction, character, company, etc.

The headlight of the locomotive is also one of the most important signals that a train carries, though it is not generally thought of as such.

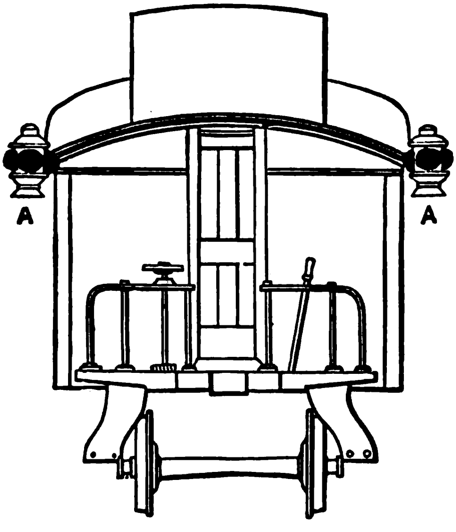


Rear of train by day.
Green flags at AA indicate rear of train.



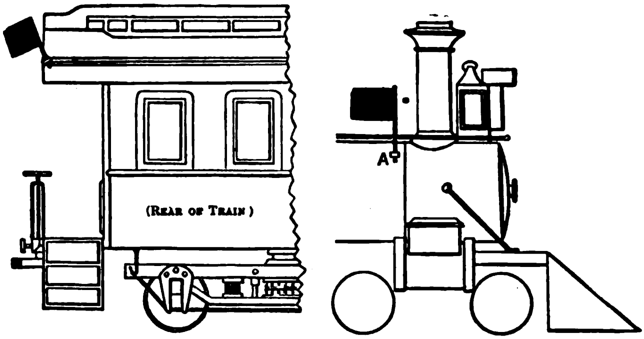
Rear of train by night while running.

Red lights at AA are a warning to any following train; green lights at sides and toward locomotive at AA indicate rear of train.



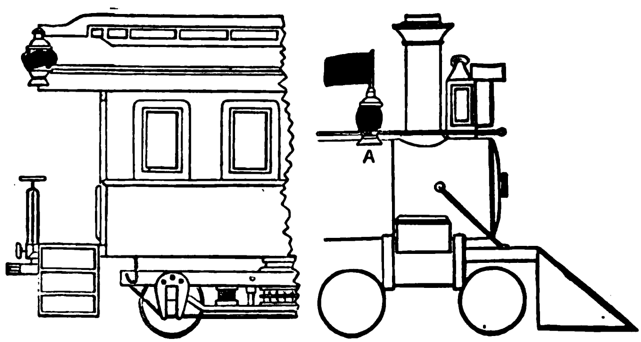
Rear of train on side track by night.

Green lights to rear at AA indicate safety to passing train; green lights at side and toward locomotive at AA indicate rear of train.



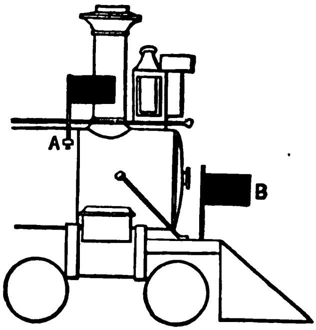
Train running forward by day.

Green flag at A indicates that a train is following.



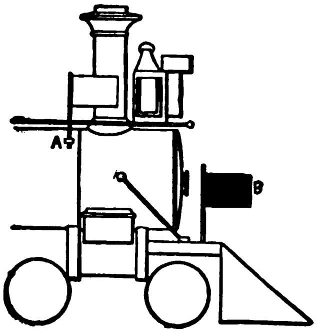
Train running forward by night.

Green light and green flag at A indicates that a train is following.



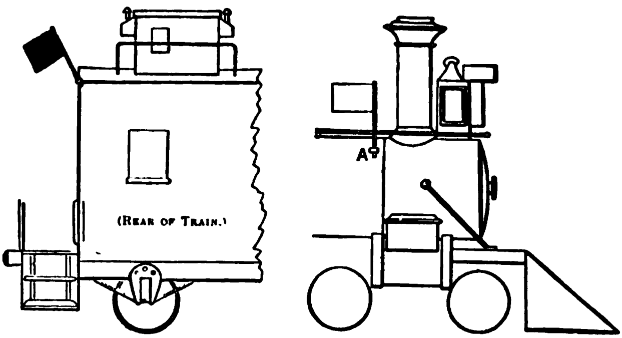
Locomotive running backward by day alone or pushing cars.

Green flag at A indicates that a train is following; green flag at B indicates rear of train.



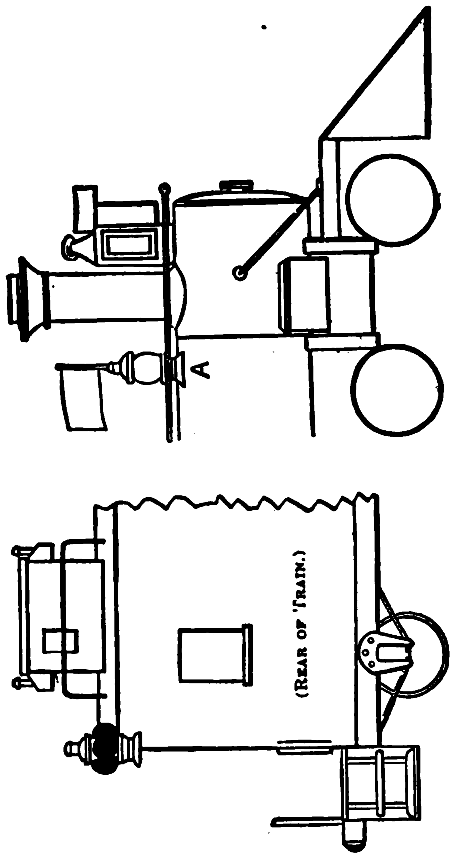
Locomotive running backward by day alone or pushing cars.

White flag at A indicates that it is an extra; green flag at B indicates rear of train.



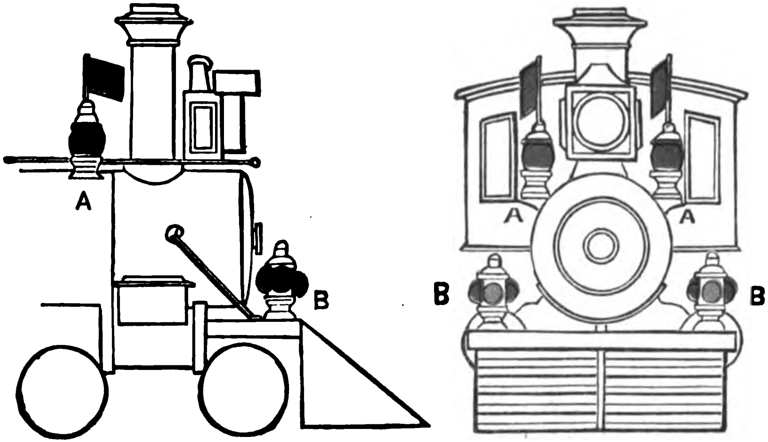
Train running forward by day.

White flag at A indicates that it is an extra.

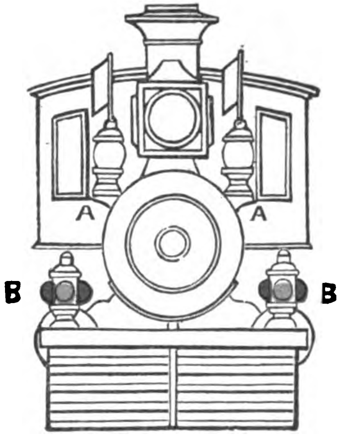


Train running forward by night.

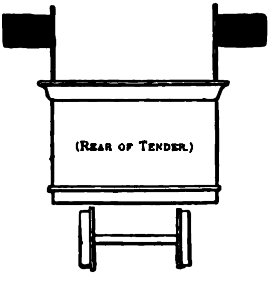
White light and white flag at A indicate that it is an extra.



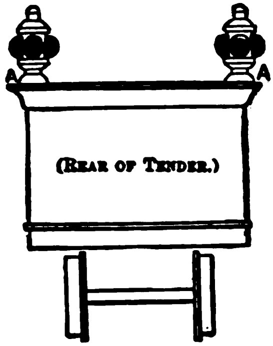
Locomotive running backward by night alone or pushing cars.
Green lights and flags at AA indicate that a train is following; red lights at BB are a warning to any following train; green lights at BB indicate rear of train.



Locomotive running backward by night alone or pushing cars.
White lights and flags at AA indicate that it is an extra; red lights at BB are a warning to any following train; green lights at BB indicate rear of train.

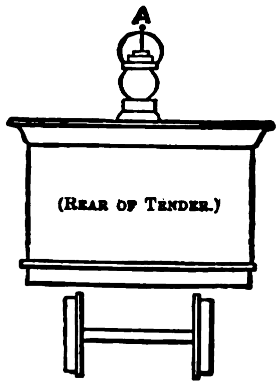


Locomotive running forward alone by day.
Green flags denote rear of train.



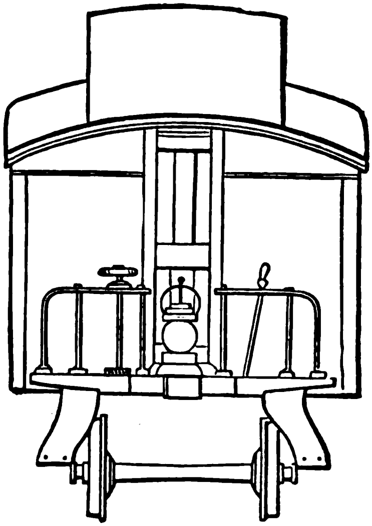
Locomotive running forward alone by night.

Red lights at AA are a warning to any following train; green lights at AA indicate rear of train.

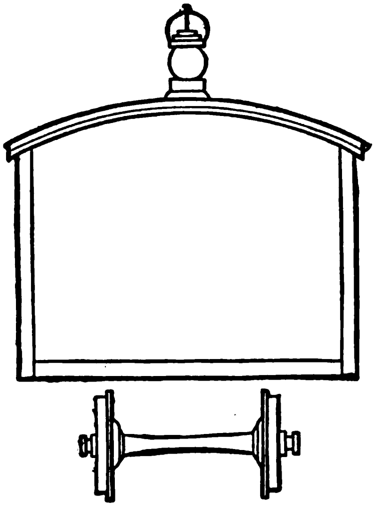


Locomotive running backward by night.

White light at A indicates front of train.



Passenger train pushed by a locomotive by night.
White light indicates front of train.



Freight train pushed by a locomotive by night.
White light indicates front of train.

CHAPTER XXIV.

TRACK SIGNALS.

An essential thing in connection with signals of this character is that they should be simple in their working and certain to operate as contemplated. They must also be plain in their import: unmistakable object lessons, so to speak, and clearly discernible at a distance from a rapidly moving train, under conditions in many cases not favorable to a perfectly clear view. They must be simple in their operation because worked by men not skilled in scientific ideas or appliances. They must be certain in their operation, for if not, they may hurry a train to destruction where it was intended to guard it against harm.

The signal forms in use by railroads are the outgrowth of practical experiments extending over the whole period of railroad operations, but it is not at all probable that ingenuity has been exhausted in this direction. Better devices will be evolved with continued experience and increased ability to pay for them.

While they seem to us to be all they should be, they are like a plant that appears perfect in its wide-spreading leaves, its beauty of color and form, and perfection of development, when suddenly a bud will be formed and out of it bloom forth a beautiful wide-spreading flower. This is the perfected fruit of a growth we have been watching and had thought to be perfect. And so it is with railway devices. They have their periods of growth and sudden expansion like the final development of the flower.

The track signals of railways are an unintelligible jumble of colors to the looker-on merely, but in their grouping and significance, convey to those interested information as well understood as speech, and much more quick of comprehension. To be sure, the language is a limited one, but the needs are limited. It is sufficient to meet the requirements of the situation.

There are many different patterns of signals used; many different forms found on the same railroad, especially if it is an extended one. They arrange themselves (or should) according to the needs of traffic and its Profitableness, but when like conditions of traffic exist on different roads there is in general no concerted belief that one system so overshadows all others as to warrant the expense of its immediate introduction and the annoyance that the removal of the old would involve. Consequently old forms continue in use more or less just as those now being perfected (and the most perfect of their kind), will continue to be used long after other and better patterns have been evolved. Ignorance and prejudice have more or less voice in matters of this kind, but practicability in the main governs just as it does in the economic affairs of families and other matters of every day life. In the first place, railways must have the means to put in new appliances, and supposing they have the means, the betterments must be such as to justify practical men in making a change.

Those who manage railways are like common sense house wives. Good judgment governs them in everything they do. Oftentimes they do not advance as rapidly as theorists think they should, but this is to their credit: an evidence of their conservatism and wisdom.

Not only are signals widely different as regards the conception men have of them, but they differ widely in the extent of their use where the same patterns or forms are employed. It depends on the business of a line and the wisdom and adaptability of those in charge. Some of the patterns I portray herewith are those of a road with a good business and paying a reasonable dividend on its stock, and having a small surplus left over. A company with a poor business could not afford such things. On many lines there is no signal apparatus whatever. The right of way and track reach out barren and bleak, without a single safety appliance to adorn them. The switches are indicated by a plain staff only, on which a lantern hangs. It may be that there is no lantern. There are certainly no home or distant signals, and yet passengers will be quite as safe on this line as on one elaborately equipped, for the reason that there will be but few trains, or the trains there are, be they more or less, will be operated under fixed arrangements that prevent collisions and other accidents. Again, if the business of a line is great and profitable, its whole extent will be dotted with watchmen, signal towers and implements designed to protect its trains and prevent their being impeded a moment unavoidably.

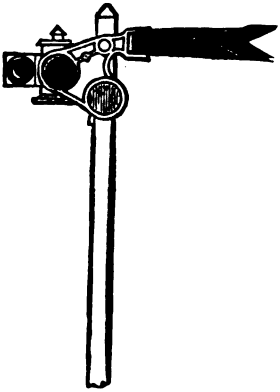
Generally speaking, the advanced ideas of those in charge of railroads, coupled with the needs of the situation, may be depended upon to enforce track signals in conformity with what is best. If the road has a medium business, medium progress will have been made; if it has a great and highly productive business, every known method will be in use to guard trains and accelerate their movements. Adjustments of this nature come about in a natural way; supply follows demand. There is no call for external pressure being brought to bear.

The colored diagrams that I append below illustrate forms of interlocking and block signaling. The colors are not such as the American Railway Association has recommended in their standard rules. They are, however, growing in popular acceptance and are more or less generally used. However, color, for purposes of illustration merely, is not material. If white instead of green is the sign of safety, then white may be substituted for the green I have used. The American Railway Association has recommended white as the signal of safety. It has always been the standard and its use for such purpose was at one time universal, but is so no longer, for reasons stated by me in the body of this volume. The question of track signals is referred to at length elsewhere herein, in connection with other matters germane thereto. I will not, therefore, pursue the subject further here.

Interlocking.

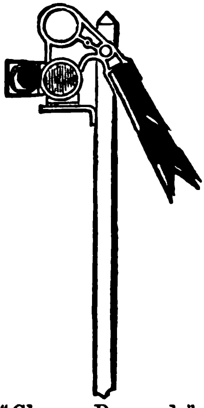
The colored diagrams given herewith illustrate semaphore forms of signals used in connection with interlocking. The standard regulations of the American Railway Association require that the distant and home signals shall be placed either over or upon the right of and adjoining the track they are intended to govern. The blades must be displayed to the right of the signal mast as seen from the approaching train. Signals of this nature may be displayed on the same support for one or two tracks, but not for three or more.

Distant signal.



"Caution. Run slow."

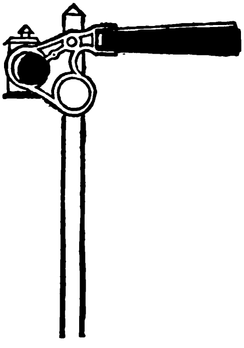
Distant signal.



"Clear. Proceed."

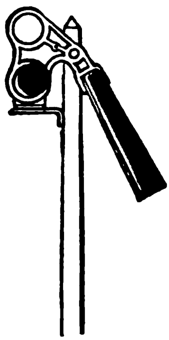
This signal is required to be placed fifteen hundred feet from danger point.

Home signal.



"Danger. Stop."

Home signal.



"Clear. Proceed."

This signal is placed three hundred feet from danger point.

Dwarf signal.

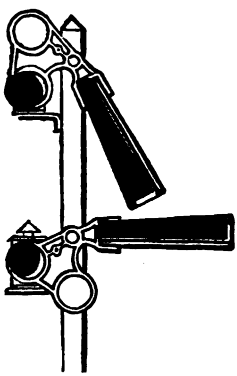
"Danger. Stop."

Dwarf signal.

"Clear. Proceed."

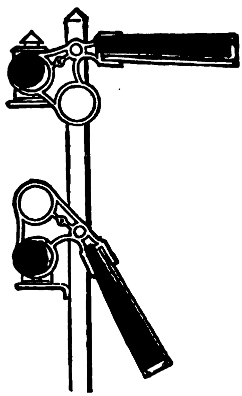
The above signal must not exceed five feet in height; and is usually not over two feet high. It is used at turn outs.

Two arm home signal.



"Main route clear. Proceed."

Two arm home signal.



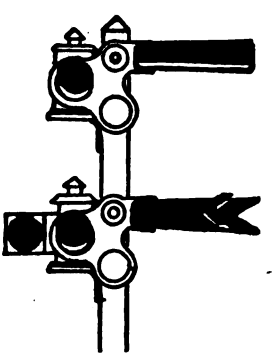
"Diverging route clear. Proceed."

This signal is used at junctions, each arm governing a particular route.

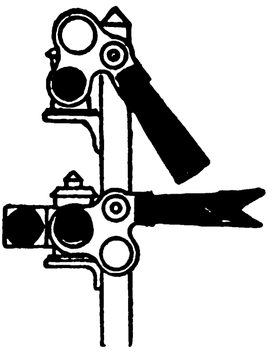
Automatic block signals; semaphore form.

The following colored diagrams portray signals used in connection with the Semaphore Automatic block signal. These signals are referred to in another part of this volume.

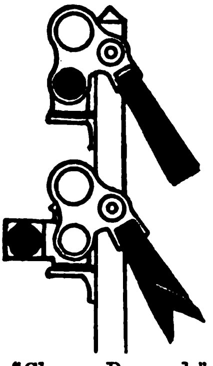
The signals are placed, according to the American Standard, either over or upon the right of and adjoining the track governed. The blades are displayed to the right of the signal mast, as seen from the approaching train. A mast may support signals for one or two tracks. The upper blade indicates the condition of the block immediately ahead; the lower blade serves as a distant or cautioning signal for the second block in advance.



"Danger. Stop."



"Caution. Run slow."

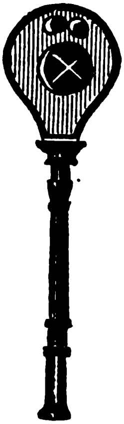


"Clear. Proceed."

Automatic block signals; disc form.

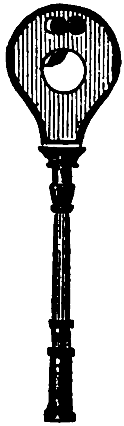
The following colored diagrams represent signals used in connection with the Disc Automatic Block signal. This form of signal is described elsewhere herein. The signal, according to the American Standard, is located on the right of and adjoining the track governed.

Distant block signal.



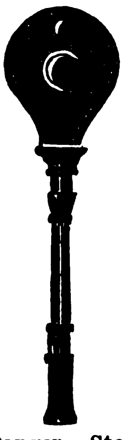
"Caution. Run slow."

Distant block signal.



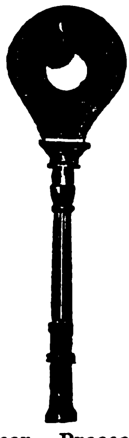
"Clear. Proceed."

Block signal.



"Danger. Stop."

Block signal.

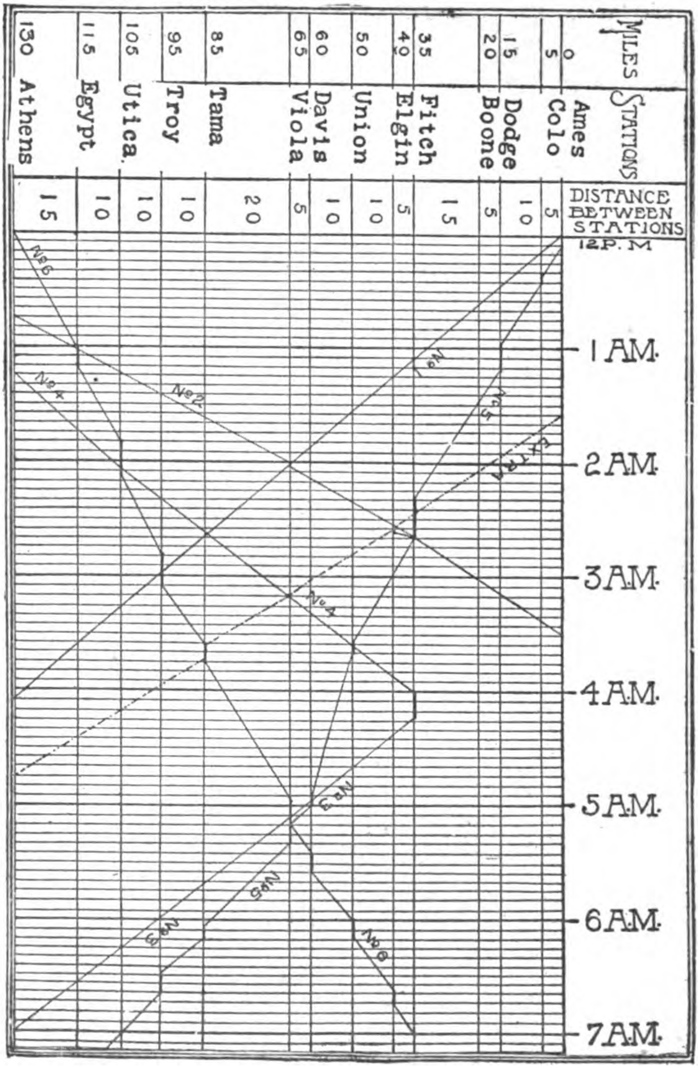


"Clear. Proceed."

APPENDIXES.

Appendix A.—Time Table Chart.

The sheet or diagram illustrated below is a chart used in making the schedule of trains, in determining their time, speed, meeting and passing points, and other particulars of the service. When a chart has been perfected the matter is copied off on to the time table and printed for the use of train men and others.



APPENDIX B.

TIME TABLE.

For the use and government of trainmen and other employes.

Station Numbers.	GOING WEST. FREIGHT. No. 5. Way Freight. Ex. Sun.	PASSENGER TRAINS. No. 1. Black Hills Passenger. Daily.	PASSENGER TRAINS. No. 3. Limited. Ex. Sun.	Distance from Fremont.	Night and Day Telegraph Station.	STATIONS.	Distance from Lincoln.	No. of Cars Sidings will hold.	GOING EAST. PASSENGER TRAINS. No. 2. Black Hills Passenger. Ex. Sun.	PASSENGER TRAINS. No. 4. Limited. Daily.	FREIGHT. No. 6. Way Freight. Ex. Sun.
	3.15 AM	4.26 PM Mt 4	9.20 AM Mt 2			Dp....... FREMONT.......Ar	52.1		8.58 AM Mt 3	3.25 PM Mt 1	6.25 PM
415	3.45 AM	4.41 PM	9.36 AM	7.0		Dp......Platte River.......Ar	45.1	37	8.42 AM	3.09 PM	5.50 PM
						2. 6					
500	4.10	4.46	9.41	9.6	D	.........Cedar Bluffs.........	42.5	43	8.36	3.04	5.35 ......
						6. 9					
502	4.35	4.58 Mt 6	9.55	16.5	N	............Colon............	35.6	34	8.23	2.51	4.58 Mt 1
						5. 9					
504	5.10	5.10	10.05	22.4	D	...........Wahoo...........	29.7	79	8.12	2.40	4.32 ......
						6. 0					
506	5.35	5.21	10.17	28.4	N	.........Swedeburg.........	23.7	36	8.01	2.29	4.05 ......
						5. 8					
508	6.00	5.32	10.27	34.2	D	...........Ceresco...........	17.9	36	7.50	2.18	3.48 ......
						5. 5					
510	6.25	5.42	10.38	39.7	D	............Davey............	12.4	34	7.40	2.08	3.26 ......
						6. 4					
512	6.44	5.55	10.49	46.1		...........Arbor...........	6.0	43	7.27	1.56	2.55 ......
						6. 0					
514	7.00 AM Mt 2	6.05 PM	11.00 AM	52.1	N	Ar.........Lincoln.........Dp	....	290	7.15 AM Mt 5	1.45 PM	2.30 PM

The rules and regulations governing the movement of trains are usually printed on the back of the time table when there is room If there is not, they are printed apart. In every case, the rules that particular time tables render necessary are printed in connection therewith.

APPENDIX C.

THE STANDARD CODE OF THE AMERICAN RAILWAY ASSOCIATION.

TRAIN RULES—SINGLE TRACK.

Adopted April 12, 1899.

(Form of order putting rules in effect.)

The rules herein set forth govern the railroads operated by the ....Company. They take effect.................. superseding all previous rules and instructions inconsistent therewith.

Special instructions may be issued by proper authority.

(Name)........................

(Title).........................

GENERAL NOTICE.

To enter or remain in the service is an assurance of willingness to obey the rules.

Obedience to the rules is essential to the safety of passengers and employes, and to the protection of property.

The service demands the faithful, intelligent and courteous discharge of duty.

To obtain promotion capacity must be shown for greater responsibility.

Employes, in accepting employment, assume its risks.

GENERAL RULES.

A. Employes whose duties are prescribed by these rules must provide themselves with a copy.

B. Employes must be conversant with and obey the rules and special instructions. If in doubt as to their meaning they must apply to proper authority for an explanation.

C. Employes must pass the required examinations.

D. Persons employed in any service on trains are subject to the rules and special instructions.

E. Employes must render every assistance in their power in carrying out the rules and special instructions.

F. Any violation of the rules or special instructions must be reported.

G. The use of intoxicants by employes while on duty is prohibited. Their habitual use, or the frequenting of places where they are sold, is sufficient cause for dismissal.

H. The use of tobacco by employes when on duty in or about passenger stations, or on passenger cars, is prohibited.

J. Employes on duty must wear the prescribed badge and uniform and be neat in appearance.

K. Persons authorized to transact business at stations or on trains must be orderly and avoid annoyance to passengers.

L. In case of danger to the Company's property employes must unite to protect it.

DEFINITIONS.

TRAIN.—An engine, or more than one engine coupled, with or without cars, displaying Markers.

REGULAR TRAIN.—A train represented on the Time-table. It may consist of Sections.

SECTION.—One of two or more trains running on the same schedule displaying signals or for which signals are displayed.

EXTRA TRAIN.—A train not represented on the Time-table. It may be designated as—

Extra—for any extra train, except work extra;
Work extra—for work train extra.

SUPERIOR TRAIN.—A train having precedence over other trains.

A train may be made superior to another train by RIGHT, CLASS or DIRECTION.

RIGHT is conferred by train order; CLASS and DIRECTION by Time-table.

RIGHT is superior to CLASS or DIRECTION. DIRECTION is superior as between trains of the same class.

TRAIN OF SUPERIOR RIGHT.—A train given precedence by train order.

TRAIN OF SUPERIOR CLASS.—A train given precedence by Time-table.

TRAIN OF SUPERIOR DIRECTION.—A train given precedence in the direction specified in the Time-table as between trains of the same class.

TIME-TABLE.—The authority for the movement of regular trains subject to the rules. It contains the classified schedules of trains with special instructions relating thereto.

SCHEDULE.—That part of a Time-table which prescribes the class, direction, number and movement of a regular train.

SINGLE TRACK.—A track upon which trains are operated in both directions by Time-table or by train orders.

SIDING.—An auxiliary track for meeting or passing trains.

YARD.—A system of tracks within defined limits provided for the making up of trains, storing of cars and other purposes, over which movements not authorized by Time-table, or by train order, may be made, subject to prescribed signals and regulations.

Yard Engine.—An engine assigned to yard service and working within yard limits.

Pilot.—A person assigned to a train when the engineman or conductor, or both, are not fully acquainted with the physical characteristics, or running rules of the road, or portion of the road, over which the train is to be moved.

TRAIN RULES FOR SINGLE TRACK.

Standard Time.

1. Standard Time obtained from ——————— observatory will be telegraphed to all points from designated offices at ———, —— m. daily.

2. Watches that have been examined and certified to by a designated inspector must be used by conductors and enginemen. The certificate in prescribed form must be renewed and filed with —— every ———.

(Form of Certificate.)

CERTIFICATE OF WATCH INSPECTOR.

This is to certify that on.............................18....
the watch of......................employed as..............
on the...*R*....
was examined by me. It is correct and reliable, and in my judgment will, with proper care, run within a variation of thirty seconds per week.

Name of Maker..
Brand ....
Number of Movement...............................
Open or hunting case..............................
Metal of case...
Stem or key winding.................................

Signed,

....

Inspector...

Address...

3. Watches of conductors and enginemen must be compared, before starting on each trip, with a clock designated as a Standard Clock. The time when watches are compared must be registered on a prescribed form.

Note to Rule 1.—In order to detect possible errors at junction points and to secure uniformity, the Committee recommends that the time be disseminated to all points at the same hour. The Committee considers it of great importance that the time be obtained from some observatory of recognized standing.

Note to Rule 3.—The conditions under which conductors and enginemen whose duties preclude access to a standard clock are required to obtain standard time, vary so much on different roads that the Committee recommends that each adopt such regulations to cover the case supplementary to this rule, as may best suit its own requirements.

Time Tables.

4 (A). Each Time-table, from the moment it takes effect, supersedes the preceding Time-table.

A train of the preceding Time-table thereupon loses both right and class, and can thereafter proceed only by train order.

No train of the new Time-table shall run on any division until it is due to start from its initial point, on that division, after the Time-table takes effect.

4 (B). Each Time-table, from the moment it takes effect, supersedes the preceding Time-table. A train of the preceding Time-table shall retain its train orders and take the schedule of the train of the same number on the new Time-table.

A train of the new Time-table which has not the same number on the preceding Time-table shall not run on any division until it is due to start from its initial point, on that division, after the Time-table takes effect.

5. Not more than two times are given for a train at any point; where one is given, it is, unless otherwise indicated, the leaving time; where two, they are the arriving and the leaving time.

Schedule meeting or passing points are indicated by figures in **full-faced type.**

Both the arriving and leaving time of a train are in full-faced type when both are meeting or passing times, or when one or more trains are to meet or pass it between those times.

Where there are one or more trains to meet or pass a train between two times, or more than one train to meet a train at any point, attention is called to it by ———.

6. The following signs when placed before the figures of the schedule indicate:

"s"—regular stop:

"f"—flag stop to receive or discharge passengers or freight:

"¶"—stop for meals:

"l"—leave:

"a"—arrive.

SIGNAL RULES.

7. Employes whose duties may require them to give signals must provide themselves with the proper appliances, keep them in good order and ready for immediate use.

8. Flags of the prescribed color must be used by day and lamps of the prescribed color by night.

9. Night signals are to be displayed from sunset to sunrise. When weather or other conditions obscure day signals, night signals must be used in addition.

Note to Rules 4 (A) and 4 (B).—The Committee has recommended two forms of Rule 4, leaving it discretionary with each road to adopt either, as best suits its own requirements.

Note to Rule 5.—The Committee recommends that each company adopt such method as it may prefer in filling the blank.

VISIBLE SIGNALS.

10. COLOR SIGNALS.

COLOR.	INDICATION.
(a) Red.	Stop.
(b) ———	Proceed, and for other uses prescribed by the Rules.
(c) ———	Proceed with caution, and for other uses prescribed by the Rules.
(d) Green and white.	Flag stop. See Rule 28.
(e) Blue.	See Rule 26.

11. A fusee on or near the track burning red must not be passed until burned out. When burning green it is a caution signal.

12. HAND, FLAG AND LAMP SIGNALS.

MANNER OF USING.	INDICATION.
(a) Swung across the track.	Stop.
(b) Raised and lowered vertically.	Proceed.
(c) Swung vertically in a circle across the track, when the train is standing.	Back.
(d) Swung vertically in a circle at arm's length across the track, when the train is running.	Train has parted.
(e) Swung horizontally in a circle, when the train is standing.	Apply air brakes.
(f) Held at arm's length above the head, when train is standing.	Release air brakes.

13. Any object waved violently by any one on or near the track is a signal to stop.

AUDIBLE SIGNALS.

14. ENGINE STEAM WHISTLE SIGNALS.

NOTE.— The signals prescribed are illustrated by "o" for short sounds; "——" for longer sounds. The sound of the whistle should be distinct, with intensity and duration proportionate to the distance signal is to be conveyed.

NOTE TO RULE 10.—The Committee has omitted giving the colors of signals (b) and (c) in Rule 10, leaving it discretionary with each road to use such colors as it may prefer.

Sound.	Indication.
(*a*) o	Stop. Apply brakes.
(*b*) —— ——	Release brakes.
(*c*) —— o o o	Flagman go back and protect rear of train.
(*d*) —— —— —— ——	Flagman return from west or south.
(*e*) —— —— —— —— ——	Flagman return from east or north.
(*f*) —— —— ——	When running, train parted; to be repeated until answered by the signal prescribed by Rule 12 (*d*) Answer to 12 (*d*).
(*g*) o o	Answer to any signal not otherwise provided for.
(*h*) o o o	When train is standing, back. Answer to 12 (*c*) and 16 (*c*).
(*j*) o o o o	Call for signals.
(*k*) —— o o	To call the attention of trains of the same or inferior class to signals displayed for a following section.
(*l*) —— —— o o	Approaching public crossings at grade.
(*m*) ————	Approaching stations, junctions and railroad crossings at grade.

A succession of short sounds of the whistle is an alarm for persons or cattle on the track, and calls the attention of trainmen to danger ahead.

15. The explosion of one torpedo is a signal to stop; the explosion of two not more than 200 feet apart is a signal to reduce speed, and look out for a stop signal.

16. AIR-WHISTLE OR BELL-CORD SIGNALS.

Sound.	Indication.
(*a*) Two.	When train is standing, start.
(*b*) Two.	When train is running, stop at once.
(*c*) Three.	When train is standing, back the train.
(*d*) Three.	When train is running, stop at next station.
(*e*) Four.	When train is standing, apply or release air brakes.
(*f*) Four.	When train is running, reduce speed.
(*g*) Five.	When train is standing, call in flagman.
(*h*) Five.	When train is running, increase speed.

TRAIN SIGNALS.

17. The head-light will be displayed to the front of every train by night, but must be concealed when a train turns out to meet another and has stopped clear of main track, or is standing to meet trains at the end of double track or at junction points.

18. Yard engines will display the head-light to the front and rear by night. When not provided with a head-light at the rear, two white lights must be displayed. Yard engines will not display markers.

19. The following signals will be displayed, one on each side of the rear of every train, as markers, to indicate the rear of the train: By day, a green flag. By night, a green light to the front and side and a red light to the rear, except when the train turns out to be passed by another and is clear of main track, when a green light must be displayed to the front, side and to rear.

20. All sections of a train, except the last, will display two green flags and, in addition, two green lights by night, in the places provided for that purpose on the front of the engine.

21. Extra trains will display two white flags and, in addition, two white lights by night, in the places provided for that purpose on the front of the engine.

22. When two or more engines are coupled to a train, the leading engine only shall display the signals as provided in Rules 20 and 21.

23. One flag or light displayed where in Rules 19, 20 and 21 two are prescribed will indicate the same as two; but the proper display of all train signals is required.

24. When cars are pushed by an engine (except when shifting or making up trains in yards) a white light must be displayed on the front of the leading car by night.

25. Each car on a passenger train must be connected with the engine by a communicating signal appliance.

26. A blue flag by day and a blue light by night, displayed at one or both ends of an engine, car or train, indicates that workmen are under or about it. When thus protected it must not be coupled to or moved. Workmen will display the blue signals and the same workmen are alone authorized to remove them. Other cars must not be placed on the same track so as to intercept the view of the blue signals, without first notifying the workmen.

USE OF SIGNALS.

27. A signal imperfectly displayed, or the absence of a signal at a place where a signal is usually shown, must be regarded as a stop signal, and the fact reported to the ———.

28. The combined green and white signal is to be used to stop a train only at the flag stations indicated on the schedule of that train. When it is necessary to stop a train at a point that is not a flag station for that train, a red signal must be used.

29. When a signal (except a fixed signal) is given to stop a train, it must be acknowledged as provided in Rule 14 (*g*).

30. The engine-bell must be rung when an engine is about to move.

31. The engine-bell must be rung on approaching every public road crossing at grade, and until it is passed; and the whistle must be sounded at all whistling-posts.

32. The unnecessary use of either the whistle or the bell is prohibited. They will be used only as prescribed by rule or law, or to prevent accident.

33. Watchmen stationed at public road and street crossings must use red signals only when necessary to stop trains.

Classification of Trains.

81. Trains of the first class are superior to those of the second; trains of the second class are superior to those of the third; and so on. Extra trains are inferior to regular trains of whatever class.

All trains in the direction specified in the Time-table are superior to trains of the same class in the opposite direction.

82. Regular trains twelve hours behind their schedule time lose both right and class, and can thereafter proceed only by train order.

Movement of Trains.

83. A train must not leave its initial station on any division, or a junction, or pass from double to single track, until it is ascertained whether all trains due, which are superior, or of the same class, have arrived or left.

84. A train leaving its initial station on each division, or leaving a junction, when a train of the same class in the same direction is overdue, will proceed on its schedule, and the overdue train will run as provided in Rule 91.

85. A train must not start until the proper signal is given.

86. An inferior train must keep out of the way of a superior train.

87. A train failing to clear the main track by the time required by rule, must be protected as provided in Rule 99.

88. At meeting points between trains of the same class the *inferior* train must clear the main track before the leaving time of the *superior* train, and must pull into siding when practicable. If necessary to back in, the train must first be protected, as per Rule 99, unless otherwise provided.

89. At meeting points between trains of different classes the inferior train must take the siding and clear the superior train at least five minutes, and must pull into the siding when practicable. If necessary to back in, the train must first be protected as per Rule 99, unless otherwise provided.

Note to Rules Nos. 88 and 89.—The Committee recommends, that where greater clearance is necessary, Rule No. 88 should require a clearance of FIVE minutes and Rule No. 89 of TEN minutes.

An inferior train must keep at least five minutes off the time of a superior train in the same direction.

90. Trains must stop at schedule meeting or passing points, if the train to be met or passed is of the same class, unless the switches are right and the track clear. Trains should stop clear of the switch used by the train to be met or passed in going on the siding.

When the expected train of the same class is not found at the schedule meeting or passing point, the superior train must approach all sidings prepared to stop, until the expected train is met or passed.

91. Trains in the same direction must keep at least five minutes apart, except in closing up at stations or at meeting and passing points.

92. A train must not arrive at a station in advance of its schedule arriving time.

A train must not leave a station in advance of its schedule leaving time.

93. A regular train which is delayed, and falls back on the time of another train of the same class, will proceed on its own schedule.

94. A train which overtakes a superior train or a train of the same class, so disabled that it cannot proceed will pass it, if practicable, and if necessary will assume the schedule and take the train orders of the disabled train, proceed to the next open telegraph office, and there report to the ————. The disabled train will assume the schedule and take the train orders of the last train with which it has exchanged, and proceed to and report from the next open telegraph office.

95. A train must not display signals for a following section, nor an extra train be run, without orders from the ————.

96. When signals displayed for a section are taken down at any point before that section arrives, the conductor will, if there be no other provision, arrange with the operator, or if there be no operator, with the switchtender, or in the absence of both, with a flagman left there for the purpose, to notify all opposing trains of the same or inferior class leaving such point that the section for which the signals were displayed has not arrived.

97. Work extras will be assigned working limits.

98. Trains must approach the end of double track, junctions, railroad crossings at grade, and drawbridges, prepared to stop, unless the switches and signals are right and the track is clear. Where required by law, trains must stop.

99. When a train stops or is delayed, under circumstances in which it may be overtaken by another train the flagman must go back immediately with stop signals a sufficient distance to

NOTE TO RULE 91.—The Committee recommends, that where greater clearance is necessary, Rule No. 91 should allow a clearance of TEN minutes or more.

insure full protection. When recalled he may return to his train, first placing two torpedoes on the rail when the conditions require it.

The front of a train must be protected in the same way, when necessary, by the ——————.

100. When the flagman goes back to protect the rear of his train, the —————— must, in the case of passenger trains, and the next brakeman in the case of other trains, take his place on the train.

101. If a train should part while in motion, trainmen must, if possible, prevent damage to the detached portions. The signals prescribed by Rules 12 (*d*) and 14 (*f*) must be given, and the front portion of the train kept in motion until the detached portion is stopped.

The front portion will then go back, to recover the detached portion, running with caution and following a flagman. The detached portion must not be moved or passed until the front portion comes back.

102. When cars are pushed by an engine (except when shifting and making up trains in yards) a flagman must take a conspicuous position on the front of the leading car and signal the engineman in case of need.

103. Messages or orders respecting the movement of trains or the condition of track or bridges must be in writing.

104. Switches must be left in proper position after having been used. Conductors are responsible for the position of the switches used by them and their trainmen, except where switch-tenders are stationed.

A switch must not be left open for a following train unless in charge of a trainman of such train.

105. Both conductors and enginemen are responsible for the safety of their trains and, under conditions not provided for by the rules, must take every precaution for their protection.

106. In all cases of doubt or uncertainty the safe course must be taken and no risks run.

RULES FOR MOVEMENT BY TRAIN ORDERS.

201. For movements not provided for by Time-table, train orders will be issued by authority and over the signature of the ——————. They must contain neither information nor instructions not essential to such movements.

They must be brief and clear; in the prescribed forms when applicable; and without erasure, alteration or interlineation.

202. Each train order must be given in the same words to all persons or trains addressed.

203. Train orders will be numbered consecutively each day, beginning with No. — at midnight.

204. Train orders must be addressed to those who are to execute them, naming the place at which each is to receive his copy. Those for a train must be addressed to the conductor and engineman, and also to any one who acts as its pilot. A copy for each person addressed must be supplied by the operator.

205. Each train order must be written in full in a book provided for the purpose at the office of the ————————; and with it recorded the names of those who have signed for the order; the time and the signals which show when and from what offices the order was repeated and the responses transmitted; and the train dispatcher's initials. These records must be made at once, and never from memory or memoranda.

206. Regular trains will be designated in train orders by their numbers, as "No. 10," or "2d No. 10," adding engine numbers if desired; extra trains by engine numbers, as "Extra 798," with the direction when necessary, as "East" or "West." Other numbers and time will be stated in figures only.

207. To transmit a train order, the signal "31" or the signal "19" must be given to each office addressed, the number of copies being stated, if more or less than three—thus, "31 copy 5," or "19 copy 2."

208. A train order to be sent to two or more offices must be transmitted simultaneously to as many of them as practicable. The several addresses must be in the order of superiority of trains, each office taking its proper address. When not sent simultaneously to all, the order must be sent first to the superior train.

209. Operators receiving train orders must write them in manifold during transmission and if they cannot at one writing make the requisite number of copies, must trace others from one of the copies first made.

210. When a "31" train order has been transmitted, operators must (unless otherwise directed) repeat it at once from the manifold copy in the succession in which the several offices have been addressed, and then write the time of repetition on the order. Each operator receiving the order should observe whether the others repeat correctly.

Those to whom the order is addressed, except enginemen, must then sign it, and the operator will send their signatures preceded by the number of the order to the ————————. The response "complete," and the time, with the initials of the ————, will then be given by the train dispatcher. Each operator receiving this response will then write on each copy the

---

NOTE TO RULE 207.—Where forms "31" and "19" are not both in use, the signal may be omitted.

NOTE TO RULE 210.—The blanks in the above rule may be filled for each road to suit its own requirements. On roads where the signature of the engineman is desired, the words "except enginemen," and the last sentence in the second paragraph may be omitted. If preferred, each person receiving an order may be required to read it aloud to the operator.

word "complete," the time, and his last name in full, and then deliver a copy to each person addressed, except enginemen. The copy for each engineman must be delivered to him personally by ———.

211. When a "19" train order has been transmitted, operators must (unless otherwise directed) repeat it at once from the manifold copy, in the succession in which the several offices have been addressed. Each operator receiving the order should observe whether the others repeat correctly. When the order has been repeated correctly by an operator, the response "complete," and the time, with the initials of the ———, will be given by the train dispatcher. The operator receiving this response will then write on each copy the word "complete," the time, and his last name in full, and personally deliver a copy to each person addressed without taking his signature.

212. A train order may, when so directed by the train dispatcher, be acknowledged without repeating, by the operator responding: "X; Number of Train Order to Train Number." with the operator's initials and office signal. The operator must then write on the order his initials and the time.

213. "Complete" must not be given to a train order for delivery to an inferior train until the order has been repeated or the "X" response sent by the operator who receives the order for the superior train.

214. When a train order has been repeated or "X" response sent, and before "complete" has been given, the order must be treated as a holding order for the train addressed, but must not be otherwise acted on until "complete" has been given.

If the line fails before an office has repeated an order or has sent the "X" response, the order at that office is of no effect and must be there treated as if it had not been sent.

215. The operator who receives and delivers a train order must preserve the lowest copy.

216. For train orders delivered by the train dispatcher the requirements as to the record and delivery are the same as at other points.

Such orders shall be first written in manifold so as to leave an impression in the record book, from which transmission shall be made.

217. A train order to be delivered to a train at a point not a telegraph station, or at one at which the telegraph office is closed, must be addressed to

"C. and E. ——— (at ———), care of ———,"

and forwarded and delivered by the conductor or other person in whose care it is addressed. When form 31 is used "complete" will be given upon the signature of the person by whom the order is to be delivered, who must be supplied with copies for the conductor and engineman addressed, and a copy upon which he shall take their signatures. This copy he must deliver to the first operator accessible, who must preserve it, and at once transmit the signatures of the conductor and engineman to the train dispatcher.

Orders so delivered must be acted on as if "complete" had been given in the usual way.

For orders which are sent, in the manner herein provided, to a train, the superiority of which is thereby restricted, "complete" must not be given to an inferior train until the signature of the conductor of the superior train has been sent to the ———.

218. When a train is named in a train order, all its sections are included unless particular sections are specified, and each section included must have copies addressed and delivered to it.

219. Unless otherwise directed, an operator must not repeat or give the "X" response to a train order for a train, the engine of which has passed his train-order signal, until he has ascertained that the conductor and engineman have been notified that he has orders for them.

220. Train orders once in effect continue so until fulfilled, superseded or annulled. Any part of an order specifying a particular movement may be either superseded or annulled.

Orders held by or issued for a regular train become void when such train loses both right and class as provided by Rules 4 and 82, or is annulled.

221 (A). A fixed signal must be used at each train-order office which shall indicate "stop" when there is an operator on duty, except when changed to "proceed" to allow a train to pass after getting train orders, or for which there are no orders. A train must not pass the signal while "stop" is indicated. The signal must be returned to "stop" as soon as a train has passed. It must be fastened at "proceed" only when no operator is on duty.

Operators must have the proper appliances for hand signaling ready for immediate use if the fixed signal should fail to work properly. If a signal is not displayed at a night office, trains which have not been notified must stop and ascertain the cause, and report the facts to the ——— from the next open telegraph office.

Where the semaphore is used, the arm indicates "stop" when horizontal and "proceed" when in an inclined position.

221 (B). A fixed signal must be used at each train-order office, which shall indicate "stop" when trains are to be stopped for train orders. When there are no orders the signal must indicate "proceed."

NOTE TO RULE 221 (A).—The conditions which affect trains at stations vary so much that it is recommended each road adopt such regulations supplementary to this rule as may best suit its own requirements.

NOTE TO RULES 221 (A) AND 221 (B).—The Committee has recommended two forms of Rule 221, leaving it discretionary to adopt one or both of these forms according to the circumstances of the traffic.

When an operator receives the signal "31," or "19," he must immediately display the "stop signal" and then reply "stop displayed"; and until the orders have been delivered or annulled the signal must not be restored to "proceed." While "stop" is indicated trains must not proceed without a clearance card (Form ——— (A)).

Operators must have the proper appliances for hand signaling ready for immediate use if the fixed signal should fail to work properly. If a signal is not displayed at a night office, trains which have not been notified must stop and ascertain the cause, and report the facts to the ——— from the next open telegraph office.

Where the semaphore is used, the arm indicates "stop" when horizontal and "proceed" when in an inclined position.

222. Operators will promptly record and report to the ——— the time of departure of all trains and the direction of extra trains. They will record the time of arrival of trains and report it when so directed.

223. The following signs and abbreviations may be used:

Initials for signature of the ———.
Such office and other signals as are arranged by the ———.
C & E—for Conductor and Engineman.
X—Train will be held until order is made "complete."
Com—for Complete.
O S—Train Report.
No—for Number.
Eng—for Engine.
Sec—for Section.
Psgr—for Passenger.
Frt—for Freight.
Mins—for Minutes.
Jct—for Junction.
Dispr—for Train Dispatcher.
Opr—for Operator.
31 or 19—to clear the line for Train Orders, and for Operators to ask for Train Orders.
S D—for "Stop Displayed."
The usual abbreviations for the names of the months and stations.

FORMS OF TRAIN ORDERS.

Form A. Fixing Meeting Points for Opposing Trains.

(1.) ——— will meet ——— at ———.
(2.) ——— will meet ——— at ——— at ——— (and so on).

General Note.—Blanks in the rules may be filled by each road to suit its own organization or requirements.

EXAMPLES.

(1) No 1 will meet No 2 at Bombay.
No 3 will meet 2d No 4 at Siam.
No 5 will meet Extra 95 at Hong Kong.
Extra 652 North will meet Extra 231 South at Yokohama.

(2) No 1 will meet No 2 at Bombay 2d No 4 at Siam and Extra 95 at Hong Kong.

Trains receiving these orders will run with respect to each other to the designated points and there meet in the manner provided by the Rules.

FORM B. DIRECTING A TRAIN TO PASS OR RUN AHEAD OF ANOTHER TRAIN.

(1.) ——— will pass ——— at ———.
(2.) ——— will pass ——— when overtaken.
(3.) ———will run ahead of ——— ——— to ———.
(4.) ——— will pass ——— at ——— and run ahead of ——— ——— to ———.

EXAMPLES.

(1.) No 1 will pass No 3 at Khartoum. ..
(2.) No 6 will pass No 4 when overtaken.
(3.) Extra 594 will run ahead of No 6 Bengal to Madras.
(4.) No 1 will pass No 3 at Khartoum and run ahead of No 7 Madras to Bengal.

When under (1) a train is to pass another both trains will run according to rule to the designated point and there arrange for the rear train to pass promptly.

Under (2), both trains will run according to rule until the second-named train is overtaken and then arrange for the rear train to pass promptly.

Under (3), the second-named train must not exceed the speed of the first-named train between the points designated.

FORM C. GIVING A TRAIN THE RIGHT OVER AN OPPOSING TRAIN.

——— has right over ——— ——— to ———.

EXAMPLES.

(1.) No 1 has right over No 2 Mecca to Mirbat.
(2.) Extra 37 has right over No 3 Natal to Ratlam.

This order gives the train first named the right over the other train between the points named.

If the trains meet at either of the designated points, the first-named train must take the siding, unless the order otherwise prescribes.

Under (1), if the second-named train reaches the point last named before the other arrives it may proceed, keeping clear of the opposing train as many minutes as such train was before required to clear it under the Rules.

If the second-named train, before meeting, reaches a point within or beyond the limits named in the order, the conductor must stop the other train where it is met and inform it of his arrival.

Under (2), the regular train must not go beyond the point last named until the extra train has arrived.

When the extra train has reached the point last named the order is fulfilled.

The following modification of this form of order will be applicable for giving a work extra the right over all trains in case of emergency.

(3.) Work Extra ——— has right over all trains between ——— and ——— from — m to — m.

EXAMPLE.

Work Extra 275 has right over all trains between Stockholm and Edinburg from 7 p m to 12 midnight.

This gives the work extra the exclusive right between the points designated between the times named.

Form D. Giving Regular Trains the Right Over a Given Train.

Regular trains have right over —— between —— and ——.

EXAMPLE.

Regular trains have right over No 1 between Moscow and Berlin.

This order gives to regular trains receiving it the right over the train named in the order, and the latter must clear the schedule times of all regular trains, as if it were an extra.

Form E. Time Orders.

(1.) ——— will run ——— late ——— to ———.

(2.) ——— will run ——— late ——— to ——— and ——— late ——— to ——— etc.

(3.) ——— will wait at ——— until ——— for ———.

EXAMPLES.

(1.) No 1 will run 20 min late Joppa to Mainz.

(2.) No 1 will run 20 min late Joppa to Mainz and 15 min late Mainz to Muscat etc.

(3.) No 1 will wait at Muscat until 10 a m for No 2.

(1) and (2) make the schedule time of the train named, between the points mentioned, as much later as stated in the order, and any other train receiving the order is required to run with respect to this later time, as before required to run with respect to the regular schedule time. The time in the order should be such as can be easily added to the schedule time.

Under (3) the train first named must not pass the designated point before the time given, unless the other train has arrived. The train last named is required to run with respect to the time specified, as before required to run with respect to the regular schedule time of the train first named.

Form F. For Sections.

——— will display signals ——— to ——— for ———.

EXAMPLES.

Eng 20 will display signals and run as 1st No 1 London to Paris.

No 1 will display signals London to Dover for Eng 85.

2nd No 1 will display signals London to Dover for Eng 90.

This form may be modified as follows:

Engs 70 85 and 90 will run as 1st 2d and 3d No 1.

Engs 70 85 and 90 will run as 1st 2d and 3d No 1 London to Dover.

Under these examples the engine last named will not display signals.

For annulling a section:

Eng 85 is annulled as 2d No 1 from Chatham.

If there are other sections following add:

Following sections will change numbers accordingly.

The character of a train for which signals are displayed may be stated. Each section affected by the order must have copies, and must arrange signals accordingly.

Form G. Extra Trains.

(1.) Eng ——— will run extra ——— to ———.

(2.) Eng ——— will run extra ——— to ——— and return to ———.

EXAMPLE.

(1.) Eng 99 will run extra Berber to Gaza.

(2.) Eng 99 will run extra Berber to Gaza and return to Cabul.

A train receiving this order is not required to protect itself against opposing extras, unless directed by order to do so, but must keep clear of all regular trains, as required by rule.

(3.) Eng ——— will run extra leaving ——— on ——— as follows with right over all trains.

Leave ———.

" ———.

Arrive ———.

EXAMPLE.

(3.) Eng 77 will run extra leaving Turin on Thursday Feb 17th as follows with right over all trains.

Leave Turin 11 30 p m
" Pekin 12 25 a m
" Canton 1 47 a m
Arrive Rome 2 22 a m

This order may be varied by specifying the kind of extra and the particular trains over which the extra shall or shall not have the right. Trains over which the extra is thus given the right must clear the time of the extra —— minutes.

Form H. Work Extra.

(1.) Work extra ——— will work ——— until ——— between ——— and ———.

EXAMPLES.

(1.) Work extra 292 will work 7 a m until 6 p m between Berne and Turin.

The working limits should be as short as practicable, to be changed as the progress of the work may require. The above may be combined, thus:

(a.) Work extra 292 will run Berne to Turin and work 7 a m until 6 p m between Turin and Rome.

When an order has been given to "work" between designated points, no other extra shall be authorized to run over that part of the track without provision for passing the work extra.

When it is anticipated that a work extra may be where it cannot be reached for orders, it may be directed to report for orders at a given time and place, or an order may be given that it shall clear the track for (or protect itself after a certain hour against) a designated extra by adding to (1) the following words:

(b.) And will keep clear of (or protect against) Extra 223 south between Antwerp and Brussels after 2 10 p m.

In this case, extra 223 must not pass the northern-most station before 2 10 p. m., at which time the work extra must be out of the way, or protected (as the order may require) between those points.

When the movement of an extra over the working limits cannot be anticipated by these or other orders to the work extra, an order must be given to such extra, to protect itself against the work extra, in the following form:

(c.) Extra 76 will protect against work extra 95 between Lyons and Paris.

This may be added to the order to run extra.

A work extra when met or overtaken by an extra must allow it to pass.

When it is desirable that a work extra shall at all times protect itself while on working limits, it may be done by adding to (1) the following words:

(d.) protecting itself.

A train receiving this order must, whether standing or moving, protect itself within the working limits in both directions in the manner provided in Rule 99.

Whenever an extra is given orders to run over working limits it must at the same time be given a copy of the order sent to the work extra.

To enable a work extra to work upon the time of a regular train, the following form may be used:

(e.) Work Extra 292 will protect against No 55 between Berne and Turin.

A train receiving this order will work upon the time of the train mentioned in the order, and protect itself against it as provided in Rule 99.

The regular train receiving this order must run, expecting to find the work extra protecting itself within the limits named.

FORM J. HOLDING ORDER.

Hold ——— at ———.

EXAMPLES.

(1.) Hold No 2 at Berlin.

(2.) Hold all eastbound trains at Berlin.

This order will be addressed to the operator and acknowledged in the usual manner. It must be respected by conductors and enginemen of trains thereby directed to be held as if addressed to them.

When a train has been so held it must not proceed until the order to hold is annulled, or an order given to the operator in the form:

"——— *may go.*"

Form J will only be used when necessary to hold trains until orders can be given, or in case of emergency.

FORM K. ANNULLING A REGULAR TRAIN.

(1.) ——— of ——— is annulled ——— to ———.

(2.) ——— due to leave ——— ——— is annulled ——— to ———.

EXAMPLES.

(1.) No 1 of Feb 29th is annulled Alaska to Halifax.

(2) No 3 due to leave Naples Saturday Feb 29th is annulled Alaska to Halifax.

The train annulled loses both right and class between the points named and must not be restored under its original number between those points.

FORM L. ANNULLING AN ORDER.

"Order No ——— is annulled."

If an order which is to be annulled has not been delivered to a train, the annulling order will be addressed to the operator, who will destroy all copies of the order annulled but his own, and write on that:

Annulled by Order No ———.

EXAMPLE.

Order No 10 is annulled.

An order that has been annulled must not be reissued under its original number.

In the address of an order annulling another order, the train first named must be that to which right was given by the order annulled, and when the order is not transmitted simultaneously to all concerned, it must be first sent to the point at which that train is to receive it and the required response made, before the order is sent for other trains.

Form M. Annulling Part of an Order.

That part of Order No ——— reading ——— is annulled.

EXAMPLE.

That part of Order No 10 reading No 1 will meet No 2 at Sparata is annulled.

In the address of an order annulling a part of an order, the train first named must be that to which right was given by the part annulled, and when the order is not transmitted simultaneously to all concerned, it must be first sent to the point at which that train is to receive it, and the required response made, before the order is sent for other trains.

Form P. Superseding an Order or a Part of an Order.

This order will be given by adding to prescribed forms, the words "instead of ———."

(1.) ——— will meet ——— at ——— instead of ———.

(2.) ——— has right over ——— ——— to ——— instead of ———.

(3.) ——— will display signals for ——— ——— to ——— instead of ———.

EXAMPLES.

(1.) No 1 will meet No 2 at Hong Kong instead of Bombay.

(2.) No 1 has right over No 2 Mecca to Medina instead of Mirbat.

(3.) No 1 will display signals for Eng 85 Astrakhan to Tehcran instead of Cabul.

An order that has been superseded must not be reissued under its original number.

In the address of a superseding order, the train first named must be that to which right was given by the order superseded, and when the order is not transmitted simultaneously to all concerned, it must be first sent to the point at which that train is to receive it, and the required response made, before the order is sent for other trains.

(To be printed on yellow paper.)

FORM——(A).

........................(NAME)........................ COMPANY.

... CLEARANCE CARD ...

.......Dover.......9:15 A. M.......March 25.......18 99

Conductor and Engineman ....No. 12....

I have no ....(further).... orders for your train.

Signal is out for ....Extra 452....

This does not interfere with or countermand any orders you may have received.

....John Jones....

Operator.

Conductor and Engineman must both have a copy, and see that their train is correctly designated in the above form.

SPECIFICATIONS FOR TRAIN ORDER FORM AND BOOKS FOR OPERATORS FOR 31 ORDERS.

Form as here shown. Blank space for order (4) inches with no lines. The mode of filling the blanks is indicated by small type.

Form (6¾ x 9¼) inches beyond perforated line. Book (6¾ x 10½ inches.

300 leaves. Stitched. Bound at side. Paper cover on face and top. Very stiff back on lower side.

Paper opaque, ——, sized, and of such thickness as to admit of making (7) good copies with No. 4 Faber pencil.

To be used with Carbon Paper (6¾ x 9) inches, and a stiff tin, same size, corners rounded.

Standard Train Order Blank for 31 Order.

FORM 31 | FORM 31

.................................(NAME.)................................COMPANY.

TRAIN ORDER No......10.......

March 27 18 99

To.................................... | At..................................... Station.

X..........(Initials)..........Opr.; ....1 45 A M

Conductor and Engineman must both have a copy of this order.

Repeated at 2 20 A M.

Conductor	Engineman	Train	Made	Time	Opr.
Jones	Brown	45	Complete	2 20am	Black
	(Omit				
	this column				
	where				
	Engineman				
	is not				
	required				
	to sign.)				

SPECIFICATIONS FOR TRAIN ORDER FORM AND BOOKS FOR OPERATORS FOR 19 ORDERS.

Form as here shown. Blank space for order (4) inches with no lines. The mode of filling the blanks is indicated by small type.

Form (6¾ x 6) inches beyond perforated line. Book (6¾ x 7½) inches.

300 leaves. Stitched. Bound at side. Paper cover on face and top. Very stiff back on lower side.

Paper opaque, green, sized, and of such thickness as to admit of making (7) good copies with No. 4 Faber pencil.

To be used with Carbon Paper (6¾ x 7) inches, and a stiff tin, same size, corners rounded.

Standard Train Order Blank for 19 Order.

FORM 19		FORM 19

[NAME] COMPANY.

TRAIN ORDER No. 10

March 27 18 99

To | At Station.

X (INITIALS.) Opr.; 1 45 A M

Conductor and Engineman must both have a copy of this order.

Made complete time 2 16 P M Black Opr.

INDEX.

This volume is carefully Indexed, but for the convenience of the reader and to render the book easier to handle, the Index is included (with a full Index of the whole work) in volume Twelve under the title "GENERAL INDEX." This "GENERAL INDEX" is also, in a measure, an Encyclopedia of Railway Knowledge.

In all previous editions of the work each volume contained an Index, but as this was already embraced in the Twelfth Volume, it has been determined to change it in this edition (as indicated above) thus reducing the bulk of each volume, and making it more convenient for the reader to handle.

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1. In one payment.
2. By remitting draft or postoffice order to the publishers (or such person or persons as they may direct), for the amount of the installments.
3. In the case of those in the service of corporations, orders on the proper officer thereof will be accepted when the publishers are able to arrange with the company to collect the same.

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