THE SCIENCE OF RAILWAYS

OPERATION OF TRAINS

MARSHALL M. KIRKMAN

Frontispiece.

OPERATION OF TRAINS.

CONDITIONS, PRINCIPLES, METHODS AND PECULIARITIES OF THE TRAIN SERVICE OF RAILWAYS—ORGANIZATION OF THE FORCE—UTILITY OF THE SERVICE AND EFFECTIVE HANDLING OF THE EQUIPMENT—THE ECONOMICAL USE OF SUPPLIES — DETAILED RULES AND REGULATIONS GOVERNING THE MOVEMENT OF TRAINS ON AMERICAN ROADS—PRACTICES OF OTHER COUNTRIES.

WITH ILLUSTRATIONS

OF THE
INCEPTION, GROWTH AND EVOLUTION OF

PRIMITIVE TRANSPORTATION.

BY
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IN TWELVE VOLUMES — VOL. III.

CHICAGO:
THE WORLD RAILWAY PUBLISHING COMPANY.
1894.

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LIST OF ILLUSTRATIONS.

ACKNOWLEDGMENT.

I wish to express here the great obligations I am under to many people for information and aid in compiling this and the accompanying volumes. While my opportunities for acquiring knowledge of railways have been exceptionally great during nearly forty years of active service as an employe and executive officer of one of the great railroads of the world, the affairs of a railway are so extended and complex that no man can ever hope alone to master all their details. It is only by long and favorable service, coupled with contact with men of every grade in every branch of the business, that general knowledge can be obtained. Not much, unfortunately, is to be gathered from the literature on the subject, as very little has been written, because the subject is so new; however, so far as it goes, I have availed myself of it to the utmost.

For the illustrations of primitive carriage contained in this and the accompanying volumes, I am indebted to friends in every quarter of the world. I am under marked obligations for kindnesses at the hands of Mr. Frederick H. Hild, Librarian, Chicago Public Library, also to Dr. Wil-

liam F. Poole, Librarian, Newberry Library, Chicago. Many of the illustrations I have found in old books of travel. My object has also been greatly facilitated by information gathered from the periodicals of London, Dresden, Berlin, Vienna and Paris. Many of the illustrations of primitive forms of carriage are from drawings of my own. The others it has been necessary to resketch or readapt, in the majority of cases, in order to make them conform to my purposes. Thirty years have been occupied in making the collection, but I must still apologize for its not being more perfect, more artistic, more varied.

CHAPTER I.

ORIGIN AND DIVERSITY OF TRANSPORTATION — CARRIAGE AMONG THE ANCIENTS.

The creation of roads, like most useful things, was not premeditated. Successive footsteps formed the first path. While these were accidental, they followed the most convenient route, adapting themselves naturally to the peculiarities of the ground with a view to the saving of time and labor. They were directed toward the hunting or grazing grounds of the clan or the rude huts of neighboring villages. These paths became in after time the highways of civilized peoples.

The discovery and perfection of ancient forms of carriage are lost in the darkness of the prehistoric age. We can only imagine them. Their origin was probably quite as accidental as that of the rude paths of the savage. When man threw the first burden off his own shoulders on to those of the ox or cow, the secret of carriage was evolved. The transfer was final. Countless ages, however, must have preceded this. Afterward rude vehicles were invented. The devices of different people were never exactly the same. Rude poles tied to a horse or ox on either side and trailing on the ground in the rear was one form of carriage. Another was a flat log drawn on the ground; this it was, perhaps, that suggested the sled; then to facilitate its progress, rollers were placed underneath. They, it may be, suggested the wheel. At first the wheel and axle were made of one piece of wood and revolved together; then wheels of solid wood were made, apart, and fastened to the axle with a linch pin; then followed the spoke, felloe, tire, and so on.*

Ancient Egyptian Carrier.

It is probable that transportation among the ancients was not noticeably different from primitive carriage among the savages and semi-barbarians of the present time. The multitude of illustrations that this and the accompaning volumes contain, of primitive forms of transportation, (some ancient, some modern), picture the progressive steps from the human beast of burden to the steam locomotive of the present day. They not only depict the successive stages of evolution, but the multudinous devices invented by widely separated people in their efforts to perfect their methods of transportation. In every country there are in use primitive methods and quaint devices that represent the carriage of the past. It is from these

* This phase of the evolution of carriage among the ancients I have elaborated more fully in a chapter devoted to "Primitive and Prehistoric Carriers," in another volume.

illustrations and the practices of primitive peoples of the present day that my selections are largely made.

The evolution of primitive carriage among the ancients occupied vast cycles of time. Savages and semi-barbarians do not reason by analogy and deduction as we do. They lack suggestion, method, appliances and inclination. Their thoughts and devices are those of children.

At the dawn of history many successive steps had been traversed by the ancients. The cart had been invented and was used both for purposes of peace and war. Among nomadic peoples it was also a house; this composite structure, drawn by oxen, was composed of wood and covered with bark, grasses, or undressed skins. It could be lifted on or off the vehicle, and varied in size according to the needs of the owner. Illustrations of these rude structures will be found elsewhere.

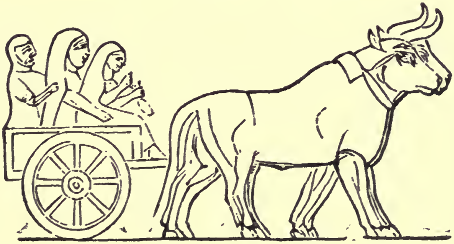
The cart was adapted by the ancients to many uses which we do not recognize. The Assyrians and other warlike people of remote antiquity attached scythes or knives to the wheels, axle and box of their war chariots. In Rome the cart was used as an instrument of punishment, the practice of crushing men on the wheel being a favorite means of torture and execution.

The ancients believed that vehicles were also used by the gods. Jupiter, Minerva and the great deities of the Romans were supposed to be transported in chariots drawn by horses; Neptune's car of shell was drawn by beings half fish, half horse. Similar superstitions existed among the Greeks. The Hindoos assigned different methods of transportation to different gods, Brahma employed a swan, other deities an eagle, bull, rat, peacock, elephant, fish, parrot, ram, lion, tiger, or horse, as the case might be. The most ancient superstition of this kind, perhaps, is that of Ea, the Chaldean's Spirit of Earth and Water, who, it was believed, protected the world by going round and round it in a great ship.

The Egyptians used a four wheeled vehicle for the carriage of one of their deities, but seem not to have used such a vehicle for any other purpose.

Primordial man did not go away from home and knew nothing about commerce. Prior to our era, trade was feeble and travel infrequent. A few favored nations carried on a predatory commerce—so beset was it with dangers—by land and sea. But their efforts were spasmodical and restricted. The world was peopled by savages. Outside a restricted ray of light all was darkness. The innumerable hordes that inhabited this unknown region never ventured beyond their own confines except in organized bands for purposes of rapine and murder. But the principle of carriage, including its fundamental methods, had been evolved. Man has occupied himself since that time in perfecting it. He has built on old models. Thus, while vessels have been greatly improved since the fall of

Carthage (140 B. C., the close of the old era), original outlines are still preserved. This is also true of land carriage. With better roads, the rude carts and chariots of the ancients have been perfected. But every important appliance is of primitive origin. The introduction of railroads, steamboats and the telegraph changed our methods in important particulars. New forces were called into being; new motors, new appliances. These so accelerate, cheapen and generalize that the ideas we have today of inter-com-



Carriage in Palestine.

munication, distant travel, diffused knowledge and vast research, render us incapable of realizing the lethargy and isolation of the ancients; we can not comprehend their state nor imagine the details of their lives.

The Common Carrier is as old as the disposition of man to travel or look abroad for a market. Wherever, in any age, industry characterized a people, and protection was accorded, there, under one guise or another, he plied his vocation. In the first instance his field did not extend beyond the carriage of an occasional traveler between neighboring and friendly villages or across some great river or branch of the sea. Men lived apart; property was precarious. With the lapse of time the art of constructing vessels was evolved, and as man progressed in methods and needs we catch glimpses of him here and there in his diminutive ships plying back and forth along the Persian Gulf or in and out among the islands of the Mediterranean.*

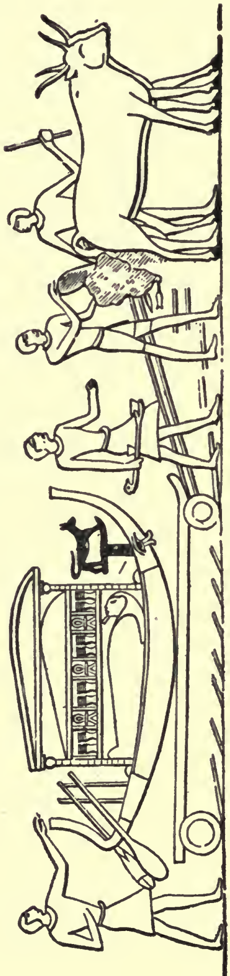
Of the facilities of the ancients for transporting travelers historians tell us very little. Even Herodotus, that most voluble, curious and amiable of gossips, is silent. He describes his journeys, the people he visited and heard about, but says nothing as to how he traveled from place to place. And this notwithstanding his voyages necessitated the most varied transportation; that peculiar to sea and river, desert and highway, mountain and valley. He tells us, with a relish that time can never dull, of the habits of the people he saw and heard about; their idiosyncracies, foibles and weaknesses—especially their weaknesses—but not a word about his means of transportation.

Herodotus penetrated the weaknesses of mankind with the prescience of a surgeon, but with the kindliness of a man of the world. He took delight in recounting his experiences. His voice

*It is supposed that floating driftwood first suggested the idea of water craft; then a raft; afterward a canoe, rudely hollowed out of a log with fire or with stone implements.

is soft and ductile as he describes what he saw and heard. He dwells with evident pleasure upon the salacious practices of ancient Babylonia, the scenes in and around the sacred temple of Mylitta, the dower-earning women of Lydia, the unclad virgins of Lacedœmon, the Nasamoian marriage rites, the anklet wearing women of Lybia, the incense burners of Persia, the loves of the Scythian nomads, peeping Gyges, and the unhappy Candaules; his narrative loses nothing in interest in reciting the legend of the blind king Pheron, the amatory habits of birds, the concupisence of animals, the propagating qualities of hares, the virility of vipers and the amorous propensities of cats; but not a word has he to say about how he traversed Syria and Asia Minor, how he journeyed from Halicarnassus to Ancient Thebes, how travelers lived *en route*, and the time it took to go from place to place. Such things he evidently esteemed of no importance, but how interesting they would be to us!

In our meagre accounts of antiquity we have reference to the voyages of other travelers before Herodotus, notably those of Lycurgus and Solon. But while we are favored with information in regard to the objects of their journeyings, details of carriage are lacking. We derive much interesting information of sea voyaging from Homer's account of the wanderings of Ulysses, but the incidents of his journeyings are so outside the ordinary course of events that we gain little insight into the methods of practical travel. The



Carriage in Ancient Egypt.

Argonauts were among the most ancient of voyagers of whom we have details, whether fabulous or otherwise. Their journey, occupying months in its execution and beset by dangers, might today be traversed by a child safely and with little cost either of time or money. Such is the progress that has been made. But this progress has neither been certain nor steady. There have been long periods in which no advance was made, while the labors of centuries have frequently been lost by the mishaps of an hour.

In the phraseology of travel, land carriage has, curiously enough, adopted much of the nomenclature of nautical life. This would seem to show, though perhaps not truly, that the latter antedated the other. For many centuries after the denizens of Shumir and the Eastern Mediterranean were accustomed to make long and successful voyages by water, it was still unsafe to travel by land except in strong detachments.

The illustrations of primitive carriage contained in these volumes show the various animals that have been utilized for purposes of transportation. Man, or, more probable, woman, was the first carrier. This was before the domestication of the wild animals that have since proven serviceable. In some countries the load was carried upon the head, in others upon the shoulders, in others strapped upon the back. Herodotus says that the men of Egypt carried their loads on their heads, while the women carried them upon their shoulders. The use of the chariot dates from very ancient times. Sharrukin, of Agade, in the records he has left of his campaign to the sea of the setting sun, fifty-seven hundred years ago, speaks exultingly of having ridden in myriads of bronze chariots. But this very reference to the means of travel would seem to indicate that it was something new—something to boast of.

In the accounts we have of the accourtrements of war in ancient times, and of the spoils captured from enemies overthrown, the chariot occupies in every instance a conspicuous place. In the invasion of Syria by the Egyptians thirty-five hundred years ago, many chariots of bronze and gold, history tells us, were captured at a great battle fought at Megiddo. Tiglath Pileser, who reigned twelve hundred years before Christ, recounts that he captured one hundred and twenty chariots in one of his campaigns in the Nairi country, a mountainous district to the north of Assyria. Afterward he tells how he constructed many of these vehicles for his own people, thus showing them to be a common medium of conveyance.

Homer, in his Iliad, refers again and again to the chariots in use at the time of the siege of Troy. He speaks of them admiringly as being decorated

> "With solid beauty . . . bright with the mingled
> blaze of tin and gold.
> The yoke of box embossed with costly pains,
> Hung with ringlets to receive the reins,
> Nine cubits long the traces swept the ground,
> These to the chariot's polished pole they bound."

Six hundred and fifty years before Christ the Assyrian monarch, Asshurbanipal, recounts exultingly how he was hauled to the temple in a chariot drawn by captive kings. The chariots of antiquity were in many instances of exquisite workmanship, profusedly inlaid with gold, silver and precious stones. The pictures left of them show a high state of perfection, both in the vehicle and the accourtrements of the horses.

The chariot offered a most effective vantage ground in battle, and its use was so general that the ancients were in the habit of resorting in time of war to particular places with a view to its effective use in battle. The great plain of Esdraelon was one of these spots. The chariot was the sole vehicle for land carriage in primitive times. The reason was simple. It was easily constructed, strong, accessible, and capable of withstanding the hard usage to which it was subjected in that rugged age.

Xerxes, in his invasion of Greece, is said to have had a carriage, which he used in common with his chariot. This is about the first mention we have of such a vehicle. Indeed, its use would not have been possible at a much earlier period. Until the time of Darius (five hundred and twenty years before Christ) highways were little known throughout western Asia. This monarch, who, above all Persians, best deserves the title of "Great," conceived the idea of connecting the widely separated districts of his empire by public roads systematically laid out and maintained. These rendered the general use of vehicles possible. Darius was, so far as we know, the first to establish regular post routes, with relays of horses and riders. They served to connect his capital with the various parts of his empire. One of the emblems of the United States Postoffice Department, a man on horseback, answers equally well for the mail carrier of Darius. The embassy sent by the Persian Megabazus to Amyntas, king of Macedonia in the time of Darius, was said to have traveled with carriages and all kinds of baggage. This was the embassy destroyed with all its retinue, by the young Macedonian prince, Alexander. Cyrus and other Persian kings are said to have carried their drinking water with them from Susa in carriages. The reference to the use of carriages by the ancients is misleading. The vehicles they used were simply rude wagons or trucks.

Many centuries passed with little or no improvement in the rude vehicles of the ancients. With safety in travel and better highways, progress was made. Covered carriages were first known in historic times in Europe in the beginning of the sixteenth century; but they were used only by women of the first rank, men deeming it disgraceful to ride in them. Their use for women was for a long time forbidden. The oldest carriages used by ladies in England were called "Whirlicotes." Coaches were first let for hire in London about 1625, at which date there were only twenty; these plied at the principal inns. Ten years afterward, however, they became so numerous that Charles I issued an order limiting their number. The covered coach was at first very unpopular. A writer in 1605 speaks thus of it: "The coach is a close hypocrite; for it hath cover for knavery and curtains to vaile and shadow any wickedness. . . It is a dangerous kinde of carriage for the commonwealth."

Of the chariots of the ancients, the best types were of bronze. This was the metal in common use. Of it shields, swords, daggers, knives and other implements were made. Iron was unknown, or, if known, sparingly used. Thirty-five hundred years after Sharrukin's time the skill of an ingenious Greek, an inhabitant of Chios, who practiced the art of inlaying gold and silver vessels with iron, was, because of his art, thought of sufficient renown to be singled out for personal mention by Herodotus.

At the time of Herodotus travel within the limits of the civilized world, while not general, was more or less common. It is not, therefore, surprising that he does not tell us how he traveled from place to place. On the Tigris rafts buoyed by inflated skins were the common form of carriage. They are still in use there today. This simple device seems to have been one of the first that suggested itself to man for water transportation. It consisted of a raft made of cane or willow, buoyed upon inflated skins. These skins were filled with air by the lungs, just as we see children inflate toy balloons in our day. The buoys were fastened to the rafts with strips of skin or osier twigs. These frail structures served for crossing streams, and upon them the great blocks of stone used in the palaces of Nineveh and other Assyrian cities were floated down from the Zagros mountains. When one of these transports reached its destination it was taken apart, the wood sold, the skins cleaned and oiled, and sent back to be used again. The boats employed on the Euphrates, in the time of Herod-

Carriage in Ancient Egypt.

otus, he tells us were round, like a wash basin; two or more men, according to the size of the vessel, accompanied it and directed its course. They used for this purpose long poles, with paddles made of bamboo strips attached to one end, very much like our oar, only not so convenient or strong. Each vessel, according to its size, transported one or more donkeys to reconvey the skins covering the bottom of the boat back to the starting point, for here, as in Assyria, the vessel was broken up and sold for firewood when it reached its destination. The voyages of these craft frequently extended from the mountains of Armenia to the Persian Gulf, many hundreds of miles. These vessels represent the second stage of constructive talent in boat building among the Chaldeans. Frail, rude, and difficult to manage, they were, nevertheless, a great improvement over preceding methods. It is probable that the vessels were owned by those who managed them. These latter were to all intents and purposes common carriers, the precursors of the Lloyds, Vanderbilts and Cunards of our day. At the time these clumsy craft were used on the Euphrates, the Egyptians were much further advanced. Herodotus refers to three different kinds of transportation used on the Nile, namely, rafts, barges and sailing vessels. Vessels were floated down the Nile and towed from the shore when going up stream if there was not sufficient wind to fill the sails.*

While the vessels I have described sufficed for inland navigation, they were not adapted to the

* It is in connection with water transportation that we find early reference to governmental control of carriage. Beckman, a writer of a century ago, says: "The floating of wood seems, like many other useful establishments, to have been invented or first undertaken by private persons at their own risk and expense, with the consent of governments or at least without any opposition. But as soon as it was brought to be useful and profitable, it came to be considered as a right or prerogative of the ruler." The ruler, being the stronger, filched from his industrious and progressive subjects; that is too often the idea underlying government supervision.

sea, and it is to the sea-faring people of antiquity that we are indebted for the form of boat we use today,—at once convenient, swift and strong. The art of perfecting sea-going vessels is due to the ingenuity of the Phœnicians. The Greeks, however, afterward excelled them in skill. The Romans took up the construction of ships (copying from the Carthaginians), not because of love for the sea or commerce, but that they might overcome Carthage, with whom they were at enmity.

For purpose of commerce, a strong, slow going vessel was designed, but for war something swifter and easier to manage was required; the trireme was the result, a galley with three rows of oarsmen; afterward followed the quadrireme, a galley with four rows of oarsmen; this was succeeded by the quinquereme, a galley with five rows of oarsmen. These vessels were also used for pleasure crafts and for the transportation of persons and goods when the traffic was such as to warrant it. They were models of strength and swiftness.

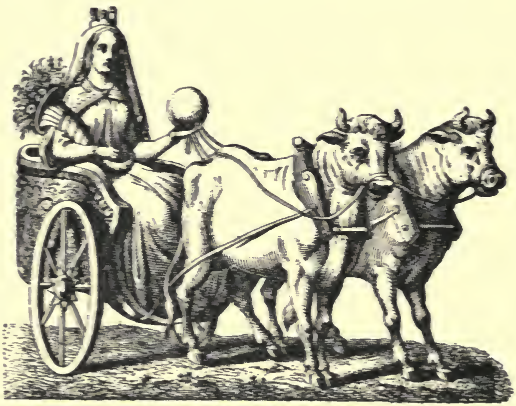
In contemplating the prehistoric age we can not but believe that Egypt, at least, with its great river, its generally peaceful pursuits, its immense transportation needs, its vast population and varied industries, had common carriers—men who devoted themselves to the transportation of persons and property on the Nile, furnishing every necessary appliance and favoring all alike. No ancient country, except possibly

Chaldea, so strongly suggests the probable presence of the common carrier. The agricultural habits of the Egyptians and the freedom from intrusion they enjoyed rendered this division of labor not only possible but extremely likely.

Many references, in Egyptian inscriptions and manuscripts, are found to primitive methods of carriage. From them we learn that in the time of the fourth dynasty (about 3000 B. C.) the ass was the only animal used as a beast of burden.* A simple car or platform laid across the backs of two asses and strapped thereto served as a seat for the traveler. Chariots and horses made their appearance a thousand years later, in the reign of Amenophis III. The framework of the chariot was of wood, strengthened and ornamented with metal. The bottom was a frame interlaced with thongs in the form of a net, which also answered in some degree the purpose of springs. The chariot had two wheels. They were strengthened at the joints of the felloes with bronze or brass bands and bound with hoops of metal. The wheels of the war chariots had six spokes; those of curricles, or private cars, four. The wheel was fixed to the axle by a linch pin secured by a thong passed through the lower end. The pole was fashioned with the axe. It was of wood and curved. It rested on a yoke

* If this date is at all accurate, it indicates that the Egyptians were much later in perfecting land carriage than the Chaldeans. As a matter of fact this is probable. The Egyptians depended upon the Nile and such simple devices as were necessary for handling goods in close proximity to it.

which was fastened to a small padded saddle on the withers of the horse. The horses were harnessed to the vehicle by a single trace on the inner side and were controlled by lines attached to a bit or snaffle. Blinkers were not used. The chariot had no seat. When used in military operations it was drawn by horses; for traveling purposes oxen were used. Chariots occupied by



Chariot of Nirthus.

women of rank had an umbrella overhead, held by a rod rising from the center of the car. The handle of the whip was of smooth, round wood, and had a single or double thong; in some cases a lash of leather twisted or plaited. The chariot of the Egyptians was highly ornamented with trappings and hangings; for these leather was principally used, adorned with metal edges and studs and dyed in different colors.

The construction of the chariot required diversified skill and in its different parts particular craftsmen were employed: for the wood work a carpenter; for the bindings, saddle and coverings a currier.

The importance of the Nile in the economy of Egypt, traversing as it does the whole length of the empire, early led to the construction and use of different forms of water craft. It is claimed that the first sea voyage of which there is any authentic knowledge was made by the Egyptians to the coast of Greece. It is probable, however, that the art of navigation was practiced on the Erythrean Sea, or Persian Gulf, quite as early, as the peoples who bordered its shores vied with the Egyptians in antiquity and culture. The inscriptions of Egypt refer to the use of boats as early as the fourth dynasty. A statue of that date of a naval constructor is extant. He is represented as seated on a stool, holding an adze in his left hand. The inscriptions of the fourth dynasty record the building of a boat ninety feet long and thirty-five feet broad in seventeen days, to be used in the transportation of stone. The Egyptians early learned to utilize the mast and sail. At first the former was double, but this was abandoned as unnecessarily cumbersome. There seems to have been three classes of Egyptian boats: those of wood, of basket work and of inflated skins. The last named were "round, in the form of a shield, without head or stern; the hollow part of the center was filled with straw.

They were of all sizes, the largest being able to carry five thousand talents weight."* The wicker boats were used principally for fishing, and were made of water plants or osiers bound together with bands made of the stalks of the papyrus or cyperus.† They were light and could be carried from place to place, past rapids, cataracts, etc. It was in such a boat that Moses was exposed. The more pretentious boats of the Egyptians were of wooden planks with ribs and keel. They had a mast, keel, prow, hold, lower and upper decks, a scuttle hole, sails, halyards, pumps and rudders. They were used for heavy transportation and for war. Though not generally large, we have references to some that equal our modern ships in size. Diodorus mentions one of cedar wood, dedicated by Sesostris to the god of Thebes, as being four hundred and twenty feet long. Another is mentioned that carried four hundred sailors, four thousand rowers and three thousand soldiers; this vessel was four hundred and twenty feet long and seventy-two feet high from keel to top of poop. Athenœus describes it as having forty benches and four rudders; the longest oars were fifty-seven feet long, and were poised with lead at the handles to make them manageable.

In the manipulation of their boats the Egyptians sometimes used four rudders. The rudder consisted of a long, broad blade and handle. The oar was a round wooden shaft to which a flat

* 468,750 pounds.

† Not the same plant as that from which paper was made.

board of oval or circular form was fastened; it turned on the thole pins or in rings fastened to the gunwale of the boat. The rowers sat on benches or low seats, or stood or knelt to the oar, sometimes pushing, but more often pulling. The Egyptians manufactured their sails and ropes from the rind of the papyrus. The sails were often colored a brilliant hue. The vessels were furnished with cabins, built of wood and painted inside and out, and fully protected the occupants

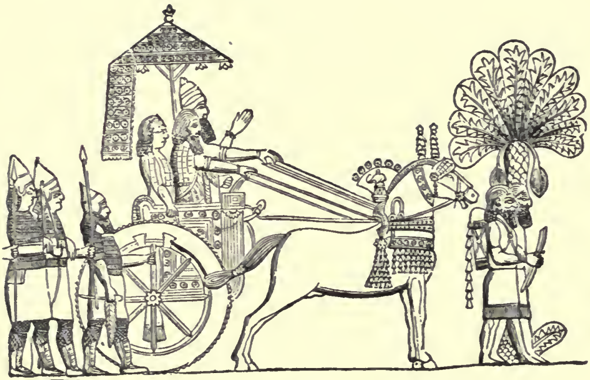
Carriage in Ancient Egypt.

from the elements. They were in many cases richly decorated and furnished. Entrance was sought by a door at the front or side.

The Egyptians were an exclusive, self contained people. Throughout the virile period of their history they looked upon mankind as unworthy of association or recognition and adopted every possible means of excluding them. The Phœnicians, however, because of their near proximity and aggressive character, always maintained more or less intimate relations with them. It is probable that many of the devices which the Phœnicians employed and which the world copied from them, they in turn owed to the Egyptians. Phœnicia occupied a narrow strip of land on the extreme eastern border of the Mediterranean. Its people were typical business men, in many respects the most remarkable of antiquity.* Their thoughts were occupied wholly with gain. They cared nothing for fame. To them wealth was the beginning and the end of life. This is why we have no account of their experience as traders and voyagers, extending over thousands of years, except as we catch furtive glimpses of them from the literature of other countries. Because of their neglect to record their acts, their personal achievements are lost as completely as the secret of their cosmetics and incomparable dyes. They were the Common Carriers of their time. But whether they operated in the earlier ages directly for the profit to be derived from the handling of men and freight, or made this only an incident of their voyages, we can not tell. In later times it is likely they had well established transportation lines. This, it is probable, is why Herodotus did not think it worth while to mention them. History was too precious to him to be made the medium of well known facts. But it is not probable that carriers were licensed; were accorded a right to exact a particular sum for a particular service, no more, no less, with the obligation attached of insuring

* See chapter on "The Carriers of Phœnicia and Babylon," in the volume "Freight Business."

what they carried against the accidents of imperfect service. These details came later, with improved appliances, better protection and higher organization. But wherever men have been free to act they have, it is probable, from the earliest times, sought profit from the carriage of men and goods. However, from the time of Cyrus to that of Victoria, little progress was made in the art of transportation, when, in a moment, it passed from the rude methods of the ancients to the luxurious devices of our day.



Carriage in Ancient Assyria.

CHAPTER II.

SOCIAL AND ECONOMIC ASPECTS OF RAILWAYS.

Differences of nationality are the outgrowth of ages of isolation and consequent ignorance and prejudice. They exist only in men's minds; thus, the descendants of a German family moving into France hate the mother country with all the intensity of an original Gaul. National lines will fade away when those who live on either side of them know each other familiarly. Steam and electricity make a Common Family possible. Social evolution and trade progress in the same ratio as intercommunication. The present rate of progress, compared to the past, is as the present rate of speed is to that of the stage coach, canal boat 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 run, the greater the traffic, the greater the intercommunication. Every train is, therefore, a factor in the evolution of mankind; has a direct effect on the relations of peoples and the growth of commerce. Its government and operation is thus a matter of especial interest; of universal concern.

The fundamental conditions governing the service are that trains must be ample, regular in their movements, adapted to the traffic they handle, and safe.

The business of railroads is governed by the divergent interests of those who use their product; by producers and consumers. Their action is based on economic laws, because they accommodate traffic regulated by such laws. It is, therefore, self adjustive. The natural laws governing it harmonize with surrounding interests. They are such as to protect and foster the community, because the community has a voice in making them. Trade is based on natural laws and is the result of mutual concessions, of reciprocal action, of careful apportionment of cost, of a minute division of profits. On the other hand, statutory laws such as those regulating rates, speed of trains and kindred details, are not self responsive and in so far as this is the case, bear oppressively upon all concerned, and, while they may for the moment seem to benefit the community, in the end cripple it.

The physical life of a railway is too great to be comprehended in its entirety by any man. But a comprehensive knowledge of the laws that regulate it is essential to every student of the subject and to every railroad man who is either prominent or hopes to become so. Many men connected with our railroads, eager to acquire this information, do not possess the facilities. This book (with its attendant volumes) is intended to be of assistance to such. It treats of the organization, duties and responsibility of the train force, employment of equipment, methods for moving trains, rules and regulations, accidents incident to railway operations, signals, and so on.

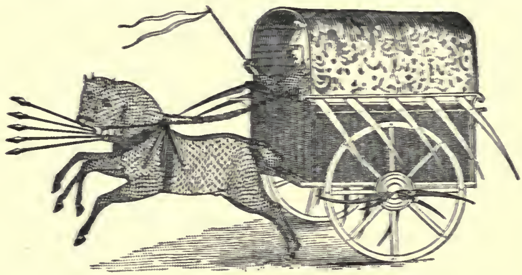
It is devoted particularly to the physical operations of trains and the rules and regulations that may profitably be used in that particular field. It is not exhaustive. A full understanding of the subject requires that collateral branches of the service should be studied. The boundaries of the departments and bureaus of railways are always faint. They have no well defined lines of demarkation, but merge insensibly at many points. The operating and traffic departments, for instance, will at times include within their purview the self same things. Hence it is necessary to refer to other branches of the subject in describing any particular one.*

I have written several books on the train service of railroads. The first one was published about sixteen years ago. There, for the first time, was pointed out the incongruities of the service, among others the conflicting rules and signals in force on different roads, and their absurdity and

* Some of these branches are described, albeit imperfectly, in the companion books on "Organization and Forces;" "Financing, Building and Maintaining;" "The Economical Purchase, Care and Use of Material;" "Passenger Business;" "Freight Business;" "Baggage, Express and Mail Business," and so on. All of these books treat of subjects connected with the operation of railway trains.

danger. In that book a complete code of train rules was first compiled; therein was first suggested the necessity of concerted and harmonious action. Every important suggestion it contained has since been carried out.

Of all the forces which have helped to accelerate development the railway has been the greatest. But its progress has been so rapid, its achievements so great, that calm and dispassionate study



Ancient Battle Wagon.

of the economic laws governing it has been impossible. We are only just beginning to understand them.*

In the operation of trains, comparisons are impossible between different railroads, because conditions are never alike. They are, therefore, not attempted herein. The train service of American railroads may be said to be as nearly perfect as possible at the present time. Managers, never-

* In the author's book "Economy of Rates. Private *versus* Government Control" will be found a study of railways from an economic standpoint. The reader will also find set forth therein the status of railways in the principal countries of the world.

theless, have been much criticised in respect to it, but without just cause. It is at once ample, safe and cheap. The growth and development of the railroad system of America has been phenomenal. It is at once the cheapest and most extended in the world. It has been achieved in the face of apparently insurmountable obstacles; the obstacles of a new and widely extended country; of a country where money was scarce, where labor was high priced, where material was costly, where taxes were excessive, and where public opinion was oftentimes unjustly and oppressively harassing.

Carriage in England, 16th Century.

CHAPTER III.

CHARACTERISTICS OF THE SERVICE AND ITS NEEDS.

The train and station force of a railroad is its creative force; the means by which it accomplishes its ends. Here is a good 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 rudiments of business in this primary school, having become familiar with the appliances they afford, the application of general principles will come easy to the student afterward, should he be promoted to more responsible duties.

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

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

A description that might represent this on one road would be deficient in some particular when applied to another; a description that embraced all its details today would be imperfect tomorrow. Not only so, but while the duties of those in charge of different trains of the same class may 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 respective rights traffic enjoys. 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, men not given to any dissipation, otherwise their habits and passions will lead them into excesses that will sooner or later precipitate accidents and other unfortunate disasters.

Members of the train service must be familiar with the route over which they pass; with the sidings, stations, grades, crossings and physical features of the line; with the signals used; with the rules governing the movements of trains; with the disposition of auxiliary forces; with the character of the people and the particulars of the traffic. They must be quick to comprehend; must be sagacious and worldly wise. They must not only know and obey the rules that govern them, but must be able to take cognizance of things not embraced therein.

Train men must be familiar with methods of operating trains upon both single and double track, so that no risk may be run in transferring from one to the other. They must obey established rules without reference to their value in particular instances; to transgress them in unimportant cases is to incur the habit of disobedience in important instances.

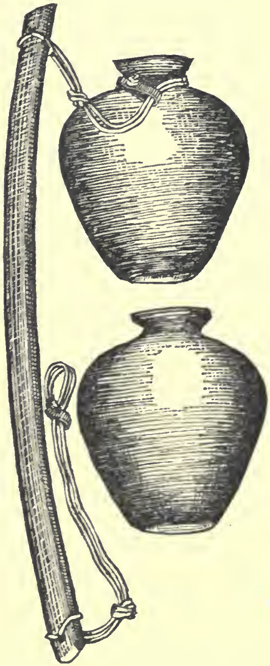
Upon them rests the responsibility of seeing that every appliance necessary to protect the train is in order; that brakes are in perfect condition; that signals are in their places; that in the event of detention on the line prompt and adequate measures are taken to protect the train. They must, in fact, be experts.

The train service is characteristic throughout. It is peculiar to railways. Associate branches of the service find their counterparts in other pursuits of life. This is original. It invites the admiration of man and boy. It is from the more adventurous among the latter that its membership has been, up to this time, largely recruited.

The hardships and dangers attending its primary duties appall all but the more daring and hardy. No favorite son, no heir apparent, has ever been allowed to brave the dangers that attend service

Indian Carrier of Mexico.

on freight trains or in the station yards. Other and less dangerous avenues to fortune must be found for the delicately nurtured. It is only those whose lines lie more apart, who are restricted in the pursuits they may follow, and who are courageous beyond their associates, who have voluntarily taken these chances. To them the risks attending the service, while real and appalling, are soon robbed of their terror by daily familiarity and by the feeling, so common to soldiers and

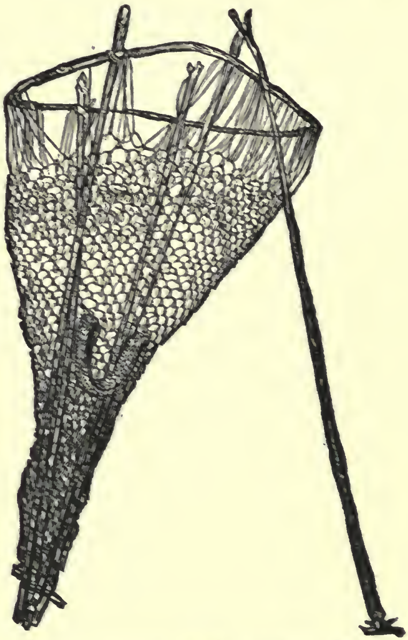


Primitive Indian Form of Carriage.

men in venturesome pursuits, that while others may be unfortunate they will escape.

Disaster may be avoided in many instances if proper care is exercised, but not always. The risks of the service are such that in many cases no forethought can guard against them. Each day, however, new appliances and better discipline tend to reduce these risks.

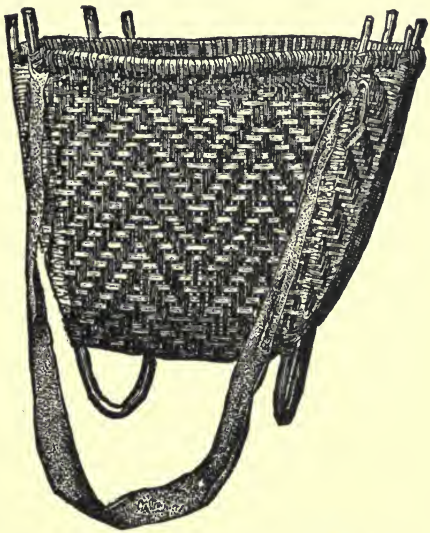
The introduction of safety appliances, such as automatic brakes, switches, couplers and kindred



Primitive Indian Form of Carriage.

devices, invites to the train service of railways men who have hitherto avoided it by reason of its danger. This will benefit all concerned. It is possible, too, that the introduction of the new devices referred to will effect a considerable modification, if not a revolution, in the place from which to start in the service.

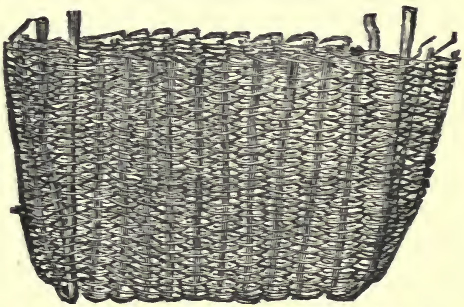
In every brakeman we see a possible railway president. This position, in common with the simpler employments about the station, is the gateway to the service. The train and station service of railways is and must be what the mer-



Primitive Indian Form of Carriage.

chant marine was to the navy before the introduction of steam—its school.

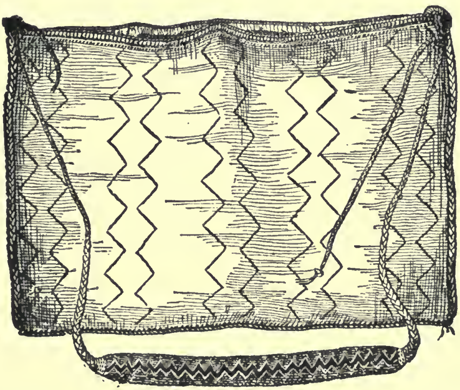
Few appreciate the great responsibilities that attach to the position of conductor or engineer. They affect in a marked manner the character and demeanor of these officials; they sober and ennoble them. No matter how boisterous they may have been before their occupancy of these places, their demeanor changes. Men who are conscious that their lives hang often in the balance, or who realize that upon their courage, vigilance and presence of mind the lives of others depend, can have little that is trivial or superficial in their natures. Those who do not appreciate the greatness of this responsibility and its attendant requirements are quickly eliminated from the service.



Primitive Indian Form of Carriage.

The difference between freight and passenger service is great, and impresses itself in a marked manner upon those promoted from the former to the latter; the facility with which they can adapt themselves to the new conditions is an evidence of their fitness and native talent. The transition is, however, expected and finds the incumbent partially prepared. But the change is so great that only those who possess great adaptability are able to quickly adjust themselves to it. With greater simplification of the service there will be greater unity in its membership, rendering transfers more easy and natural. The desirability of this no one can appreciate so highly as those immediately connected with the service.

The duties and responsibilities of the train force in the United States differ materially from those of other countries, requiring the exercise of greater intelligence and exacting greater personal responsibility. This is so especially of the



Primitive Indian Form of Carriage.

passenger service. Its members are required to come in constant contact with the public, and hence must cultivate assiduously the art of getting along pleasantly with the traveling public; must study the art of satisfying the patron without sacrificing the carrier. The mechanical duties attached to the service may be learned by practice, but ability to get on pleasantly with the public can only be acquired by the exercise of an enlightened understanding and cheerful and kindly disposition, which latter is the basis of all true politeness.

The train force of a railroad must be highly drilled; must be expert, prompt, active and trustworthy to an unusual degree. It must be able to think and act quickly. Hesitation may at any time precipitate disaster involving the life of the employe, the lives of those entrusted to his care, and the destruction of valuable property. No government would think of licensing a dull witted man as an ocean pilot. The risk would be too great; it would be an unkindness to the man and a wrong to the public. The same conditions apply to the train force of a railway. Dull men in its ranks menace the safety of both life and property. Men upon whose action such vital interests depend should possess quick perception, good judgment, and a resolute will. This is especially necessary in the train service because the vicissitudes attending its operations can not be anticipated, and occasions frequently arise when those in charge must exercise their judgment.


Hindoo Carrier.

Whether men filling responsible positions in the train service possess the qualities essential to their occupation is to be determined by long continued observation and minute examination. The latter is necessary in every case. By it particular needs, such as knowledge of reading and writing, good hearing and eyesight, may be definitely ascertained.* Such examinations may not always be agreeable, but are necessary and their usefulness is now generally recognized. They may be the means of protecting the life of the person examined; without them defects would, in the majority of cases, remain unknown till revealed by some grave disaster. While such examinations are desirable, it is also true that they may be carried to an absurd length. All that is required is that the employe should be experienced, know the rules, be able to read and write, have good hearing, perfect eyesight, reasonably stable health, and a courageous spirit.

It is important in the handling of the train force that its members and accessory branches of the service should not be worked to the point of exhaustion. Due time for rest, sleep and recreation must be accorded. To deny this is to invite carelessness, inattention and indifference; to court disaster. Train men are not, as a rule, overworked. Instances to the contrary are exceptional. But there should be no exceptions.

* The prevalence of color blindness is well known and, 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 aggravation."

Here the rule should be inviolable. The legislation that has been enacted on the subject is not uniform as to the maximum number of hours that men may work without rest.*

It has become, in recent years, the practice for railroads to require trainmen to wear uniforms. It was objected to at first by employes on the grounds of cost, conspicuity, the necessity of frequent changes of garments not alike in texture or warmth, and for other reasons. However, upon examination these objections proved to be more imaginary than real, and uniforms were ultimately found acceptable to those who wear them. The innovation was a good one. The train service requires the discipline of military life; it should be governed with like justice, punctuality and mercy. The train employe must be equal to the soldier in courage and presence of mind. The unavoidable mishaps that attend his life enlist everyone's sympathy and suggest permanent provision for him so far as possible.

Among the divergent practices that characterize the train service of different companies may be mentioned the handling of the crews of freight trains. Upon many lines the system

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*Thus, 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. It is probable that the maximum specified in both cases is too great. Men may, in emergencies, work for twenty-four hours continuously without injury when not engaged in responsible duties, but it would not be a safe course to follow with those who have charge of or are responsible for the movement of trains.

known as "first in, first out" is observed. Upon other roads crews are assigned to particular trains, with which they become identified. The former practice stands high in the favor of train men because it equalizes their pay and prevents favoritism. Operating officials favor it for the same reason. It relieves them of complaints and enables them to secure certain safeguards and comparisons which would otherwise be impossible. An objection to this method, however, is that it breaks up the habits of train men; prevents their eating, drinking and sleeping in an orderly way like the rest of mankind. Moreover, it is urged that it robs the service of an incentive to progress by treating all alike without reference to capacity, length of service or faithfulness. Where there is no prospect of promotion, where there is not something to strive for continually, it is said men lose interest; competition is as valuable here as elsewhere.

The methods and principles depended upon in improving the service of corporations generally, may be also depended upon to improve the train service of railways. The requirements of this particular field are implicit obedience to rules, watchfulness, energetic prosecution of work, careful economy in time and judicious use of material. These objects may be approximately attained by the exercise of prudence and forethought; by the careful selection of members of the train force; by necessary discipline; by wise government; by teaching the force to consider

Dutch Carrier.

its interests and the interests of the company as identical. This last may be accomplished by making the community of interest actual; by considering the present and future interests of the employe; by making the employe regard the Permanent prosperity of the company and not its ability to pay him his wages for the current month only; by rewarding him according te the interest and intelligence he displays. This may be done in many ways. One of the means of doing it, where time or material may be saved by the exercise of superior care and intelligence, is by the payment of bounties in recognition of results attained.

In the operation of railroads rewards may, perhaps, be profitably granted, but the only punishment should be suspension or dismissal. Bounties may be granted, but fines should be avoided; encourage with praise, but avoid threats; promote the worthy, but do not degrade the unworthy; reward unremitting vigilance, but overlook mistakes not the result of carelessness or indifference; deal leniently with errors of judgment, but punish with dismissal all unfaithfulness or disloyalty. A service governed by such principles must, in the end, be animated by a high respect for itself and a clear conception of its duty to its employer. Those who look after the bridges and track of railways and the physical appliances at stations and shops as well, should be similarly governed. Deficiencies here, as in the train service, are fatal to the proprietor and add to other injurious effects the element of danger, loss of prestige and destruction of property.

There is nothing new in the practice of giving rewards for superior efficiency.* It is as old as the details of business, as the disposition of one man to interest another in his affairs. Thus, in the case of railroads they give those who perform the greatest amount of work with the minimum amount of fuel or oil some tangible recognition of the superior value of their services; awards or premiums are also granted men for work which in other respects shows the greatest skill and interest upon the part of the person performing it. The giving of premiums has been found valuable in improving the train service. Thus, a record is kept of the acts of trainmen, the number of cars moved, whether trains were on time or not, accidents, complaints against employes, errors of the latter, deportment, dress, the condition and cleanliness of the cars, and so on. This record is made the basis for awarding

* A belief in them is not, however, general. I know personally many great properties that are operated efficiently where premiums are not paid or other extraneous influences brought to bear to secure satisfactory relations between employe and employer except justness and manliness on the part of the management. But I am inclined to think that while the efficiency of this method can not be questioned or its great value to a property overestimated, yet is it not dependent upon the life of the individual who practices it? Is it not merely an INCIDENT in the life of a corporation, which is ETERNAL; which sooner or later will be subjected to the vicissitudes of commonplace, even inadequate, management?

a sum of money in addition to the regular pay and for making promotions; a passenger conductor 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, receives a sum in addition to

Russian Carrier.

his pay; proportionate sums are paid his brakeman and baggageman also. So with the freight train crew whose train hauls the greatest number of cars and averages the best time, about whom the least number of complaints is made, and which displays generally the best management. The engineer, also, who, all things considered, makes the best record for the month, receives a premium. These records, in addition to furnishing the data upon which prizes are awarded, are also made the basis of promotion, a bad record being looked upon as a mark of inferiority, while a good one indicates the reverse. A company thus encouraging its train force is benefited in many ways: in increased number of cars hauled; in accelerated movement of trains; in fewer accidents; in lessened complaints; in decreased payments for overtime; in quickened interest and heightened desire to achieve results. The premiums are of little consequence to the employer, 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 expanse of territory and unwatched faithfulness is the measure of service, incentives such as these can not but be beneficial. To secure the best results, recognition of high merit must be general and prompt.

To be effective, premiums must be the spontaneous act of the employer. They then indicate a lofty appreciation of the value of faithful service; they dispel the idea that everyone should be treated alike, without reference to capability or merit. Their effect can not but be to make men plan and strive to achieve high aims. Herein, it is claimed, railways are deficient, especially in connection with their train service.

The continued improvement in railway appliances demands increased intelligence upon the part of those who use them; increased study and application upon the part of employes; greater care in the selection of men; encouragement to men to study, to familiarize themselves with their position and collateral duties. The engineer of today must be more skillful than his predecessor twenty years ago, because the appliances

Carriage in Africa.

he uses are more complicated, require greater intelligence to understand, greater experience and skill to manipulate. This is also true of other classes of employes connected with the train service.

In order to build up a train force to the highest standard, those who are admitted to it should be chosen with the care and foresight that characterize the selection of the force of a bank. Two purposes should be kept in view, namely, present and future uses,—ability to do the work in hand, and capacity to fulfill duties of a higher character when required. This particular feature of the service has not, because of circumstances that could not be overcome, been considered heretofore with the care it should have been. But this criticism can not be made exclusively of the train service. It is the accompaniment of the comparative newness and inexperience of the railway service generally. It is not likely that any department of railway service has been considered with reference to this feature as carefully as it will be hereafter. Men have oftentimes, necessarily, been chosen haphazard; their antecedents have not been carefully scrutinized; nor, after installation, has effort been put forth to lead them to study and otherwise fit themselves for promotion.

Applicants seeking to enter the railway service should be passed upon by men who are good judges of human nature and otherwise interested in building up and ennobling the service. To be connected with the train service of a railway should be in itself an evidence of high intelligence and especial fitness. Each year shows improvement in this respect. Each year develops higher aspirations in the force and greater skill in the performance of duties.

In connection with the question of how the most desirable results are to be attained in the organization of the operating force of railways, an official of considerable experience says:*

"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 offence; 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 leniency. 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 error 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 offences, 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."

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* J. S. Gadsden, President Association of American Railway Superintendents.

Mr. Gadsden's regime is: For violation of rules or neglect of duty, first, fines; in the next instance suspension from duty without pay for a definite period; and finally, dismissal from the service. In regard to details, he says:

"The first fine imposed upon an employe in any calendar year will be one dollar and each succeeding fine during the same year will be increased by one dollar.

"The fifth fine in any calendar year will be accompanied by suspension from duty one week without pay.

"Any employe who has been fined five times in any calendar year will, for the sixth offence, be dismissed from the service.

"Any fine for violation or neglect of train rules will be accompanied by one week's suspension from duty without pay.

"An employe whose carelessness or neglect results in injury to property must, at the discretion of the superintendent, make good such injury at his expense; except that any amount deducted from pay under this rule shall not, in any month, exceed one-fifth of his average monthly pay, and such deductions for any one offence shall not continue for a longer period than twelve months.

"All fines, deductions, suspensions and dismissals under this rule must be authorized by the superintendent and duly entered on the pay roll. Such entries must state the order or rule that has been violated or neglected.

"A record of these penalties will 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, will be donated to the Employes' Mutual Relief Association.

"These rules do not limit the power of the heads of departments or other authorized persons to dismiss an employe for incompetency or because his services are not required."

I have not believed the enforcement of fines to be desirable. That is, however, merely an opinion. Others are much better qualified to judge of such matters than I. Great railway companies have tried the experiment and found it to work successfully. There must, therefore, be some merit in it. How much its success has resulted from merit and how much from the tact and wisdom of the officials in charge, I do not know. But in regard to the necessity of carriers having definite rules for employes, and enforcing those rules, there can be no question. They are necessary alike to the employe, the

Carriage in Jamaica.

employer and the public. In many cases the courts have saved carriers harmless for damages inflicted because of the rules which they had endeavored earnestly to have carried out by employes and which, if obeyed, would have prevented harm.

Japanese Carrier.

CHAPTER IV.

THE TRAIN FORCE — ITS MEMBERS — THEIR DUTIES, QUALIFICATIONS AND CHARACTERISTICS.*

Passing from the general, though limited, consideration of the train force attempted in the preceding chapter, a more accurate appreciation of its character and duties may be secured by a brief description of its individual members. And first—

THE ENGINEER.

This highly trusted employe is sometimes called an Engineman; in England he is 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 constituting the engine outfit. He must understand also how to take a locomotive apart; how to put it together. Hence it is necessary that he shall have grown up in the business. He must also have thoroughly familiarized himself with the working of his machine, with its multifarious forms, with the varied uses and weaknesses of its every part. The acquisition of this

* For a generalization of the duties of the employes of railroads, the reader is referred to the volume "Organizatio and Forces."

knowledge requires practical experience and observation, many years of laborious work.

Each locomotive has its peculiarities. No two are alike. There may be no difference in them so far as the eye can discern, but their steam making power, their inherent force, their behavior, is different in every case. The engineer is required to fathom the secrets of the locomotive he runs, to understand its weakness and strength, how to use its forces, how to overcome its inherent defects. The extent of his ability to do this, coupled with ability to supervise and direct the energies of his fireman, is the principal measure of his capacity.

The necessity that those who run engines should be men wedded to their office, 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 neither the knowledge nor the conservative instincts that an engineer should possess. He, above all men, must be practical, conservative, possessed of an apprehensive mind, anticipating always what is before him. 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 of the pyrotechnical or 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 true engineer. That such a man will be temperate in what he eats and drinks goes without saying. He should have vigorous health. His life is such as to preserve this vigor to him for the allotted span of existence. The hardships and exposures of his

Chinese Carrier.

occupation are not such as to break him down if he is temperate. Over against the harassment of his duties there are counterbalancing conditions so that he is not subjected to a greater nervous strain than others. Directly the contrary. Moreover, the necessity of his being able to always act with judgment compels him to preserve his mental equilibrium. And what is said of the engineer in this respect applies also to the fireman, the engineer in expectancy.

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. Education forms a basis, and a general knowledge of the multitudinous affairs of a railroad involved in the duties of engineer require a good foundation on which to build. Those who would seek to climb higher must explore still wider avenues of information, must read, observe, question, experiment, digest, practice. The possession of these qualities makes good agents, whether engineers, conductors or officers.

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

The effectiveness of a locomotive is largely dependent upon the skill of the engineer. One who seeks to become an engineer should lose no opportunity to add to his experience by actual work and observation in a machine shop; in learning how an engine is constructed; how put together; how taken apart; its details, their relation to each other and general unity. Such experience, coupled with long and intelligent service as a fireman, makes a good engineer. Quite a number of valuable books have been written on the locomotive and its surroundings.* One of these should be secured and carefully studied. They contain a valuable fund of information, the result of years of experience, observation and study.

One of these writers† 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

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* By Forney, Sinclair *et al.*

† Mr. Sinclair.

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 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 wages 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, it is apparent, grows more important with each advance in railway operations. The more complicated the machine, the more varied its requirements, the greater necessity there is for ability and experience upon the part of the person handling it. The position of engineer is the immediate stepping stone to that of master mechanic. To be sure everyone can not become a master mechanic, but that does not matter. The position carries this honorable aspiration. Nor does promotion necessarily end there. No other place affords better opportunities for acquiring knowledge; for becoming familiar with the physical operations of a railroad. Every superior office is thus open to the engineer if he possesses capacity and adaptability. Here, as everywhere else, knowledge is power.

The engineer, above all members of the train force, must be familiar with the rules and regulations and the signals governing the movement of

Carrier of India.

trains. The vicissitudes of his life teach him to be prudent; to be otherwise is to invite disaster.

The modern practice of keeping engines continuously employed has changed early customs in many respects. Thus, amongst other things, it has suggested the employment of inspectors whose duty it is to make a critical examination of engines at particular places, in addition to the inspection made by the engineer. In practice and theory every precaution is adopted to escape mishap.

Prevention is the essence of safety in the operation of trains. It is attained by constant watchfulness. The engineer quickly becomes imbued with this spirit. Nothing escapes his searching scrutiny. He examines his machine when it comes from the shop to see that no omission or mistake has been made; he watches it unceasingly afterward to see that it is maintained at the highest state of efficiency. Every detail, every bolt, nut, screw, link, key, rod, guide, spring, oil box is scrutinized by him with the same unflagging industry that the more important parts of the machine are watched. He realizes that the operation of his engine is dependent upon its every part being in order, and that perfection is the result of constant watchfulness and effort, not 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 sand box 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, and should frequently examine the outside running gear, and 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 round house he should watch the

Mexican Carrier.

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."

I wish to reiterate here the desirability of engineers supplying themselves with such works as those of Messrs. Sinclair and Forney. They broaden the view and increase the understanding of the most capable.

THE FIREMAN.

As the boy is father to the man and indicates unmistakably the character the latter will possess, 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 fire box of the engine, or blown through its smoke stack unconsumed, amounts in the aggregate to a large percentage of the gross sum expended by railways in their operation. 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 and written as to how his duties should be performed. Experts have been hired to personally instruct him. Manuals have been written for his benefit. Perfection, however, if attained in particular instances, is not universal, as the vast volumes of black smoke emitted by locomotives, oftentimes the result of poor firing, evince. Firemen are born, not made. Some possess the art instinctively. But practical experience is necessary to everyone. Thus alone can men be fitted to perform their duties properly. This experience, in the case of the fireman, must be carried on under the eye and direction of some one skilled in a knowledge of the principles of combustion, especially as applied on the locomotive. Now while essays on the subject of firing may be valuable only as suggestions, it is possible to lay down formulas as the basis of the art of firing. These formulas are not difficult to learn. An instructor in this particular field of industry * explains graphically that combustion of coal is:

"A chemical union of the atoms of the coal with the atoms of the oxygen of the air, to effect which 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

* George H. Baker.

1800 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 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 also enters with considerable particularity into the practical duties of the fireman; they are, he says, 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 shall 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 as evenly as possible, giving the sides and corners the preference.* He further directs that coal is not to be thrown in heaps on any part of the fire; that it is to be put on lightly and frequently; that the door is to be closed between each shovelful when the engine is working; that the 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; that if clinkers accumulate in the fire box they are to be removed at the first opportunity; that the steam pressure is to be kept within

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*This is known as the "spreading system." There is, however, another system of firing practiced known as the "banking system." Where the later is employed the coal is piled up at the back part of the fire box, sloping down towards 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. The spreading system is more generally practiced, especially in the western states, although the banking system has been used upon some roads with good results.

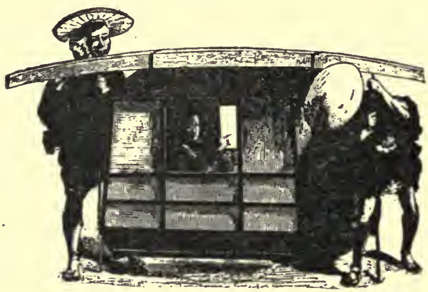
prescribed limits and not permitted to change rapidly either way; that the blower is to be used while the injector is working so as to prevent change of temperature of the boiler; that, to prevent or stop the engine blowing off, the supply of water is to be increased or the damper dropped; that, if necessary to open the door of the fire box while the engine is working, it is to be done slightly or swung open and shut; that 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

Brazilian Carriers.

prevented; that ash pans and fires are not to be cleaned near a bridge, culvert, depot or building, or on a frog or switch, and that the fire is to be thoroughly extinguished with water before leaving it; and 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."

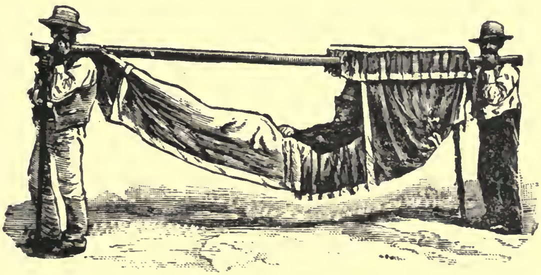
The item of fuel is one of the largest in the operation of railways. It is probable that in time some substitute will be found for coal, but until that time arrives, it should be utilized in the most effective manner by the scientific construction of engines and fire boxes, and skillful firing, so as to effect such saving as circumstances will permit. Much study has been given the subject, and so far as firemen are concerned, considerable pains taken to instruct them in their duties where they need instruction. 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



Japanese Carriers.

smoke boxes. . . . The nature of fuel, the composition of the air that fans the fire, and 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 can not unite freely till they reach a certain high temperature, when they combine very rapidly with violent evolution of light and heat. . . . Having mentioned the leading elements that take part in keeping a fire burning we will now apply the operation to the work done in the fire box of a locomotive. . . . 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. . . . Where 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 fire box, 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 fire box, 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 fire box. 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 fire in ready for the start. When the train is pulling out he is not found tumbling in the coal as fast as his scoop can transfer it from the tender. He is quietly looking out for signals and switches, and when the engineer hooks up the links and the pull of the exhaust begins to get light, he begins to replenish the fire. . . . Although he replenishes and keeps up his fire at stations and stopping places, this fireman does not make his engine a nuisance to the people by pouring out a cloud of black smoke. He prevents this by never putting



Carriers, Canary Islands.

in a heavy charge of coal at one time. This enables him to maintain a flame on top of the fire, which consumes the gases that would make smoke. When it is necessary to put in considerable coal while standing at a station, he closes the dampers, opens the fire door slightly, and starts the blower lightly. By this exercise of care and intelligence he makes his locomotive a light consumer of coal and a perfect consumer of smoke."

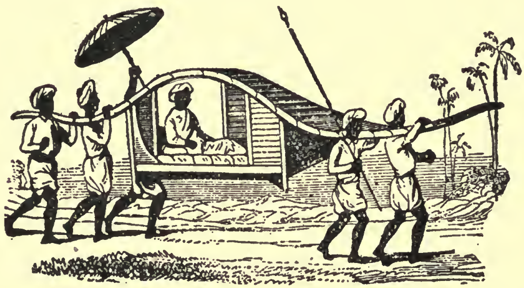
It is as true of the fireman's duties as it is of the engineer's that each year's experience in the operation of locomotives teaches some new thing, adds something to his knowledge by which he is able to make his work more effective. While the fireman has not, perhaps, become a scientist, he has become better acquainted with the most effective means of generating steam at the lowest cost. While he does not understand scientific formulas, he fires according to scientific principles. He adds fuel to the fire in quantities best adapted to the preservation of uniform temperature and perfect combustion. He is governed in his work by the load to be hauled, the speed to be attained, the peculiarities of the engine, the kind of coal, the weather, the character of the road, and so on.

The fireman's physical attributes must be of the highest type. He must be of robust constitution, because the work is laborious, arduous and perplexing. This is especially true at first. With time, however, these peculiarities become less apparent.

Although the fireman's duty, as the title indicates, is primarily to look after the fire, he incidentally attends to replenishing the tender with water, ringing the bell, cleaning the ash pan, shaking the grates, filling the oil cans, attending to the lights and keeping the engine clean. "He notes how the boiler is fed; and, upon his knowledge of the engineer's practice in this respect, much of his firing is regulated. The different methods of using steam by engineers, so that trains can be taken over the road with the least expenditure of coal, are engraven upon his memory. . . . As his experience widens, his fire management is regulated to accord with the kind of coal on hand, the steaming properties of the engine, the weight of the train, the character of the road and of the weather. Firing, with all the details connected with it, is the central figure of his work, the object of preeminent concern."

The fireman, according to the customs of railways, is an engineer in embryo. He is frequently called upon to act for the engineer and is, therefore, in many respects, his deputy. In case of accident befalling the engineer while on duty, the fireman must be able to supply his place until another engineer is forthcoming. His office, therefore, is something more than that of a fireman. It is dual in character. A good fireman will make a good engineer because he possesses intelligence, industry and sobriety, careful habits and an observing mind. He necessarily receives a thorough practical training. By the side of the engineer he learns his duties. Familiarity with the performance of his engine by day and night, in all kinds of weather, on every conceivable kind of track, enables him to tell with almost mathematical accuracy the speed the machine is making. This knowledge can not be acquired in any other way. Exactly how he is able to determine this, he himself can not tell; it is an intuition—the sound of the revolving wheels, the motion of the locomotive, the fleeting objects by the wayside, aiding him in his conclusions.

Only by long familiarity with the workings of a locomotive are men able to detect instantly anything wrong in its working, to distinguish normal from abnormal conditions. "It requires an experienced ear to detect the false note which indicates that something is wrong. Amidst the mingled sounds produced by an engine and train hammering over a track, the novice hears nothing



Carriage in India.

but a medley of confused noises, strange and meaningless as are the harmonies of an opera to an untutored savage. But the trained ear of an engineer can distinguish a strange sound amidst all the tumult of thundering exhaust, screaming steam and clashing steel as readily as an accomplished musician can detect a false note in a many voiced chorus. Upon this ability to detect growing 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 by a few weeks' industry; it is the gradual accumulation of months and years of patient labor." Long experience is necessary to enable a person to handle a locomotive with ease and smoothness, to preserve uniformity of motion in all the varying circumstances of starting and stopping. All these various acquirements come with observation and practice; by what is seen in the shops, by watching, by thought, by asking questions.

The fireman learns little by little. In the course of time he is able to pass the necessary examination preparatory to assuming the more responsible office of engineer. These examinations are not general, but each year are more and more practiced by railroads. There is nothing about them to be dreaded by a person competent to run an engine, as they have reference to hourly duties only. 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 too many to be described in detail. Only the more apparent can be enumerated. Among the latter these may be mentioned: He must be at his post before starting on a trip in ample time to wet the coal, when coal is used; to see that the oil cans are filled and ready for use; that the fire is properly made; that the engine is clean. He must see that all supplies necessary for the trip are in their places; that the flags, lanterns and other signals are on hand; that the lamps are trimmed; that the ash pan is clean;

that the necessary tools are on hand for handling fuel or attending to the fire; he must see that the water tank and sand box are full; that he is ready at the proper time to take in water with the least delay; he must clean the cinders and clinkers from the grates, and the ashes from the ash pan, when stops are made at coaling stations; that the fire he maintains is equal to the work the engine has to perform, and that the fuel is applied in such a way as to secure the greatest possible volume of steam. He must, moreover, keep a sharp lookout for signals and report from time to time to the engineer anything he discovers necessary for the latter to know. The list of duties might be greatly extended. The foregoing section is, however, such as to call attention to them and indicate their importance. I do not seek to do more here.

THE CONDUCTOR.

The duties of the conductor are multifarious. He collects more or less of the railroad's revenue, is the custodian of much of its property, and looks after the safety of all that is transported while in his charge.. He is the trusted representative of his company, and a semi-public official. In his former capacity he inspects the cars in his train to see, so far as a superficial examination can accomplish this, that they are in good order and answer the requirements of the service. He represents the company in all its dealings with passengers aboard his train. He is in immediate charge and it is his duty to see that the train force is attentive and properly regardful of the property and the conveniences and prejudices of the traveling public. He is also the conservator of order and quiet, and compels the observance of the decencies of life by all upon his train.

Each year lessens the responsibilities and duties of conductors in some directions and adds to them in others.* The better systemization of the service and the introduction of new and approved appliances make the work of the conductor, in some directions, less than formerly. On the other hand, increased business and more complicated methods of ticketing passengers add to his duties and responsibilities. The old time canal boat captain and stage driver did very well for conductors in their day, but at the present time greater affability and more polished manners are required.

The duties of the conductor require that he shall have the utmost tact. The demands upon his patience and forbearance are constant. He must be discriminating, and must be wise in order to discriminate properly. To illustrate: His rules require him to collect a ticket, or in the absence of a ticket a fare, but there will be exceptions to the rule, such as the cases of men

* In speaking of conductors 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 England and on the continent of Europe are very much less comparatively.

well known to him who are traveling constantly, suburban passengers, and the like. In such cases he must know when to enforce the rule, when to make an exception. According to the judgment he exercises in such matters will depend, in a measure, the good name and earnings power of his company.

The conductor's duties are onerous. His train and its passengers require his constant attention.

Indian Carriers.

So far as possible he scans, as his trip progresses, each person entering the train. Afterward he must be able to locate and identify those from whom he has collected a ticket so as not to continually disturb them with importunities. To the casual observer the conductor often appears to wander carelessly back and forth through his train. In reality his mind is employed every moment. When traveling his moments of leisure are rare. He is constantly called upon to interest himself in the affairs of the nervous, or inquisitively inclined, among his passengers. The rattle of a loose brake rod or the occurrence of anything unusual throws the former into a spasm of fear, and precipitates a deluge of questions from the latter.

In a fiduciary way he is beset with annoyances. His virtues, even if like those of Cæsar's wife, are oftentimes the subject of question. This is the unutterably sore spot in his life. If trustworthy as a fiscal agent, he is still liable to misrepresentation; if unfaithful, to detection. That he is sometimes called upon to suffer unjustly, there can be no doubt. A remedy for this unfortunate situation is exceedingly difficult.*

The difference in the degree of excellence that conductors attain in their ability to satisfy the just and unjust requirements of passengers, without sacrificing the company's interests or prestige, is remarkable. It covers all degrees of adaptability, tact and talent. Thus, with one conductor an accident or detention will be made to appear natural and excusable; with another avoidable and inexcusable.

THE BRAKEMAN.

The trustworthiness of brakemen on our passenger trains is proof against temptation; as stable as that of a bank clerk. It is also without ostentation. Every traveler has observed some-

* I have taken up this particular phase of the subject in my books on fiscal affairs.

time in his life acts of honesty upon the part of these members of the service worthy of praise; acts performed in a matter-of-fact way that characterizes only those inherently honest. Yet a "tip" in such cases is gratefully received, for the brakeman is not proud to the extent of refusing favors of this kind.

The brakeman is the lieutenant of the conductor. His nervous system, like that of his comrades, the conductor and engineer, is so finely attuned to his business that the slightest break or disarrangement of the machinery of the train instantly attracts his attention.

He is a man of averages. He soon finds it impossible to please everybody. He therefore endeavors to please the greatest number and to soothe the others. He can not keep the car heated to the temperature some would like; he therefore endeavors to strike the happy mean,—a moderate heat likely to prevent the full blooded from fainting and the thin blooded from freezing. But when importuned he will open a window, or close it, if the request is not too glaringly inconsistent with the comfort of others. His amiability leads him to please all.

The brakeman's life is beset by annoyances. He is harassed constantly by freaks and cranks; to them the car is too hot or too cold; is dirty from neglect, or damp with cleanliness; is mouldy with age, or smelling too rankly of fresh varnish. He bears his burdens with patient fortitude, finding compensation in the wages he gets. His intercourse is largely with extremists. Not that he cultivates such; far from it. He can not avoid them. He is not eccentric himself and does not like eccentric people. But in his peregrinations through the cars they lie in wait for him. He can not escape; he can only dally.

The disposition of the brakeman is accommodating. As he stands at the steps of the car assisting passengers to enter or alight, he is full of kindness and benignity,—a man of information and precedents. His position is apparently a sinecure; prosy, monotonous, dull. This is its normal condition. There are emergencies—cases of accident or detention—however, when he is called upon to act in the face of danger,—when he must decide quickly and bravely.* There are times when his patience and courage are tried to the utmost by unruly or vicious passengers, and while he always seeks to avoid a conflict he has no fear and, if necessary, will attack a mob with a coolness and matter of fact courage that chills the blood of mere lookers-on. He fears neither pitols, bludgeons or knives. He seizes the unruly passenger as he would a bag of feathers and hurrying him to the platform ejects him with resistless dexterity.

The system more or less in vogue in the United States and elsewhere of making the brakeman the guardian of the rear of the train in case of

*This is also true of the Baggageman; his duties and characteristics are described in the volume on "Baggage, Express and Mail Business."

detention on the main track and elsewhere, makes him a tremendous factor in the safe operation of railways. Consequently it is of the utmost importance that he should be possessed of good judgment, should be energetic, conscientious and quick in the discharge of his duties, hence the necessity that his selection and appointment should be made with care and judgment. Upon his fidelity to the trust reposed in him will oftentimes depend the safety of life and property.

CHAPTER V.

HOW TO SECURE EFFECTIVE USE OF CARS—CAR INSPECTION—HYGIENIC REGULATIONS, ETC.

Upon the active employment of their equipment and the expeditious handling of their traffic, passenger as well as freight, depend largely the profits of carriers. The earnings of a car may be quickly frittered away in the cost attendant upon delays at yards, stations, bridges 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 no traffic can be carried which does not pay cost of carriage and the wear and tear it engenders.

It is, consequently, of the highest importance that the equipment of a company should be fully utilized; should be kept constantly earning something. Cars that lie idle and exposed on sidings, or in the yards of shippers, earn nothing, but the cost of maintenance goes on without cessation.

A means of preventing idleness of cars is to be found in the exercise of vigilance; in systematically looking after each car. An effective method of accelerating the movement of cars is to make a charge against shippers for cars allowed to lie idle while waiting to be loaded or unloaded. A means of enforcing this is found in the United States in the appointment of a common agent to act for all the railroads at points where a number of lines converge. This concentration prevents jealousies and secures unity of action among carriers, without which a charge can not be systematically or effectively enforced.*

Shippers do not always acquiesce in the right of carriers to enforce a demurrage charge, and seek relief in the courts. What the outcome of these suits will be it is impossible now to tell, but the equities of the case seem to be clearly with the carrier.

American railways have many standard rules in connection with the systematic use of equipment.† Further investigation and experience will add to the number. The general trend of these rules is that the distribution, movement of, and accounting for, cars shall be placed under a single head in the transportation department; that such head shall make full returns daily of empty and loaded cars to the division superintendent, who shall have charge of the distribu-

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*The reader will find the subject of car service further elaborated in the book "Freight Business."

†These largely emanate from the American Railway Association.

tion of cars on his division; that a summary of the returns shall be sent to the chief operating officer; that a record shall be kept of cars delivered con-

Madagascar Carrier.

necting lines and a return of such cars shall be rendered daily by the local junction agent; that companies using the cars of other lines shall send to such lines an accurate statement of the mileage of such cars; that in the interchange of cars between carriers a uniform charge shall be made for the various classes of cars; and finally, that a uniform charge shall be made for the temporary use of tracks and other facilities in the case of washouts or other emergencies.* It is also recommended that a charge of one dollar per day be made against the patrons of carriers for delay in loading and unloading cars after the expiration of forty-eight hours from the time of delivery of cars; also that a form of organization be effected for the car service agencies for enforcing the dollar charge at junctions, specifying the rules to be observed and forms to be used and so on.

While the equipment of a railway should be kept constantly earning something for its owner, it must also be watched with the closest scrutiny, must be carefully and systematically inspected. This duty is very carefully attended to in the case of passenger cars, but is not always attended to 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 such neglect, there can be no doubt it has caused the loss of property. Many wrecks attributed to defects in the track

*It is also thought that in addition to the rate per mile a company should pay the owner of a car a certain rate per diem. It is also thought that railways should have joint agents at common centers to weigh freight in car lots to prevent under billing, giving of false weights, etc.

have been due to defects of equipment, and there is reason to believe that derailment of cars attributed to the breaking of rails is often due to defective equipment. Many accidents attributed to the track should really be charged 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

Peruvian Carrier.

similar reasons. They are worthy of mention here because they emphasize the necessity of cars being inspected systematically and at frequent intervals.

To insure proper knowledge of cars used in interline traffic they must be inspected at all junction points; this is necessary to ascertain the fitness of vehicles for service and their condition with a view to determining liability for repairs and so on. There will be points at which it will not be practicable to have joint inspection of cars at transfer points, but the practice should be general. Its proper consummation is a mere matter of detail, that will in time be fully perfected.

With the advance in knowledge of sanitary laws and the realization of the importance of their observance, the equipment and property of railways have fallen more or less within their purview until the hygienic department of a railway has become one of its important adjuncts. The comfort of patrons and their protection from noxious and infectious diseases is greatly enhanced thereby. The subject merits continued attention and well defined rules and regulations. The health and strength of employes will also be greatly enhanced by such a course. The ends to be attained are cleanliness, prevention of water pollution, disinfection of articles and places likely to breed or disseminate disease. Stations, offices, shops, buildings, water closets, outhouses, yards and tracks are to be kept clean, and accumulations of decaying matter systematically removed or rendered harmless; water closets, privies, drains and sewers especially are to be periodically cleansed and disinfected; cars are to be heated, ventilated, cleansed and disinfected under well defined rules; drinking water is to be guarded from contamination; clothing, linen and upholstery is to be cleaned, aired and, when necessary, disinfected; passengers afflicted with contagious diseases are to be properly guarded and other steps taken to prevent the spread of disease. These hygienic questions receive more and more the earnest attention of railway managers, and some companies think the matter of sufficient importance to maintain a bureau whose duty it is to attend exclusively to such matters. The labor is a growing one. Each day sees some advance of method and appliance. Thus, the primitive way of ventilating cars by opening windows and transoms is rapidly giving place to scientific contrivances, the dangerous and expensive car stove is giving way to steam or hot water, the oil lamp is giving way to gas or electricity, and so on. The service in these respects is in a transition state; the appliances of today are supplanted by something better tomorrow; the aim of managers here as elsewhere is perfection, so far as the revenue of their lines renders this possible.

Carrier of Arabia.

CHAPTER VI.

HOW THE NUMBER AND MOVEMENT OF TRAINS ARE REGULATED—THE SCHEDULE.

The manipulation of trains is ever a subject of wonder and speculation, even to railroad men. The secrets enveloping the construction of the schedule under which trains are moved are to many profound and impenetrable. How officials control the labyrinthian movement of trains, how watch them as they wind in and out, how adjust so nicely the time of their arrival at meeting and passing points, how keep them all in motion, regulate their speed and give to each the exact consideration its importance merits, are questions many can never understand. They know that somewhere there is a mysterious chart, whereon at intervals the superintendent works; that upon this he fixes the character, speed and stopping places of trains, notes their meeting and passing points, the time they shall start and the hour they shall reach their destination. Some of them have had surreptitious glimpses of this wonderful chart through partly closed doors, but their view has been obstructed and their faculties of observation numbed by the presence of the superintendent, who paced the room with measured stride, or bent over his work, pencil in hand, with absent air and corrugated brow, like one who sought in vain the solution of some difficult problem. They have noted with awe the hieroglyphics, pregnant with meaning, that covered the broad white surface of the mysterious chart; the stations printed in big black letters of varying size and type and evidently deriving a fictitious importance from that fact; the broad lines of different color that traversed its face. Nor have they failed to note the faint, irregular lines drawn by a tremulous hand here and there, apparently without method or object, beginning and ending in space, feeble, inconsequential, indefinite, like disconnected dreams or half completed thoughts. While they know or surmise that these faint, irregular, half obliterated lines forecast moving trains, that they represent organized, harmonious action, that each line is a completed idea, they do not know how these ideas, clothed in the symbolical language in which they see them spread upon the chart, are to be subsequently arranged and grouped, how condensed into the simple form they present in the printed schedule.*

* Sometimes twine or thread of different colors is used on the chart instead of pencil marks. In such cases one color will 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 are used. In preparing the time 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, 12 midnight will be marked at the top of

While any of us may without much labor become acquainted with the charts that the superintendent uses in constructing his table of trains, we can not without study, and long association with his duties and responsibilities, understand the nice distinctions that govern him in his work. Each schedule, however, presents many features that seldom change; thus, certain passenger trains are like the staple articles the grocer is compelled to keep, whether profitable or not; their abandonment is not contemplated, and the most trivial changes in their organization or time precipitates upon the management the indignation of the community; its outraged feelings find utterance in long petitions, sarcastic newspaper arti-

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the first perpendicular line, and the twenty-four hours following, until the next midnight. 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, by still lighter lines. A passenger train with a running time of, say, thirty miles an hour, leaves one terminus of the road, Chicago for example, at 9 a. m.; a red thread represents the train, and is attached to a pin which is inserted in the horizontal line for Chicago at the 9 a. m. time 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, and at the place where it is crossed by the line representing 9:30 a. m., and the red thread stretched to and wrapped around this pin. 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., and the thread stretched along the station line to this and again fastened, and stretched to the next stopping place, and so on. The other regular trains are indicated in a similar manner, until the time chart when finished looks like some new kind of fancy lace work. All that remains to be done is to copy the stations and time on a blank schedule for the printer.

cles, mass meetings, waiting committees and other devices intended to awaken the sensibilities of the officials in the most lively manner.

Aside from this feature, the amount of business, its source, and the direction it will take, are carefully considered in constructing the schedule. These calculations, which are considered anew as

Carriage in India.

new schedules are constructed, have reference more particularly, however, to freight traffic, and the number of trains required to do the business with expedition and economy. But the growing passenger traffic of many lines necessitates similar calculations in regard to this department of the service.*

* The life of a schedule varies from a day to six months; it is the creature of circumstances.

The number of passenger trains is seldom reduced. New trains are added as business increases. The standard passenger trains run year after year, with the monotony of an ever swinging pendulum, until each train in time comes to have a name and character along the route, and people speak of it as they do of the sun or moon or the recurring crops.

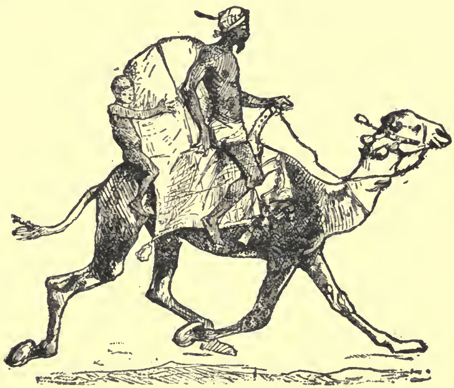
Many freight trains also are to be classed as staple; a certain number is necessary to do business. In common with passenger trains they will at certain seasons of the year oftentimes present a beggarly appearance, but they are so necessary to the convenience of the community that they escape the reductions that overtake unproductiveness elsewhere.

Many other things are to be provided for in constructing the schedule. Thus close connections at junctions with other roads are to be made, and this phase of the subject oftentimes tries the patience and ingenuity of the officials to the utmost. All of us, perhaps, feel grateful for being able to make easy and swift connection at the junctions on our route, but few of us stop to realize that this happy conjunction of circumstances is the result of many compromises among the companies in interest, of many long and angry communications, much bitterness of feeling, much contention, closed finally by satisfactory agreements and counter agreements. Oftentimes the connections with other lines have to be made only at one end of the road. It thus becomes of the greatest importance that trains going in that direction should reach their destination at a particular hour. But when these trains shall start upon their return journey is a purely local question, to be considered only in relation to other local questions.

The economical management of railways requires that the schedule should provide only for the minimum number of trains. It specifies the precise minute each schedule train shall start, the time it shall leave the various stations and sidings, and the hour it shall reach its destination. In the appendix hereto will be found a diagram used in making up the schedule (time card) for a single track road. A reference to it will explain more clearly than words how it is used. The diagonal lines represent trains, the dotted lines a special train, *i. e.*, one not provided for on the regular time table. The stations where the lines intersect each other represent meeting points. The diagram also shows the time trains stop at the different stations when such stops exceed five minutes. The heavy vertical lines divide the twenty-four hours from midnight to midnight into hours. The lighter vertical lines subdivide the hours into periods of five minutes each. The zigzag line shown on the diagram, it is evident, represents a way freight, the time being slow and the number of stops frequent, seven hours being occupied in running ninety-five miles.

Irregular trains, supplementing those not provided for on a time card, are oftentimes run as sections of regular trains—either preceding or following the latter and having the same rights. When not practicable to run extra trains in this manner, their movement is outlined on the diagram by an additional line and they are operated under special orders, telegraphic or otherwise.*

Trains provided for in the schedule are called regular trains; each has its number; those going in one direction bear odd numbers, those moving



Carriage in Aden.

in a contrary direction are given even numbers. Thus 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

* Appendix A.

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 reports submitted to the general manager and others of the lines interested."

The relative importance of trains is indicated by the grade given them, as first, second, third and so on. The number of grades is unrestricted. The schedule fixes the grade of each train. The rules and regulations forming a part of the schedule accurately define the rights possessed by each grade. Thus they will provide that passenger trains northward bound will only be required to wait five minutes at meeting points in the event trains of the same grade moving in an opposite direction are delayed; after that they will proceed on their way, keeping five minutes behind their schedule time, until the belated trains are met; but in the event a north bound passenger train is delayed, the train going south will be compelled to wait thirty minutes at the meeting point before proceeding; after that it may resume its journey, keeping, however, thirty minutes behind its time until it meets the delayed train.

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 with 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.*, pursuing its way from point to point as ordered, without reference to the time indicated in the schedule), it is called a special train.* The special trains in motion upon a line are sometimes greatly in excess of the number of regular trains provided for by the schedule.

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, in America the telegraph is brought into use to accelerate their movements. This phase of the subject I take occasion to refer to elsewhere.

The clerical work involved in the preparation of a new time table or schedule is quite laborious and requires the utmost clearness and exactness. The work is not difficult when once understood, but a proper understanding requires experience and study. The practices of railways in different countries are very much alike in respect to the preparation of their schedules; the usage of

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

one is the usage of all. An English writer* thus describes how a time table is made:

"The time tables of the London & North-Western 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 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'

Carriage in Khiva.

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 ensure 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

*Colonel Findlay, "The Working and Management of an English Railway."

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."

The mechanical skill required in constructing a time table will, in common with many other like duties, it is probable, be taught in our public schools in the course of time, just as they now teach many less interesting and instructive things.

Moorish Carrier.

CHAPTER VII.

HOW TO SECURE THE MOST EFFECTIVE MOVEMENT OF TRAINS—THE TRAIN DISPATCHER AND HIS METHODS.

The experience and skill required to move trains with economy and safety upon a single track is much greater than upon two or more tracks. Indeed, the ability required may be said to be in the inverse ratio to the number of tracks used. Upon a double track meeting places need not be provided; where there is but one track this is of the greatest consequence. Sidings are oftentimes of sufficient length to enable passenger trains to meet and pass, but not adequate for freight trains. Hence the nicest calculations must be made to arrange the meeting or passing places of such trains at points where the accommodations are sufficient.

When there are three tracks the provision required to be made upon double track lines for passing trains moving in the same direction is lessened, if not obviated. When a train is to pass another upon a three track road, the forward train pursues its way at reduced speed upon the third track, while the train following overtakes and passes it on the main track. However, it sometimes happens that the third track is required simultaneously by slow trains moving in opposite directions; when this is so one of the opposing trains must of course wait.

When four tracks are available, the manipulation of trains is very simple. It is still, however, a matter of calculation, affording abundant scope for the exercise of experience and good judgment. Where there are four tracks, trains of the same class, or of equal or approximate grade, follow each other, and only local trains are required, at infrequent intervals, to give way to faster trains. Four tracks reduce the danger to life and property to the minimum, while facility of movement and economy of operation reach the maximum.

When separate tracks are provided for trains moving in opposite directions, it would seem as if life and property were surrounded with every possible safeguard. Disaster, however, perpetually 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 everyone who has not given the subject thought, but there can be no doubt of its truthfulness. The danger of rear collisions is constant and menacing, and one of the most harassing questions that railway men have to contend with

In order to secure satisfactory movement of trains, it is desirable that they start at the time

* "Railroad Gazette."

specified by the schedule.* When this is impossible the schedule should be changed so that patrons may have so much more leeway. Those who manage trains are apt to 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 of through trains and no one may be finally inconvenienced, it is not so in

Carriage in Caucasia.

regard to suburban and local trains; they can not and do not make up the lost time, and thus not only are passengers compelled to lose time, but they and their families are annoyed and put to inconvenience. It is easy to attain

* In the departure of seventeen trains between the hours of six and seven-thirty o'clock in the evening at a station of a Philadelphia road, it was found that they were all from three to eight minutes late in starting.

efficiency and promptness in the movement of trains if skill and intelligence are displayed in the preparation of the schedule and in other details incident to their movement. Regularity in the movement of passenger trains at least may be said to be a *sine qua non* of the service; an absolute essential. However, the prompt and uninterrupted movement of all trains is important. It reduces to the minimum the number of locomotives, cars, sidings and employes, and also lessens the cost of construction and the expense of operating.

One of the most valuable agencies that may be employed to facilitate the movement of trains is the telegraph. It constitues an important auxiliary arm of the service when trains are delayed or their movements are interfered with. The practice of directing the movement of trains by telegraph from a central office is a distinct feature of American railway practice. It is both effective and economical. It has been found safe and superior to all other methods of accomplishing results when trains are delayed. Each year adds to its utility and emphasizes its usefulness. Under its operation a single track may become as useful as a double track under a less facile system. When, for any reason, a train is delayed, the train at the scheduled meeting point does not wait for the belated train, but proceeds on its way without sensible pause, new arrangements having been made by telegraph to meet the circumstances of the case. The telegraph is also effectively used in getting special trains safely and expeditiously over a road.

In the movement of trains by telegraph there are two methods in vogue, known as the "single order" and the "duplicate order" systems. The latter is generally deemed superior. Under the duplicate order system, as its name implies, the order given to a train is an exact copy of the one given to the other train concerned. This being so, the order may be sent to all trains affected simultaneously. Under the single order system this can not be done, as the orders to different trains read differently. Mistakes are, therefore, liable to be made under the latter, as, for instance, a meeting place may be differently stated in the orders to the respective trains. Under the duplicate order system this could not occur, because the dispatcher transmits the order to both trains simultaneously and in the same words.

The duplicate order system it is claimed minimizes the telegraphic service and otherwise expedites the movement of trains. Moreover, by reason of the orders to different trains being alike the mental strain on the dispatcher is less than under the other system.

In moving trains under telegraphic directions great importance attaches to the order. It needs to conform to certain well defined requirements. It should be explicit. It should not be encumbered with extraneous matter, but should relate solely to the movement directed. It should be brief, clean cut and simple. It should

Carriage in India.

be expressed in certain formulated and well understood expressions, free from ambiguity. It should relate to one transaction only. The recipient of an order can not construe it as authorizing him to do something not specifically stated. Nor can he be allowed to apply its directions to any other trains than those specified.

Details connected with train orders are equally important. It is necessary that they be legibly written; that they be numbered consecutively to permit of their identification; that each order be written on a separate paper; that the engineer be furnished with a place for posting his orders, so that they may be before his eyes while he is attending to his duties; that duplicates shall be made by some mechanical or manifolding process so that no possibility of variance shall occur. Each step taken in the issuance of an order should be noted on the original by the dispatcher. The document will thus record on its face all its salient features, such as the name of the person who issued it, the names of the operators concerned, the time each step was taken, to whom the order was addressed, and so on. It is also important that the greatest care should be exercised in receiving and delivering orders to the persons interested. Every station should be provided with a device or signal by which the operator can stop trains for which he holds orders. This device should be of a distinctive character, so arranged that it can be worked by the operator without leaving his instrument.

Special care must be taken to avoid giving orders to one person that are intended for another; to facilitate this receptacles should be provided, so arranged that they will prevent orders becoming mixed. Finally, every person receiving a train order should be required to sign a receipt therefor.

The following are the steps to be taken in transmitting train orders: The order is written down as received. It is then repeated back to the dispatcher. The dispatcher responds, saying whether it is correct or not. If wrong he corrects it. The receiving operator acknowledges this response of the dispatcher. The order is compared (if it is not copied in manifold) by the person to whom addressed with the operator's copy. The person receiving it then signs his name. This signature is telegraphed to the dispatcher. The dispatcher then replies, acknowledging the signature, and directs that the order be delivered. This authorization is endorsed on the order. The order is then delivered to the persons to whom addressed.*

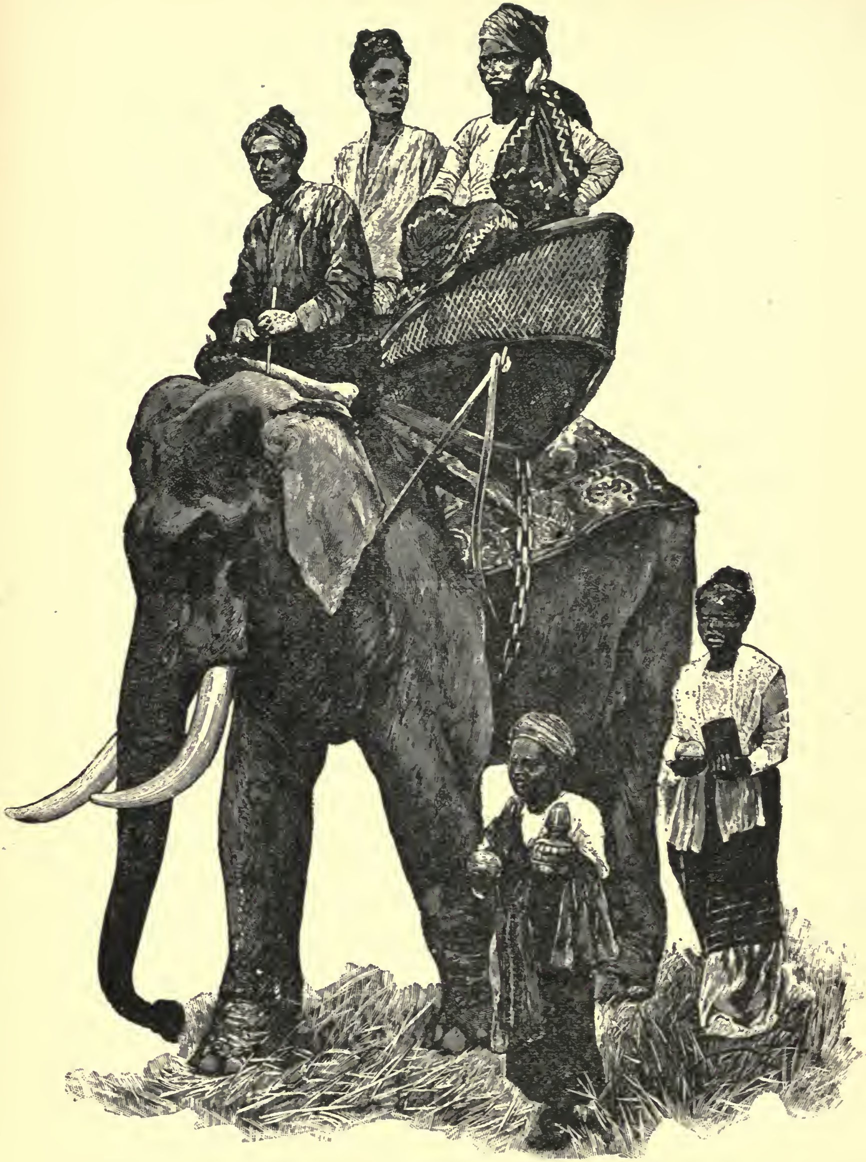
The telegraph is an auxiliary merely, not the principal factor in the movement of trains. Care is taken to avoid the necessity of using it except in emergencies. The time table is the chief reliance; but circumstances constantly intervene to render it, by itself, inadequate; accidents hap-

* When a young man, I acted as train dispatcher and thus became practically familiar with the movement of trains by telegraph. I am also indebted to J. A. Anderson's book "The Train Wire." M. M. K.

pen, unforeseen delays occur, the road becomes blocked, special and extra trains require to be run,—a thousand circumstances occur to render it necessary to supplement the schedule with the use of the telegraph.

It is desirable on economical grounds, if no other, 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. The practice of starting trains without regard to the time table and moving them from station to station on telegraphic orders results in more or less confusion and loss of time. This adds to the cost. Trains operated under special orders can not 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. So that while the telegraphic movement of trains is valuable in emergencies, it is not so economical as the operation of trains by printed schedules.

While the telegraphic movement of trains has been of great utility to railroads and has added enormously to the convenience, comfort and profit of the public, it has its drawback in the fact that it is attended with more danger than the slower and more methodical government of trains by printed schedules. The risk has, however, never been such as to excite attention or to offset the advantages that the system affords.



Carriage in Burmah.

In England, where the block system is in general use, train dispatching is unknown. The telegraph is, however, 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 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."

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* Colonel George Findlay.

In the United States train dispatching by means of the telegraph is a necessary adjunct to the operation of trains upon the great bulk of our

Carriage in India.

roads. Moreover, it has reached a state of development in this particular field that has rendered it an art so intricate that years of experience are required for its mastery. As in other branches of the service, perfection can not be said to have been reached. Added experience and improved appliances each day suggest some advance. The use of the telegraph enables the official in charge to view, as in a mirror, the whole traffic of a line and issue such orders for its better government as the exigences of the moment require. This officer is known as

THE TRAIN DISPATCHER.*

This officer is governed in his methods by certain well understood regulations that do not admit of variability of interpretation. Thus he must be sure that his orders reach those they are intended to govern and that the latter advise him of their interpretation of them.

The force must also have absolute confidence in his skill. Upon his efficiency depends the good repute of the company, the safety of life and property, the expeditious and economical discharge of business.

The work of the train dispatcher requires his undivided attention; he has no other duties. His office is purposely isolated. He is usually an operator, acquainted with the road, its cuts, curves, gradients, sidings, business, etc. He knows accurately the capacity of the equipment with which

*The duties of the train dispatcher and superintendent are always closely allied; in many cases both offices are filled by the same incumbent. For a full description of the superintendent and his duties, the reader is referred to the volume "Organization and Forces."

he works, and is a man of good judgment and habits. He is assisted when necessary by competent operators. These assistants are especially adapted to their work, and, in fact, possess the same general characteristics as their chief, whose place they in the course of time will fill.

The duties of the train dispatcher are greatly lessened with the double tracking of a road, the disciplining of its forces and the perfecting of its equipment and track. The train dispatcher is the creature of emergencies. He is the doctor that is called in when his patients (the trains) become irregular; when the digestive or respiratory organs become clogged. He watches the trains as they creep along the road very much as a spider watches the flies that buzz about his web. The moment anything irregular occurs he seizes them, and tells each conductor and engineer what to do. These latter go to the station to receive their orders and obey implicitly what he says. The telegraph is his amanuensis. He is imperturbable; nothing disturbs the equanimity of his temper. His head is clear, his mind comprehensive, his action prompt. Familiar with every detail, he takes advantage of every circumstance. He knows every rule and regulation by heart, and the experience, talents and characteristics of the men are as an open book to him.

It is the especial duty of the train dispatcher to designate the meeting and passing places of trains operated by telegraphic directions. Trains are thus kept in motion that would otherwise have to lie inactive awaiting other trains. The convenience that this affords the traveling public and shippers of freight no one but those versed in railway matters appreciate.

It is exceedingly difficult for a number of trains of varying weight and power, advancing from opposite directions upon a single track, to move with the regularity necessary to enable them to meet and pass each other at places designated in advance on the schedule. Many things conspire to accelerate or retard the progress of particular trains, such as the number and weight of cars, the efficiency of engines, the skill of drivers, the state of the track, the character of the grades, the direction of the wind, the density of the atmosphere, the activity of the station force, and the efficiency and industry of conductors and their assistants. The train that moves forward without difficulty at the rate of fifteen miles an hour today may be barely able to make ten miles an hour tomorrow. All these irregularities and inequalities are recognized and provided for by the train dispatcher. He advances trains from one point to another without reference to the schedule, when advantage is to be gained thereby. Thus, trains are moved ahead until slower trains are met, the meeting place depending upon the exigencies of the hour.

When regular trains are moved by telegraph, they do not necessarily lose the rights awarded them by the schedule, except so far as they may be specially affected. The moment a special order is fulfilled, or ceases to operate, the train it concerns resumes the fixed rights it possesses as specified in 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 seeks the protection of a regular train.

Special orders are rarely if ever issued that affect passenger trains, except when they are behind time, in which case the telegraph is brought into requisition for the purpose of expediting their movements, and at the same time keeping other trains in motion.

When there are a great number of freight trains in motion, in excess of those provided for by the schedule, or when they are for any reason delayed, they are moved by the dispatcher on special orders, without much, if any, 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 adapted to the exigencies of each occasion and executes it with clearness, expedition and safety. Of course there are degrees of excellence here as elsewhere; the mind of one dispatcher will be clear, quick to apprehend and execute; the mind of another slow, heavy witted, fatty. The duty requires a good memory and the exercise of the nicest judgment. Where there is more than one track the problems are greatly simplified.

The capacity of a single track road may be doubled and quadrupled by a skillful use of the telegraph in the movement of trains.

The statement appended below of the performance of trains for fourteen consecutive days upon a single track road one hundred and eight miles in length, shows apparently how much business may be done by the skillful use of the telegraph. The bulk of the trains were thus moved. No accident or mishap of any kind attended their manipulation. The results indicate an expert dispatcher and an efficient organization. They demonstrate the possibilities of a single track line.*

The more the question of the movement of trains by telegraph is studied, the simpler it becomes. This is the secret of its popularity and success. Through its aid managers are able to make meagre resources accomplish great results. It is worthy of study and practice therefore in every country.

The so-called staff system is a favorite means of protecting trains on single track roads in England. It may thus be described: The road

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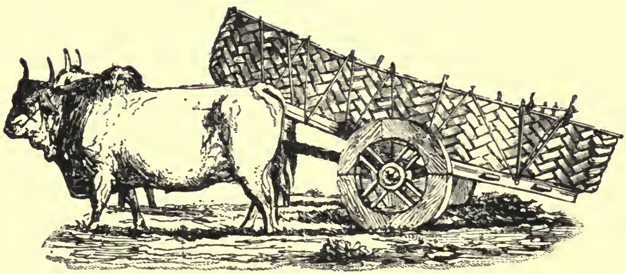
* Total number passenger trains west bound,			56	
" " " " east "			56	
" " freight " west "			308	
" " " " east "			301	
				721
Freight cars in west bound trains, - - - - -			7,701	
Freight cars in east bound trains, - - -			7,272	
				14,973
Average number of cars per train, - - - - -				24.59
" "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

is divided into sections. On starting out, the engineer is 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 can not be started before the staff is returned. On arriving at the end of the section,

Nubian Carriers.

the engineer hands the staff to a designated person and receives another 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 roads use tablets or tickets exclusively.

Some of the drawbacks to the staff system are the time required to return the staff to the starting point and consequent delay of following trains; delivery of the staff by an engineer without being sure that he has the whole of his train; difficulty of delivering the staff to the engineer without slacking speed; liability of dropping or losing the staff en route, etc. The value of the staff system has been 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 can not be reached or used. By this means the necessity of awaiting the return of the staff may be 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 can not 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.



Carriage in India.

CHAPTER VIII.

INCIDENTS AND APPLIANCES CONNECTED WITH THE MOVEMENT OF TRAINS—THE LOCOMOTIVE AND ITS DEVELOPMENT, POSSIBILITIES AND LIMITATIONS—SPEED—LUBRICATION—BRAKES—MARSHALLING TRAINS—SWITCHING BY GRAVITATION, ETC.

In considering the movement of trains, the motive power and other important mechanical appliances can not be ignored. To consider the subject in its entirety, however, is neither desirable nor practicable in a work of this kind. Such elucidation would involve an essay on the varied devices used; a treatise on mechanics, in fact.

The locomotive has a great deal of work to perform besides overcoming the inertia, the dead load, of the train it hauls. It has to overcome the resistance of the air; the back pressure of steam on the pistons; the friction of the working parts of the machine, the axles in their boxes, the wheels on the rails, including that of the flanges when passing over curves; the resistance caused by the oscillation of the train, also that offered by its own weight. In ascending a grade it must lift the train, including its own weight, a distance equal to the height of the ascent.

The resistance of the atmosphere has been found by experiments to be a very important factor with high speed trains, amounting sometimes to more than one-half the total resistance, the greater portion of which applies directly to the locomotive. This was proved by two engines of which the resistance was measured separately and found to be 19.8 pounds per ton at thirty-seven miles an hour. Being coupled together and again tried, the resistance fell to 14.3 pounds per ton, the second engine being masked by the first. It is thought, therefore, that by a suitable contrivance at the front of a locomotive a saving of from eight to ten per cent. of the effective power might be made, and that by shielding the intermediate spaces between the coaches, a further and very material reduction of atmospheric resistance might be effected. "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." *

The resistance to trains has been the subject of much experiment; more so in Europe than in America. The result of these experiments indicates that it requires a force of from four to six pounds per ton of two thousand pounds to move a car slowly on a level and straight track after it has been started. As the speed is increased so

* J. S. Jeans.

also is the resistance. It is claimed that the latter increases with the square of the velocity, *i. e.*, 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 moving power is increased as the speed increases. From experiments made in 1890 on the state railways of France it was found that the maximum power of a passenger locomotive of a certain class was developed at a speed of twenty-one and three-quarter miles per hour, but beyond that the power decreased as the speed increased. The curves of a railroad afford another element of resistance, but the different degrees do not appear to be known. European authorities estimate that, with their cars, which, as a rule, have long and rigid wheel bases, the resistance is increased about one per cent. for each degree of curvature. In America, where the double truck is generally used on cars, the resistance would be less.

The ability of an engine to haul a load increases with its adhesive power, that is, with the weight on its driving wheels, and the size of its boiler. So that, except for the injury to the track and driving wheels of the locomotive, occasioned by enlarging the machine, there would be, practically, no limit to the load that might be hauled. But while this is true, it is also true that to overcome the destructive power occasioned by the increased weight, all the various parts of the machine must be made proportionately strong. This obstacle will, therefore, it is apparent, forever limit the weight of the machine and, consequently, the load it may haul.

The speed with which a locomotive may haul a train will also always be limited, because the retarding force of the train increases greater, relatively, than the speed.

The hauling power of a machine is increased by adding to the number of driving wheels, provided the weight thereon is increased proportionately. In the case of switching engines, the whole weight of the machine is thus placed. Surprising progress has been made in the construction of locomotives, until we have engines especially adapted to the particular uses to which they are to be put.*

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*Among them may be enumerated these:

Light four wheeled switching engines for yards and average service.

Medium four wheeled switching engines for yards and average service.

Light wheeled passenger engines for the various classes of trains on the main line and branches.

Medium wheeled passenger engines for the various classes of trains on the main line and branches.

Heavy wheeled passenger engines for the various classes of trains on the main line and branches.

Heavy six wheeled switching engines for work in the larger terminal yards.

Medium wheeled freight engines for ordinary branch and main line service.

Heavy wheeled freight engines for ordinary branch and main line service.

Consolidation engines for heavy slow freights.

Mogul engines for heavy fast freight and passenger.

Ten wheeled engines for heavy fast freight and passenger.

Decapods for the heaviest work on long grades.

In the calculation of forces that govern a locomotive it is estimated that the force required to make its wheels slip, under normal conditions, is equal to about one-fourth the weight thereon. Forney, in his valuable catechism of the locomotive, says: "The proportion of the adhesion to the weight on the driving wheels is about as follows: On dry sanded rails it is equal to one-third; on perfectly dry rails, without sand, it is one-fourth;

Caucasian Carrier.

under ordinary conditions, without sand, or on wet sanded rails, one-fifth; on wet or frosty rails, one-sixth."

The locomotive is the ideal feature in railway life; the complete train its fullest fruition.

The evolution in the constituent parts of a train since the first one was operated has been great. Gradually the form and utility of the locomotive and car have adjusted themselves to actual conditions of business. At first the latter was merely a duplicate of the old fashioned stage coach. The locomotive differed little from the stationary engine. The utilization of steam was the one thing new. In the pictures still extant of the first car that ran we see a duplicate of the stage coaches then in use. There has been less departure from the original model in England than in America. In England passengers are still required to enter at the side as in olden times, while we, consolidating three or more coaches into one, enter upon platforms designed for the purpose at the ends of the consolidated coach.

The earliest reference to steam engines is said to be made by Hero of Alexandria about 130 B. C. He describes two devices operated by steam, one of which was used for opening and closing the doors of a temple. No great progress seems to have been made in the utilization of this force till the seventeenth century. In the middle of the eighteenth century came Watt and after him Trevithick and Stephenson, who adapted Watt's discovery to locomotives. The first machine manufactured by Stephenson possessed little to recommend it except the idea it illustrated. The improvements that have since been made have been so numerous and important that about all we can credit to Stephenson is the utilization of steam. The development of the locomotive has been like the growth of a tree. The machinery required to construct its intricate parts has had to be invented. Ability to utilize a discovery, therefore, has in every case been dependent upon another discovery or invention. Happily these have gone hand in hand. Thus inventors and manufacturers have advanced until the extent and nature of their efforts surpass our ability to describe. In the early history of railroads an American company offered a prize of four thousand dollars for the best locomotive, the weight of which was not to exceed three and one-half tons; it was to be able to draw fifteen tons and possess a maximum speed of fifteen miles per hour. Today locomotives weigh seventy-five tons and are capable of hauling three thousand tons.

The latest 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 has long been utilized with marine and other engines. Those, however, who do not favor its adaptation to the locomotive claim that the compound engine is not suitable for a variable class of service; is more difficult to keep in condition; is not so regular in performance; costs more for lubricants, and needs more repairs than the ordinary machine.

Many of the locomotives now being constructed can attain a speed of eighty miles an hour. It is impossible to say what rate may be reached hereafter.

The attainment of an average speed of one hundred miles per hour is not visionary. Already trains have been run for considerable distances at an even greater rate. The attendant conditions, however, mean much besides the construction of the machine. They mean that the road bed must be scientifically constructed of the best material and maintained in perfect condition; that bridges must be of commensurate strength; that grade crossings must be carefully guarded, or abolished

Carriage in Buenos Ayres.

altogether; that curves and gradients should be reduced to the minimum; that rails should be of the heaviest type and of the best metal; that equipment should be strongly constructed; that brakes should be efficacious; that switches should be proof from accidental misplacement; that drawbridges should be made secure beyond peradventure; that methods of signaling and operating should be of the most approved character; that employes should be capable, vigilant and trustworthy, and governed by a discipline that will develop their highest capabilities and obedience.*

The speed of trains is an element of enormous economic importance at all times, but especially so in a country where trade centers are widely separated. Carriers may expand or contract these distances at pleasure. Speed is an element of especial importance in suburban travel of railroads, a saving of ten or fifteen minutes being sufficient to enormously increase a traffic.

The speed of trains varies greatly in different countries, according to the character of the road and the traffic hauled. The speed of trains of all

* "The real danger in increasing the speed of expresses driven by steam 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."—*The Spectator*. It is probable that the writer has particular reference to English roads and machinery, especially the latter. The adjustable character of American equipment he probably knows nothing about.

kinds has heretofore averaged higher in England than in America. In England the speed of freight trains is probably double that of similar trains in America, while the average speed of passenger trains is perhaps a third greater. The reason is, the vehicles are lighter and the road bed more carefully constructed. This last obstacle is, however, being rapidly overcome in America. For many years the American companies were poor and the traffic light. Railroads were required to be cheaply built in order to be built at all. Economical management was also a necessity. Neither of these things was conducive to fast trains. Both have, however, been overcome in many, perhaps the majority of instances, so that a speed of sixty miles an hour is not a matter of rare occurrence at the present time.

With growth of business and improvement in construction, railroads will still further increase their speed. Ultimately they will carry three loads where they have carried one. The world is too busy, facilities of carriers too limited and time too valuable to be wasted in getting from place to place. A carrier that can perform in thirty minutes what has before taken an hour and a half, will save so much; his patrons too will be saved, and the commerce of the world accelerated correspondingly. The carriers' profits will be greatly enhanced in the future from increased utilization of his equipment, property and force by increased speed and economy of time.

The added protection that faster trains will need is a detail merely.

Trains earn money only while in motion. The quicker a train reaches its destination, all things considered, the greater the economy. To lessen the speed of a train unnecessarily, or detain it at a switch, station or water tank, adds to the cost of operating and reduces the earnings capacity, not only of the train, but of the property as a whole. The time will come in the operation of railways when nothing but the loading and unloading of traffic will be allowed to impede the the progress of a train.

Carriage in Madeira.

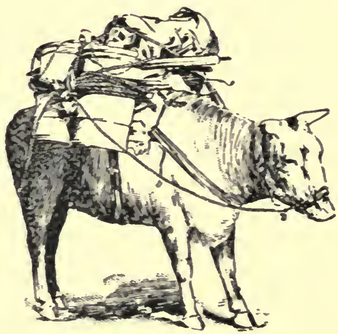
In conclusion it may be said that the more nearly a train can be moved at a uniform rate of speed, wherever the character of the road is similar, the better. How to secure this uniformity occupies the thought of those concerned in such matters. One means is the use of automatic records indicating the speed of the train at every point thoroughout its course. After the trip is over these records are forwarded to the person whose duty it is to look after the matter. Any loitering or undue haste he discovers. It follows from this that those who operate trains most favorably receive credit therefor, while those who are inefficient do not escape detection. Two things of especial importance are secured, avoidance of undue wear and tear of property by reckless running, and waste of time by idleness and inefficiency.

The movement of trains each year becomes more orderly, more regular. Improvement will go on, it is probable, so long as railways are operated. A perfect train service is not attainable, any more than perfection in anything else. However, it may approximate perfection. One of the means to this end is more perfect appliances. Among others may be mentioned a journal box that will not heat. Those versed in such matters ascribe hot boxes to defects in design, poor quality of metal and the use of inferior oil or waste. They are also caused by insufficient lubricants and by allowing the waste next the journal to become foul through imperfect protection from dust or long use. In the latter case the lubricant can not percolate through the waste to reach the journal, a gummy surface forming on the waste preventing perfect lubrication. Hot boxes are also caused by fibres of waste working between the bearing and the journal; also by use of new waste and heavy and continued application of brakes.

To prevent hot boxes, frequent and careful examination must be made and defects remedied. The difficulty may be avoided by frequent application of small quantities of good oil and so constructing the boxes as to prevent the entrance of dust. These measures, while difficult of fulfillment, are not impossible.

Great advancement has been made in the economical use of lubricants; by tests; by comparison of results; by more careful and scientific methods of preparation and use; by mixing different qualities and grades for different uses; by the application of devices whereby the parts are fed with oil drop by drop as needed. It is apparent, however, that methods and devices are still exceedingly crude and that great advances are likely to be made in this branch of the service in the near future. There is great room for improvement in the quality of the lubricants used and in devices for applying them automatically and otherwise. In the practical application of oils only enough oil should be applied to create a film between the journal and the bearing,—a drop. How different is this from early practices. A system of comparisons of records of oil used on different engines has had a beneficial effect in creating interest in the subject. Similar comparisons of car mileage with given quantities of different oils and appliances have also led to valuable results.

The brake is another important device in the movement of trains. Its requirements are, however, not much better known, generally, today than fifty years ago. Great improvements have, however, been made. But what we esteem perfect today is far from satisfactory tomorrow. So far as we are able to judge, at this time, a perfect brake is one that perfectly controls the train under every circumstance as regards speed, weather, load and grade. It must be automatic and self applied in case of the separation of a train or other accident. It must work uniformly in stopping and release its hold quickly and surely when its application is no longer needed. It must be simple, quickly and easily repaired,



Carrier of Japan.

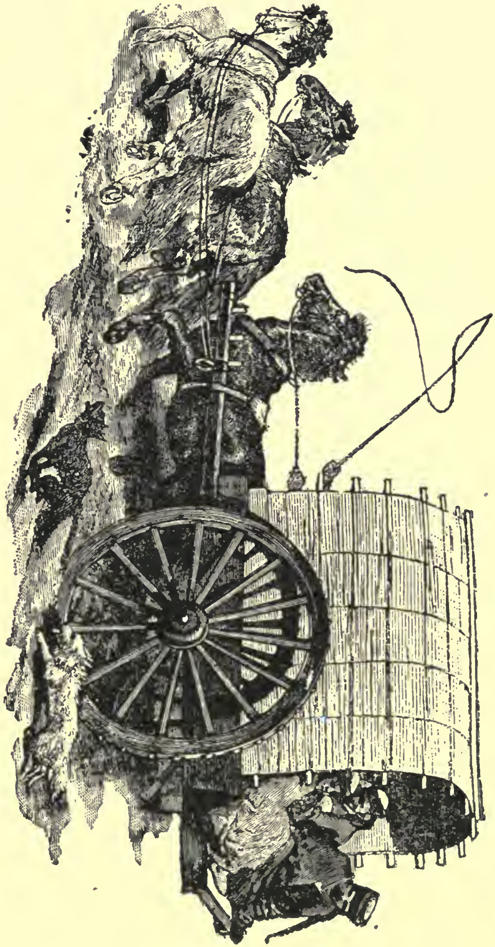
and reasonably economical as regards construction and maintenance. In the use of brakes, especially those operated by steam or air, the brake shoe becomes a thing of great importance; the action of the brake on the wheel is directly affected by its quality. These shoes are made of cast or wrought iron, cast steel, combinations of iron and steel, wood, leather, and even paper. It is desirable, in order to secure uniform application, that the material of which the brake shoe is made should be uniform. A writer on this subject says:*

"The same air pressure throughout a train of cars on which shoes of different hardness are used, will apply a widely different friction on the wheels of the different cars. It is then impossible to obtain the maximum braking power for hard shoes without sliding those wheels to which soft shoes are applied. It is desirable to fix upon a standard mixture for foundrymen making cast iron brake shoes. Brake shoes are made for three kinds of service: on chilled wheels, on steel tired driver wheels, and on steel tired coach wheels. Those designed for the first mentioned service are made of cast iron, or cast iron with wrought iron pieces in the face, or cast iron with chilled sections. . . . When cast iron is used a strong, tough metal soft enough to grip the wheels is economical, although its first cost is greater than a burnt grate bar scrap mixture. A mixture of number two foundry car wheels and heavy cast scrap has given good results. The combination cast and wrought iron shoe is much more durable than the plain shoe, and more desirable in respect to uniformity, because the same amount of wrought iron, forming one half the surface of each shoe, will be nearly of the same hardness. . . When two surfaces rub together the harder will abrade the softer and the latter wear away quicker, but we are limited in the hardness of the shoes by the co-efficient of friction necessary. They must be hard enough to press the tire, without the case hardening of spots which will score it, but soft enough to afford the fric-

* George M. Sargent.

tion necessary to make stops. It is evident that for the different classes of engines different kinds of shoes will be required. The suburban passenger engine, making frequent stops, should be equipped with shoes less hard than applied on a through passenger engine. The combination cast iron and steel shoe has the advantage that the proportion of each metal may be varied to suit the requirements of the service. Brake shoes for steel tired coach wheels are applied under entirely different conditions. They are made either plain or flanged. The plain cast shoe should be soft and tough. Whatever kind of metal is used in the flange coach shoe, care should be taken that the shoe is a good fit to the tire and so hung that the flange grooves in the shoes are directly opposite to the wheel flange, and above all that the brake beam be free to move laterally as the wheel and axle move. Experiments have proved that a brake beam hung rigidly from the truck, in combination with the flange brake shoes, forms a grinding machine capable of turning a V shaped flange, and that even with the plain shoe, lateral motion is of decided advantage in protecting the flange."

Another important problem involved in the movement of trains is the marshalling of freight cars into trains. This is largely done at junctions and centers where the business handled is large. In order to insure economical movement of traffic it is necessary that trains shall run uninterruptedly and with full loads between important points and that the traffic of intermediate stations should be cared for by way trains, which will also collect the through business and



Carriage in Cashgar.

carry it to the junctions where it may be classified and marshalled into trains that will take it through to its destination. Many plans for the expeditious making up of trains are in vogue, including unique sidings and turntables of various devices and degrees of utility. I do not know that I can close this chapter more profitably than by describing the system of switching and marshalling of trains by gravitation as practiced on an English road. The arrangement is thus described by the manager of the line:* "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

*Colonel Findlay.

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." The system of switching thus described grew out of the peculiarities of the ground and the impossibility of selecting any other. The emergency suggested the method of switching described. Its more general use in the future is likely to grow ort of the experiment.

Carriage in Pekin, China.

CHAPTER IX.

RAILWAY ACCIDENTS AND THEIR PREVENTION—(PART ONE.)

The occurrence of accidents is rightly esteemed to be inseparable from travel. This will be the case so long as man is fallible and his devices fall short of absolute perfection. Accidents are the penalty we pay for abandoning primitive methods of travel; for emancipation from humdrum conditions. Each day's experience, each new device, however, makes them more rare upon railroads. That they ever can be wholly avoided is not probable. But such catastrophes as the collision of two trains; trains running into open draw bridges; mishaps at switches, and so on, will, it is probable, be in time wholly avoided by the use of automatic appliances and other devices.

Railway accidents have, from the first, been the lurid theme of impassioned writers and speakers. It is a favorite metaphor with them that thousands are annually doomed to death because of the cupidity and carelessness of railway companies. This is not true even in part. These carriers employ such safeguards as come within their knowledge and means. When a man is run over by a truck 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 is required to be exercised in contemplating railway accidents. It is, for instance, just as reasonable to require that trucks and omnibuses shall not frequent the streets we walk upon as it is that passengers shall be absolutely excluded from the track of a railway. Such safeguards as are reasonable, and within the ability of the carrier to

Carriage in Rustchuk, Turkey.

provide, should be provided. The matter is one to be regulated by good sense and the pecuniary interests of the carrier and those he serves.

Marked interest is evinced by railways in all safety appliances, and, stimulated thereby, inventors have been and are making surprising progress in such matters.

Railways are interested in adopting appliances that afford the greatest protection; this on humanitarian grounds and on grounds of self-interest. If they sometimes appear dilatory, it is because their means are circumscribed or the devices are unknown to them or untried. In the multiplicity of devices offered, it is difficult even for experts to separate those that are valuable from those that are worthless. The clamor of inventors and promoters only heightens the doubt and confusion.

In this connection it will be instructive and interesting to review briefly some of the devices that have been tested and found useful. And first the interlocking switch. This device is worked from a central point, or tower. It is especially valuable in yards, at railroad crossings and draw bridges. It is a contrivance by which a track upon which a train is proceeding is closed to all others. Thus, if the switchman in the tower at a point where two or more railways cross each other 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 roads, so that the trains of the latter are derailed or diverted in the event they attempt to cross.

Aside from the safety that the interlocking switch affords at railroad crossings, the fact that trains may cross without stopping when the track is clear adds enormously to the value of the device. The interlocking switch, as a safety device and means of facilitating business, is also of value at draw bridges. In the latter case, the draw in opening, by a mechanical device, disconnects the track approaches to the bridge, so that an engine or train that does not stop (*i. e.*, disregards the signal) is diverted or derailed. The fact that this prevents absolutely any train running into an open draw renders it unnecessary, as a precautionary measure, for trains to stop that approach such bridges when the draw is closed.

The split switch is another mechanical device (not dependent upon man's carefulness) by which an open switch in front of a train is closed mechanically by the action of the wheels of the locomotive.

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.*

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*Of all safety appliances, the air brake is probably the most important. It has reduced the distance in which a train can be stopped to one-fifth of the distance in which it could be stopped by hand brakes, or perhaps even less; that is, it has been shown in actual trials that a train of fifty cars running at forty miles an hour can not 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 with the air brake. Indeed, a fast express train with the aid of the air brake apparatus in good condition ought to be stopped from a speed of forty miles an hour within its own

The block system is a contrivance to prevent accidents. If the principle upon which it is based is enforced, two trains or engines can not be upon a block or section of track at the same time; thus, if two trains are going south, the first must have passed from a section before the other can enter it. But the block system will not prevent accidents where its working depends upon man's care or intelligence. Accidents under such circumstances have been both numerous and disastrous. Thus, through oversight a section will be reported clear by the signalman when it is not; it may be occupied by a train, or by a switching engine or a detached car. The signalman is not more infallible than ordinary mortals; indeed, where low priced men are employed, as is frequently the case, they are exceedingly fallible. Opportunities for omissions and mistakes are numerous and aggravating. This system, while affording considerable security, is far from infallible.

The devices that are being introduced every day for operating the block system automatically

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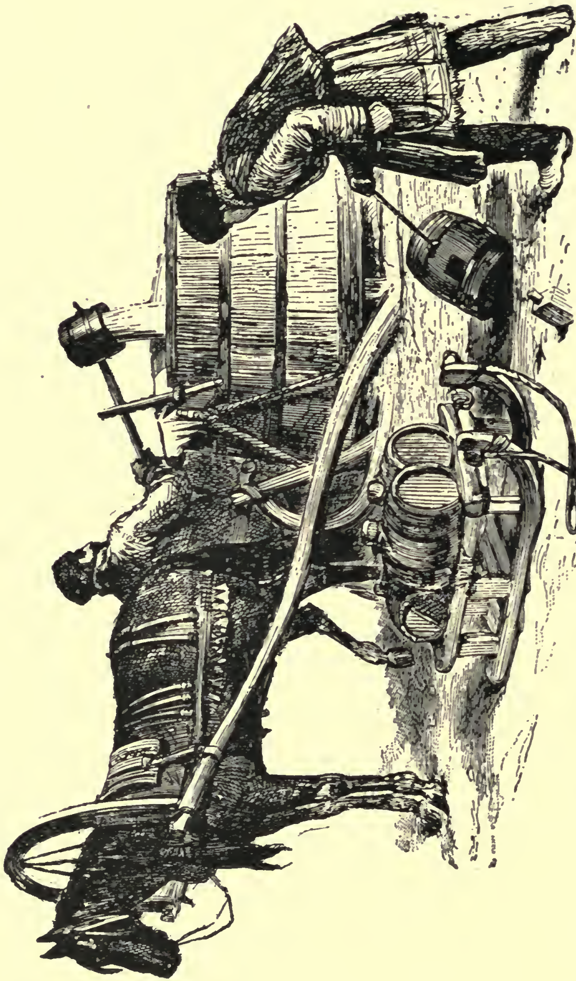
length. But the most remarkable fact about the air brake is the automatic feature. It is this feature which stops a train if broken in two, or if the hose is burst. It also enables the train to be stopped instantly from any car without the loss of time necessary to communicate with the engineer. But 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 freight train, and that will make it possible to run long and heavy passenger trains at speeds that are now seldom reached."—*Arthur W. Soper.*



Carriage in St. Petersburg.

are both numerous and interesting, and indicate that railway trains will sooner or later be protected absolutely in this way. The cost is so great, however, that the expense can not be borne except where the business of a road is large and remunerative.

The automatic systems that just at this time are attracting more attention than any others may be described as follows: Under one system 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, nothing would indicate the fact. On the contrary, so far as the signals indicated, the track would be clear when the train referred to left the station.

Under another automatic device, by which the track is protected as indicated above, the signals would remain at danger if a car should be detached en route, or if there should be even a pair of trucks left on the section; the electrical device governing the signals is connected and disconnected 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 this purpose as a whole train and would keep the signals at danger until removed.

It is claimed for both these systems that, in the event the apparatus is out of order in any way, the effect is instantly to place the signals protecting the section at danger. Both these automatic devices are great advances over anything previously known, though of course the last described is much more perfect than the first. But until these systems, and all others, are supplemented by another device that will divert automatically any engine or vehicle from a section that is occupied (until, in fact, the efficacy of the system is not in any way dependent upon the watchfulness of the engineer or fireman), we shall be very far from what is needed to protect trains on the main track. As already explained, the expense of any of the block systems described is much too great to be warranted on railroads generally, but upon nearly every railroad there is some portion of the line that would warrant such a system, where, in fact, the needs of business justify its introduction.

Various devices are in more or less use as substitutes for the dangerous car stove and lamp. Gas and electricity are replacing the oil lamps, while steam promises to supplant the stove.

The automatic coupler is another device intended to facilitate work and prevent accidents. Its use renders it unnecessary for trainmen to go between the vehicles to couple or uncouple them, thus one of the most prolific causes of accident to employes is surmounted, while work is greatly simplified and accelerated. Automatic couplers are no longer confined to the cars of passenger trains, but are rapidly coming into use on all kinds of cars. A recent order of the Interstate Commerce Commission of the United States specifying the standard height of drawbars will further accelerate this.*

Uniformity of height of drawbar is necessary to secure proper utilization of the project to adopt a uniform automatic car coupler. And in regard to this latter, it is probable that no appliance ever conceived approaches it in value as a safety device for employes. The accidents to employes that have occurred in coupling and uncoupling cars since railroads have first been introduced have been very great in number and frequency. Referring to this subject, Mr. 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

*The order is as follows: "It is ordered, that notice be at once given to all common carriers, owners, or lessees engaged in interstate commerce in the United States, that the standard height of drawbars for freight cars, measured perpendicular from the level of the tops of the rails to the centers of the drawbars, has been designated and determined by the American Railway Association, mentioned in the Act of Congress, approved March 2d, 1893, as to be thirty-four and one-half inches for standard gauge railroads in the United States, and twenty-six inches for narrow gauge railroads in the United States; that the maximum variation from such standard height to be allowed between the drawbars of empty and loaded cars, both for standard and narrow gauge railroads in the United States, has been fixed and determined by said Association at three inches; and that such determination has been duly certified by said Association to the Interstate Commerce Commission."

itself down to where there were six links and pins and six vertical hooks 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 railroad 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."

Another device is that by which two or more vehicles are thrown into one by means of the so-called vestibule, by which people are prevented from falling from the platforms while the train is in motion. Its effect also is to steady the train and greatly mitigate the effects of collisions.

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

Insertion of blocks of wood or other material in the space between the rails at frogs is another safety device of especial value to railway men.

Little progress has been made in strengthening passenger cars. It is not too much to say that the maximum security that may be thus attained is not too much to ask. Where the resources of a company are limited, comfort may here be measurably sacrificed to safety. Too much thought can not be given the subject. Humanity and business interests alike suggest it. This fact both manufacturers and carriers appreciate more and more every day.

While freight cars have been greatly strengthened and their carrying capacity doubled, and in some cases trebled, very little progress has been made in passenger cars. They are not much, if any, stronger than formerly, while the proportion that the dead load bears to the paying load is greater now than ever before. The tendency is in the direction of more elaborate and costly decorations, fixtures and furniture. The tendency is to make passenger cars more costly to build, more expensive to maintain, but without adding to their seating capacity. In some of the passenger day cars exhibited in Chicago the amount

Carriage in Russia.

of dead weight per passenger equalled one thousand two hundred and sixty pounds; it did not formerly exceed eight hundred pounds. In adding to the weight of passenger cars they are not more able to resist the effects of derailment or collision than formerly. When they come together they still continue to telescope, notwithstanding the protestations of the car builder that they will not; and when they turn on their side, collapse as quickly as in earlier days. It is probable that with increased experience greater care will be taken to protect the ends and sides of cars and less attention will be paid to ostentatious decorations and costly woods.

In considering the subject of railway accidents it should not be forgotten that passengers must be protected from themselves, from their own ignorance and carelessness. The erection of fences between the tracks at stations so as to prevent passengers from getting off the cars in front of moving trains has this purpose in view. Ultimately, it is probable, the practice will become more general. In the absence of fences, closed gates on the platforms of cars, compelling passengers to alight on the right side of the train, are sometimes used. As a rule English and continental railways use fences and overhead bridges at stations to prevent access to the tracks; in the absence of such devices through trains must stop at, or pass slowly, stations where other trains are loading or unloading passengers. One of the chief recommendations of the compartment car is that it compels people to enter from the station platform and to alight thereon.

Safety appliances, to be of the greatest value, must be mechanical in their action; must not depend for their efficacy upon the care of employes. The time will undoubtedly come in railway practice when every train will be protected by automatic devices. Roads will be divided throughout into sections and the operation of the block system so perfected 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 be avoided. The problem does not offer insurmountable or impracticable difficulties. Expense is the deterring element. Wherever railways can afford it, man's ingenuity will quickly find the way.

A melancholy feature of railway operations is the accidents to employes. They are partly unavoidable, partly the result of imperfect appliances, partly the result of indifference (oftentimes contemptuous) of those immediately concerned. Everyone connected with the movement of trains is familiar with the risks incurred. While sometimes unavoidable, they may be minimized by the use of safety appliances and the exercise of care and intelligence. That progress is being made is evinced by the fact that accidents grow fewer, relatively, each year. Efforts in this direction are co-operative; trains are handled more scientifically; train men are more careful, more experienced, more efficient; yard men are more skillful; the yards themselves are safer, have better appliances, are better arranged and better lighted at night; automatic couplers and other fixtures for handling cars with safety are becoming more and more general; the road bed and its appurtenances are each year rendered safer.

Information in regard to train accidents is exceedingly meagre; thus we do not know how many accidents occur from neglect to protect trains standing upon the main track from rear collisions; how many other accidents are the result of carelessness, of incompetency, of inexperience, of excusable mistakes and omissions, of defective appliances, of imperfect rules and regulations.

Of all the dangers that menace trains, those from rear collisions are, perhaps, the most imminent. The block system provides the best safeguard against collisions of this nature now in general use. To the extent, however, that its operations are dependent upon the care or watchfulness of man, it is defective. Upon the majority of roads the protection of the rear of trains is left to the brakeman. That he fulfills his duty with reasonable intelligence and faithfulness there can be no doubt. The trustworthiness of many such employes has, however, never been tried. Whether they will perform their work faithfully is, consequently, always an open question. That the difficulties of the situation tempt them in many instances to slight their duty there can be no doubt; the weather may be inclement, the time unpropitious, the distance they must walk if left behind, or the time they must wait if left to be taken up by another train, tempt them oftentimes to omit needed precautions. Many things render the brakeman unwilling to go back any further than he is compelled to in flagging his train. The sufficiency of the service is, therefore, always doubtful, oftentimes questionable. His discretion, however, is fortunately shared with the conductor

Carriage in Spain.

and engineer. It has been suggested that the responsibility of protecting the rear of the train might better be vested wholly in the latter.

One difficulty of the service is the necessity oftentimes of employing unskilled and untried men. Any sudden increase in the traffic of a railroad necessitates the employment of new men; of placing upon the directing and operating force burdens to which they have not been accustomed. Thus, there is less danger of a collision on a road running fifty trains a day regularly than on one which, having been accustomed to run only twenty trains, suddenly increases the number to forty.

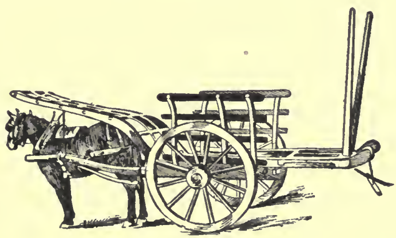
Taking the accidents of railways as a whole, undoubtedly the larger proportion is the result of causes beyond reasonable control. The attempt of carriers to improve their service is constant, even where the means are crude.

A comparison of the methods of railroads in different countries shows that they are constantly borrowing of each other. Each will be benefitted by familiarity with the practices of the other. The experiences of each are peculiar; thus, the English roads have had much greater experience than those in America in the conduct of heavy traffic through a densely populated country. This experience American companies may utilize to advantage in many ways; the problems that such a traffic engender press upon them more and more each year. In all matters affecting the movement of trains the ounce of prevention is worth the ton of cure.

A frequent cause of train accidents upon cheaply built and equipped roads is the attempt to make excessive speed with freight trains. When appliances are not adequate these trains should be run at a very moderate rate of speed, and the rules of every road contemplate this—in theory. As a matter of fact freight trains are more often than otherwise run at a much higher rate of speed than the rules allow. In many cases the traffic demands it.

Wherever changes in the service are frequent or laxity of discipline prevails, accidents will be frequent. Those familiar with the details of the service often have occasion to notice that things forbidden under the rules are really matters of every day, perhaps hourly, occurrence. So long as an accident does not follow, the infringement is allowed to pass unnoticed. In partial 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 greatly weaken the discipline of the force; to make it disregard essentials as well as non-essentials. The result finally is disastrous. Rules, however necessary, will not enforce themselves; they must be intelligently, uniformly and consistently administered. The occasional discharge of an offender because a practice which he and his associates have for a long time 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 offence is quite likely repeated. Reliance on the fear of dismissal as a means of discipline is unworthy an enlightened management. But, on the other hand, the strictness and refinement of military rule can not at present be attained in the railway service, nor would such discipline apparently conduce to the benefit of carriers in a business way in dealing with a commercial community.

The dealings of railroads with employes as well as with patrons are based on business principles. In this way the temper, ambition and affection of men, as well as the economic law of supply and demand, are not lost sight of. Not only is it necessary that men who have to do with the movement of trains, and who are responsible for their safety, should be carefully chosen, but they must be made to feel that methods and results are intelligently scanned; that the rules framed for their government are



Carriage in Jersey.

reasonable and necessary and that faithful compliance with the same will result to their advantage.

In judicial notices of railway accidents, the inclination of judges and juries to place a charitable construction on the acts of those concerned, is observable. They remember that it is human to err; that perfection is a divine attribute. There is, however, a growing disposition to hold railway employes 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 imprisonment. It may go still further. Such punishment, however, is to be regarded as impersonal, as disciplinary merely; as evidencing a determination, where life is intrusted to men, to compel them to meet all requirements of the emergency without reference to their fallibility. This disposition is to be deplored. But, while deploring it, we can not but recognize it as a progressive step; one that, while likely to be frought with more or less injustice to individuals, will in its results redound finally to the good of employes quite as much as to the public. The equities of the case should, however, be observed by public prosecutors. Discrimination should not be practiced; want of care and observance of necessary precautions upon the part of the community itself is noticeable. To these are attributable a large percentage of the fatalities and injuries that occur. Our laws are exceedingly remiss in this respect, and such as we have are not enforced. Thus, men get on and off the cars while in motion, trespass upon the track of railroads, contrary to the laws, and when accident or death overtakes them the press and 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 the property of the company, the magistrate releases him in every case. When judges and juries are found who will send men to jail or fine them for trespassing upon the property of railroads, the offence will cease, but not until then. But few people are killed or injured in Germany at road crossings, although crossings at grade are as frequent 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 signal man has warned him back would be fined or imprisoned. In America the carrier would be blamed and the victim acquitted.

Because of the newness of the country and the poverty of carriers the American railroads are far behind those of Europe in providing station precautions. Those in Germany are much more ample. Fewer people are killed and injured by the railroads, relatively, in England than anywhere else. There, however, carriers have gone to the extreme in precautionary measures, with the result that untold sums of money have been sunk in safety appliances, which should have been used to secure lower rates and greater station and train facilities.

Vast expenditures have been made by the English railroads for tunnels, overhead bridges, and in the introduction and enforcement of the block system that might better have been expended for equipment and sidings. The comforts and necessities of a people as a whole are more important than an isolated life that requires for its preservation the constant watchfulness of policemen and the presence of superabundant and costly appliances. The English craze for safety appliances sets half the world watching the other half to keep it from being run over. Every dollar wasted in this way is so much withdrawn from the ability of railroads to make low rates; so much added to the cost of living; so much added to the cost of the necessaries of life. A happy mean should be observed here as elsewhere. It is to be found in the calm, dispassionate co-operation of the state and the carrier. If this can not be secured, then the matter should be left absolutely to the carrier. He will not abuse the trust and is not likely to sacrifice the material interests of the community in vain efforts to attain theoretical ends.*

It is said that 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 still much less than the risk incurred in traversing the streets of cities and the highways of a country. While the precautions that railways adopt to prevent accidents are each year more complete, the most effective preventive after all is the growing knowledge, intelligence and experience of the community.

The easy approach to railway tracks in America and the indisposition of the courts to enforce necessary regulations, greatly increase

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* The legal and medical aspect of the question of the settlement of claims on account of persons killed and injured by railroads is referred to in connection with the duties of the attorney in the volume "Organization and Forces."

Carriage in South Africa.

the number of casualties from moving trains. The absence of proper precautions in some cases by carriers has not arisen so much from lack of appreciation as from absence of necessary means. When roads do not render any return upon the investment, or at best an inadequate one, owners can not be expected to provide precautions against ordinary casualties from their personal means.

In the operations of railroads complete freedom from danger, it may be said generally, can only be secured by prodigious expenditure. It requires, among other things, that access to tracks shall be prohibited; that there shall be no grade crossings; that at stations access to the track shall be prevented; that trains shall run at low rates of speed.

The statistics of railroads show that the mishaps of trespassers greatly exceed those of employes or passengers.* The occasion of accidents at grade crossings have been thus enumerated by a writer on the subject: (*a*) The number of tracks; (*b*) the speed at which trains are run; (*c*) the number of trains; (*d*) the character

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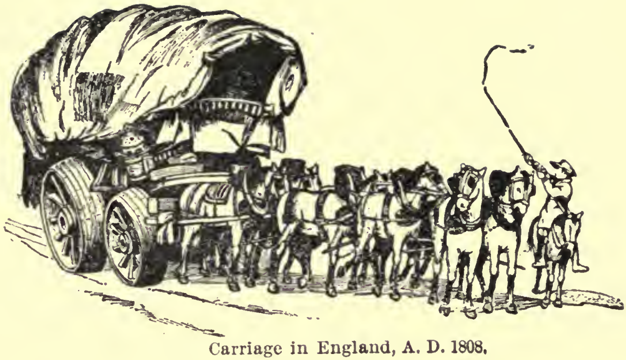
*Writing on this subject in their annual report for 1891 the Massachusetts Board of Railway Commissioners state: "About a year ago a member of the board, in coming from Beverly to Boston on the train leaving Beverly at 4:10 p. m. and arriving at Boston at 5:05 p. m., counted one hundred trespassers on 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.

of the approach to the railroad by the highway, *i. e.*, whether the highway approaches the track on a level, or ascends or descends to it; (*e*) the number of vehicles and pedestrians using the highway and the character of the traffic. The statistics of accidents at crossings protected by gates show that they arise mainly from the neglect of gatemen; from their inability to calculate the speed at which trains are moving; from the inability of drivers to control their horses, and from the haste, inattention and indifference of pedestrians. By far the greater number is occasioned by the refusal of the public to regard the signals of the gateman.



Carriage in England, A. D. 1808.

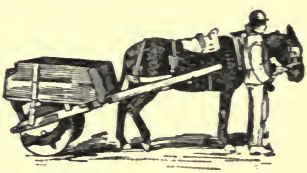
CHAPTER X.

RAILWAY ACCIDENTS AND THEIR PREVENTION—(PART TWO.)

In the United States railways have from the start 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. The kind of line builders should construct was not regarded so long as it was reasonably safe for passengers and freight. While this method of construction is unavoidable in new or poor countries, it entails hardship afterward, both on the carrier and the community. It is impossible to prevent accidents occurring on such a line; every crossing invites them, while the use of the track as a highway by pedestrians, which public opinion will not condemn and magistrates will not punish, adds to the embarrassment.

The grade crossing is the *bete noir* of railways. Much has been said, and wisely, in regard to its abolishment. But the practicability of so radical a change is oftentimes not considered. The owners of railroads are more sensible of the advantages to be derived from the abolishment of grade crossings than anyone else, and when their resources warrant it the change is quickly made.

But like prudent business men in every walk of life, they are governed by the income of the property. In every case where resources permit it, and in many cases where they do not, overhead or underground crossings have been provided. This has been especially so in the vicinity of cities. There is every inducement afforded railroads to make these changes as rapidly as possible; it relieves them of public criticism, expedites business and lessens expenses in certain ways. Judicious agitation of the subject within these limits is not harmful. But action, when



Carriage in Ireland.

taken, must be of a conservative character; must be a matter of consultation and agreement between the authorities and the railroad companies; must not be dictated by public clamor. It must take cognizance not only of the desirability of the change, but of the ability of the railroad to make it. In some cases the cost of the change should be borne by the railroad company; in many instances it should be borne by the community. If equitably distributed, it will tend to prevent undue multiplication of crossings, occasion greater conservatism, and lessen injustice.

Reference has been made to the grade crossings in Germany. The law of that country requires that they shall be strictly guarded. They must be provided with strong and visible gates. Turnstiles are required for pedestrians. Bells must be rung at crossings before closing the gates. Gates operated from a distance are limited to highways upon which there is little travel. Dangerous crossings are required to be minutely watched. Gates must be closed three minutes before the arrival of trains and this limit can not be shortened without permission from the authorities. Gates at private crossings must be kept locked. Gates at public crossings where travel is light may be kept locked if permitted by the local government board, but must be opened at the request of persons desiring to pass. This is indicated by their ringing a bell, with which these crossings are provided. Women are allowed to attend crossings and are found to fill the position admirably.

While the German roads are governed with military precision and employes are held to a rigid accountability, the public, on the other hand, must observe every rule 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 station precincts no one except those connected with the line is permitted. Fines are imposed where regulations are disregarded. Railway employes are clothed with police power to enforce regulations; it is owing to this fact and its rigid enforcement that accidents on German railroads, at crossings and through trespassing, are so much more rare in Germany than in America.

Another phase of the subject is the protection that shall be afforded where railroad tracks cross each other; it is second only in importance to that of road crossings. Each day adds to its interest and importance. The practice in America is to cross at grade; an overhead bridge or tunnel is the exception. At many points a little skill and additional cost would have avoided a grade crossing. But this latter could not be afforded in the early history of railroads. It is so in many cases today.

The inconvenience of grade crossings is not appreciated in the early construction of railroads. It is only when trains have been greatly multiplied that the danger and embarrassment are fully realized. When business is light and trains are few, railroads cross each other at grade without stopping, but as traffic increases the practice is discontinued voluntarily or laws are made requiring it. Where, however, crossings are protected by interlocking switches, referred to elsewhere, it is not necessary to stop when the track is clear. No more admirable or ingenious device has ever been invented for the protection of

Carriage in Gwalior.

trains than the interlocking switch, and there can be no doubt but that its use will become universal at draw bridges and railroad crossings.

Whenever a safety appliance is practicable, and within the means of a company, its adoption follows as a matter of course. The self interest of the carrier requires it. Extraneous interference is not necessary to secure this, though governmental supervision can do no harm if experienced and not animated by demagogical influences. The pecuniary interests of the owner compel him to be vigilant. Diminution of prestige, destruction of property, loss of revenue, expenses incurred, delay of traffic and the loss of the confidence of the community afford an all sufficient incentive to him to adopt measures to prevent accidents. Every avoidable mishap is a reflection on the company responsible therefor. If occasioned by the ignorance, indifference or inefficiency of an employe or lack of proper appliances, the case is aggravated. The owners of railroads are therefore bound, in self defense, to adopt every possible precaution. They do this in the physical appliances they use, in the servants they employ and in their method of governing them. There is no incentive so great as that of self interest, and it is to the interest of owners to see that necessary rules and regulations are established for the protection of lives and property. Every reasonable precaution is taken to prevent accidents to life or limb. But to say that every human precaution should be taken, is to exaggerate the situation. The revenues of the world would not meet this requirement. As soon might the law making power say that the people should be taxed to provide precautionary measures until not an accident could happen on the streets and highways. 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 reasonable precautions shall be taken.

The safeguards that railways are able to throw around the public to protect it from accidents and death depend, as in the case of private individuals, upon the amount they are able to expend in this direction; upon their income; upon the profitableness of their business. A company with an unproductive business can not keep up its property to the maximum standard or provide many desirable safeguards. This is also true in many cases of railways doing a profitable business but unable to borrow money; such properties are numerous in every new country and in many old countries. These and many other conditions must be taken into account in considering the relative care exercised by railways. Where means justify it will be evinced in many ways: in the intelligent discernment of managers; in the strength and durability of the permanent way; in stable bridges and culverts; in good equipment; in the character of the signal service; in precautions taken at stations and crossings; in payment of wages needed to secure competent men; in traffic facilities.

A company operating an unproductive property can not 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 misappropriated or frittered away. And in this last connection it may be said that every death that occurs, every injury that is inflicted, every dollar of property that is destroyed, when the inability of the carrier to prevent the same grows out of the interference of the state or its disregard of well known trade laws in governing railway properties, should be paid for by the public.

The mishaps of every kind 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. In all cases men are governed 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, bridges, yards, stations and a traffic force. These are the concomitants of life. If there is anything to spare, that is, if there is more than enough to operate the property and pay interest on its capital, then the luxuries of life intervene, such as stone culverts, steel bridges, fully appointed cars, a carefully regulated signal service, well guarded crossings and so on. These things depend wholly upon the productiveness of a property. When business does not warrant it, railways can not afford more than 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 accidents or the diseases that nature imposes as a penalty for violated laws. Nothing can prevent this class from getting in the way of moving trains or suc-

Carriage in Jowaki, Northwestern India.

cumbing to the thousand and one dangers of life. In providing safeguards, therefore, they need receive only cursory attention. They are fated! God himself, it seems, has denied them the instinct of life, the disposition to guard it with reasonable care. In the operations of railroads it is easy to adopt so many precautions as to render it impossible for business to be done

*Safety devices of railways find further reference in the volume "Financing, Building and Maintaining."

as cheaply as the necessities of the public require; to prevent carriers rendering the accommodation that is necessary to enable the people to live comfortably. There are many things in the world of greater consequence than the preservation of the lives of isolated individuals. Such sacrifices, however much to be regretted, are not by any means the greatest calamity a community or country can suffer. For this reason adoption of precautionary measures by railroads must be left for those to deal with who are familiar with the properties and the duties the public good requires of them; they only are able to weigh the good of the community as a whole in the balance against the vicissitudes of the few.

Enactments of different countries are not uniform as to the precautionary measures railways shall take to prevent accidents. While in the main fair, they are unjust, unwise and excessively severe in many cases. The safeguards that carriers should be required to enforce should, as already pointed out, be in harmony with their business and income. Anything expended in excess of this is a restriction placed upon the commerce and the necessaries of a country. There can be no doubt but that the English people pay altogether too high a price for their arbitrary enactments against railways in this direction. Their effect has been to add fully six per cent. to the operating expenses of railroads, and the high rates charged are due to this fact.

The power of the state to enforce needed safeguards is now universally recognized. But the possession of this power is valuable mainly for its quieting effect on the public mind. It should be used carefully and sparingly. There can be

Carriage in Central Asia.

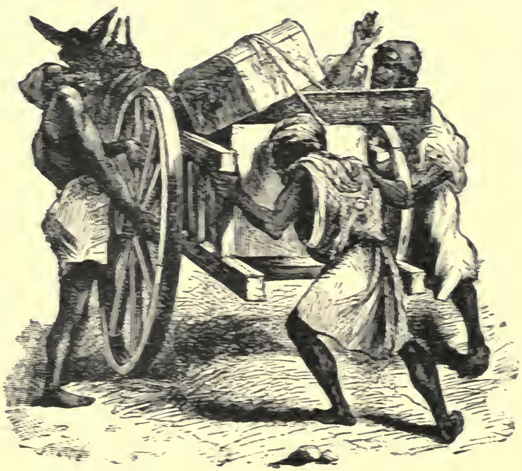
no doubt of the disposition of carriers to take up such matters as rapidly as circumstances will permit. When so taken up the work is done intelligently and without sacrificing other and greater interests. Arbitrary interference of governments, while beneficent in particular things, will, in the majority of instances, result in greater harm than good. Such interference, moreover, when frequent and systematic, is to be deplored because of its tendency to lessen the responsibility of carriers; because of the opening it affords them to shield themselves behind the government. Under such conditions it quickly becomes necessary for the government to take the initiative in every case, thus substituting for the experienced servants of the carrier the spasmodic and ill-conceived efforts of a less trained body of men.*

The devices of railways require, in every instance, to be passed upon by experts. Their use, when approved, is qualified in various ways, as already pointed out. But it follows from the ever present self interest of the owner that those best adapted to the service receive his attention and preference. In order to attain the highest efficiency of the service that is possible, *i. e.*, in

* It was not until a great and inexcusable accident happened in Ireland in 1889, caused by operating cars without brakes, that the British government enforced the system of continuous brakes and interlocking switches. This late action would not have been necessary had the government exercised intelligently its supervisory power *before* the accident: a suggestion to the railway company on whose line the accident happened that it should supply its cars with better brakes, would have secured action on its part. In matters of this kind it may be safely assumed in every instance that a government will not act, even when it has the power, except in some great emergency or after some dreadful calamity, whereas owners of property having a personal interest in which pride is more or less mixed up, anticipate the calamity and may be depended upon to introduce as fast as practicable every needed precaution.

order to secure the right thing at the right time and in the right place, it is necessary that governments should restrict their interference with railway operations mainly to that of inspection and condemnation. Referring to this subject the Royal Commission of Great Britain in the year 1877 said: "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 faulty 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 its capacity for usefulness." Governmental interference should only occur in extreme cases, and in every case should be discriminatory, *i. e.*, should recognize inequalities of properties, traffic, and differences of location. In the protection of seamen it is not provided that vessels shall all be alike or shall be 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 any surplus it may have to securing accessories of the service, the *entrees* of the feast, so to speak. Not that any company should be permitted to use unsafe vehicles or structures of any kind, but further than this, and the exercise of common precautions, it is not incumbent to go in such cases.

The precautions adopted by the railways of Great Britian to prevent accidents have already been referred to. They are the most perfect in the world. The enormous sums they have cost are, however, a great burden in many ways. But principally in the heightened rates they render necessary. The block system increases the expenses of the railroads of Great Britain for labor and material fully six per cent., not including interest on the first cost of the plant. When we remember the great number of accidents that have attended the use of this system, the expediency of its general introduction in any country may be questioned. It lessens the danger but does not obviate it. On the other hand, it entails hardships on the poor of England much greater than the benefits it confers. It is a burden placed upon the internal commerce of the country. That the rates of English roads would be much less except for the excessive cost of this and other similar appliances for preventing accidents, there can be no doubt. The application of the block system, like other safety devices, it may be said in conclusion, should be enforced wherever business justifies it. Practical, not utopian, theories should govern. Appliances not warranted by the business and resources of a company, whether they embrace the block system or other safety devices, become simply "fads." Many roads upon which these expensive appliances are used today would be much better if operated under the simple and inexpensive methods of far off Dakota.



Carriage in Egypt.

CHAPTER XI.

COLOR BLINDNESS—ITS DANGERS, DEGREES, MANIFESTATIONS, SENSATIONS AND PECULIARITIES—HOW IT MAY BE DETECTED.*

Color blindness is defined as partial or total inability to distinguish particular colors. The latter form of manifestation is exceedingly rare. It is sometimes hereditary, sometimes caused by disease, excessive use of alcohol or tobacco or both, accidents, a sudden jar, or overtaxing the eyes. A person, therefore, who has good eyesight today may not be similarly blessed tomorrow.

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 sometimes yields to treatment. The disease is much more rare in women than in men. People who are color blind are frequently not aware of the fact. They are not conscious that other people do not see things as they do.†

*A chapter on this subject appeared in a former book. It is, however, entirely revised and rewritten here.

†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 else did not see things exactly as I saw them: the discovery that my eyesight was not accurate was quite accidental.

Those who are color blind are oftentimes very sensitive about it. In many cases man's intelligence and judgment unconsciously 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. 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

"*Color Blindness; Its Dangers and Detection," by B. Joy Jeffries, M. D., page 100.

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." *

Carriage in Arabia.

The unconsciousness of color blind people of their defect illustrates in an apt way the dissimilarity and mental peculiarities of people. We understand a thing in a certain way and think

* "Color Blindness; Its Dangers and Detection," pages 104, 105.

others who differ with us stupid or ignorant or stubborn.

Many nice shades of difference exist in the peculiarities of color blind people; thus, some of them see certain colors perfectly while they can not distinguish others; or, at best, these latter have only a shade of difference. It is this shade of difference that deceives them into believing that 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 may be demonstrated by comparison and selection. In many cases those who are color blind can not detect a shade of difference between such radical colors as red and green.

The orbit of our vision is exceedingly restricted. Dr. Jeffries, in his admirable book, says:

"Our point of best vision on the retina 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; a red light to such frequently seems green.

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" ever since. Thomas Young and Professor Helmholtz, who have given the subject of color blindness most exhaustive study, describe its physiology as follows:

"There are in the eye three kinds of nerve fibres. Stimulation of the first produces the sensation of red, the second that of green, and of the third the sensation of violet. Object-

African Carrier.

ive homogeneous light excites these three kinds of fibres in varying degree according to the wave lengths. The red perceptive fibres 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 fibres—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 fibres, feebly the red; sensation, blue. Simple violet stimulates strongly the violet perceptive, feebly the other fibres; sensation, violet. Equally strong stimulation of all the fibres 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 violet. 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

Carriage in Spain.

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 are blind to 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 colors 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."

The violet blind are rare.

From statistics gathered from the examination of some ten thousand people, it is 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 carriers are almost invariably red or green.

Testing for color blindness is required by many governments, and is practiced more or less systematically by carriers in other cases. Attempts to legislate in regard to it in the United States have met with much opposition; laws passed to enforce examinations of those connected with the train and signal service of railroads having 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 our apprehension. If the defect is only occasional and unimportant, why such apprehension? If serious, it is interesting for other employes of carriers as well as those

Carriage in Palestine.

who travel to inquire as to the exact risks they run because of it. If other devices than colored signals were possible it would not make so much difference, but they are not.

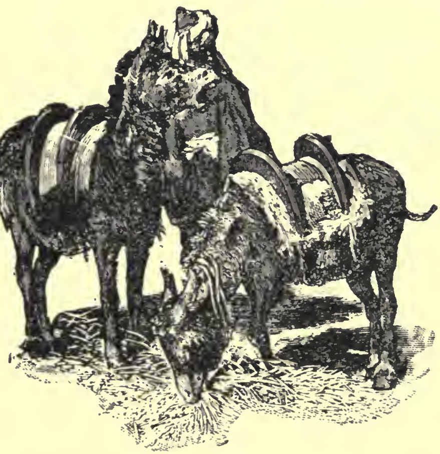
Color blindness being established as a fact, the question naturally occurs, how may we most surely detect it? By taking those to be examined to the different signals of railroads and asking them to describe them? By no means. It must be done scientifically. Otherwise, those inclined to conceal the fact will oftentimes be able to hide their defect, or to render its presence at least questionable. Many different methods have been suggested by scientists for detecting color blindness through 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 especial 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

14

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, can not 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



Carriage in Chinese Turkestan.

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 can not 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 himself, by an act of his own, 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 here to do more than give some of the salient features that arise in connection with color blindness as it relates to the operation of railways. Dr. Jeffries amplifies the subject at great length in all its different phases, especially its prevalence and the means of detecting it. The subject is one that should be studied by all who are interested in such matters. He gives the methods and results of all who have experimented up to the time of writing his book. He urges very strongly that the safety of the traveling public requires an examination of railroad employes, with a view to the detection and exclusion from the service of all who are unable to distinguish correctly the colors used for signals. He lays especial stress upon the theory that color blind persons are generally able to distinguish the signals used by the difference in light and shade alone, and will probably be able to do so if examined merely by the signals to which they are accustomed, but that such reliance is an exceedingly unsafe one, and will sooner or later lead to serious accidents. He also insists that only experts can conduct such examinations. Acting upon these representations,

Carriage in Andalusia.

the legislature of Connecticut in 1880 passed a law requiring that all trainmen, station agents, switchmen, flagmen or signalmen employed by railroad companies in that state, be examined in regard to color blindness and visual power, under rules prescribed by the state board of health, by medical experts appointed by the governor.

Upon putting this law into effect, many trainmen who had never been suspected of any difficulty in distinguishing the signals in use were found unable to correctly match the colored worsteds or fulfill the other tests required. The first man rejected was one of the oldest and best engineers in the state; not, however, on account of color blindness, but because 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 entirely normal, were unable to pass the examination, simply from nervousness, and one man fainted entirely away under the ordeal Great indignation existed in regard to the new measure among railroad men. Accordingly a mass meeting was held at which the fairness of the tests used was questioned. It was demanded that they should be made by the colored signals in general use, and the letters used on the signboards of the railroads, the men examined to be at their usual posts. The leaders of the opposition party in the legislature hastened to make such political capital out of the matter that the law was at once repealed.

In Massachusetts the legislature referred the matter to the board of railroad commissioners with instructions to investigate and report. Their report presents a very interesting résumé of the subject. A few extracts may serve to show its tenor:

"Of course 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 distinguish 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 distinguish 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 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 conclusions of the board are as follows: "That the existence of color blindness, total and partial, is a well established fact, and that there are men who, by reason of such defect, are unfit for positions on railroads requiring ability to distinguish color signals; that the extent of dangerous color blindness (*i. e.,* such color blindness as unfits persons for railroad employment) has been greatly exaggerated: that examination may be properly made by persons not medical experts, and that such examination 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."

Afterward the legislature of Massachusetts passed a law requiring all railroad employes whose duties required them to distinguish form and color signals to be examined at least once in two years for color blindness and other defective sight.

American practices are not nearly so searching in regard to color blindness among railway employes as those of Europe. The subject is, however, receiving more and more attention from American managers. As a rule, however, tests have been confined to the signals actually in use. A letter of inquiry was addressed to the superintendents of American railroads for information on the subject, some time since, by a railway paper.* While responses were not general, those returned concurred in saying that in no known instance had accident been occasioned by color blindness. The majority did not think examinations desirable. They believed that signals might be arranged so that the color blind could distinguish them without difficulty.

It is noteworthy that not a single accident on an American railroad has been definitely traced to color blindness. But this fact is not at all

* "The Railway Age and Northwestern Railroader."

conclusive that such accidents may not have occurred. Cases have been known of collisions of vessels because of color blindness of pilots. But it is probable that accident would be more likely to occur at sea from this cause than upon a railroad. The engineer of a railroad can stop his train in the event of doubt, while this would in many instances be impossible in the case of a vessel.

Carriage in Lapland.

CHAPTER XII.

SIGNALS — THEIR ORIGIN AND EVOLUTION — VALUE AND USE — LIMITATIONS — VALUF OF UNIFORMITY—(PART ONE).

The efforts of railway companies to insure safety of life and property are constant and intelligent. A glance at the track of a railroad displays the forethought they exercise. However, wherever disaster is to be apprehended, there signals supplement other devices. At night these signals are confined mainly to lights of different colors. During the day greater latitude is possible, symbols supplementing the use of colors and explosives.

No branch of the railway service has been characterized by greater progress than the signal service. This is natural. Upon it depends largely the safety of passengers and operatives, the easy operation of trains and the preservation of property. From the start the endeavor has been to obtain the most perfect appliances. But, like all other matters of a business nature, economic conditions have had to be considered. Everything involving the safety of human life, every measure of protection, appeals to our warmest instincts. But expenditures here as elsewhere must be prudently made, lest a worse evil follow. In one or two great countries the extravagance of carriers, coupled with legislative interference, has resulted in such lavish outlay for safety appliances as to greatly cripple business and seriously enhance the price of necessaries of life.*

At the commencement each railroad company sought to be original; to have signals different from its neighbor. This spirit still obtains to a certain extent, although experience is fast convincing those interested of its shortsightedness.

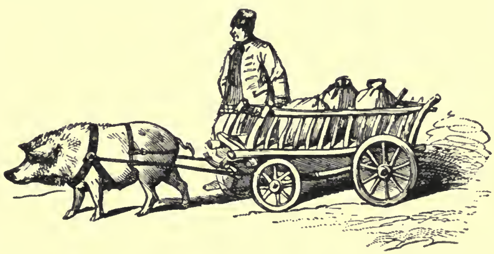
One of the first signals of a railroad was a lighted candle, placed in the station window as a notice to trains to stop. This was succeeded, in the course of time, by stationary lights and objects, until it is no longer possible to classify or enumerate the devices used. The evolution is still going on.

Under ordinary circumstances nothing is more to be commended in men than well defined individuality. It indicates native vigor and a higher ideal. A company whose managers do not possess it soon loses its progressive character. But how far this individuality may be carried in adopting, changing and annulling train rules and regulations without reference to the practices of other railroads, is a question. Intercommunication of railroads has been carried so far that it becomes more and more desirable every day that, so far as practicable, train sig-

* This phase of the question has, however, received consideration in the second chapter herein on Railway Accidents.

nals and methods should be the same everywhere.*

The safety of the lives of passengers and others depends continually upon the intelligence with which signals are manipulated; upon the employment of the right signal at the right moment, and its instantaneous interpretation. Hence, it is apparent that their use should be stripped of all ambiguity and reduced to the minimum in number.



Carriage on the Banks of the Danube.

A correct understanding of the subject of railway signals and the diversity of practice that exists requires that we should remember that the men responsible for the safety of trains are not wedded to the service of a particular line. They are cosmopolitan, constantly changing. These changes are accelerated or retarded by

* But in enforcing uniform practices provision must be made here as elsewhere to secure still further advances; committees and associations of railroads must keep the regulations agreed upon always before them with a view to securing something better. Unless this precaution is observed uniformity will prevent further progress.

various causes. The increase of the business of a company, a strike among its employes, political disturbances along its line, may render it necessary to employ untried men. These men may understand generally their duties but be unacquainted with the peculiar methods of their new employer. At different periods of their lives they may have served upon many different lines. This varied service will have familiarized them with many systems and signals. Herein lies the danger of diversity. In a matter requiring definiteness, singleness of purpose, precision, a knowledge of many systems may possess a sinister meaning—may be pregnant with disaster. The traveler remarks that upon one road a green light is a signal of safety, a signal to trains to go ahead; that all is well. But upon another it is a signal of danger; its warning is imperative, absolute; it says, Stop: not at some indefinite point, but there, where the lamp burns. Death lies beyond. But suppose the engineer has but recently entered the service of the last mentioned company after many years of service with the former. Enginemen are always making changes of this description, and this one, a skillful mechanic, and noted for his watchfulness and fidelity to duty, is a valuable acquisition, and so, after a month or two, he is given the night express. This train is heavily loaded. It makes no stops, and keeps pace with the flying clouds. As it advances through the darkness the engineer observes a green light shining upon the track before him. He has seen it under similar circumstances many times before. Its reflection gladdens his heart like the face of an old friend. It relieves the monotony of the dark night. It tells him that everything is right. As the train plunges by he leans lazily out of his window, but the signalman, wild with rage and fright, hurls his lamp full at the cab, and it is smashed into a thousand pieces. In an instant the truth flashes upon the engineer. Upon this line green is a signal of danger. A chill of horror seizes him. He is running at sixty miles an hour; he reverses his engine, the whistle sounds, the brakes are applied. The engine trembles with the tremendous strain put upon it, but it is too late. And so in the stillness of the night, in the far off country, the great black engine with its load of cars filled with sleeping passengers, plunges to its destruction. This is what a diversity of signals means to the tired and nervous traveler. How far are his fears justifiable? Could the case we have supposed actually occur? Probably not. Yet it is true that the signal that correctly interpreted on one line says to the engine driver, "all right; go ahead; the track is clear," means something entirely different upon a neighboring road. More or less, not many, accidents occur upon railways that are inexplicable. The occasion of them is enveloped in mystery. The religious frequently attribute them to God. Are any of these disasters occasioned by a misunderstanding of signals, or by confounding the rules and regulations of different companies?

An investigation of train regulations elicits many curious things. Upon one line two green lights in front of an engine is a notice to trains it meets that the track is clear; no trains following; go ahead. Upon another line

Russian Carrier.

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 the last named company, would bring his train in collision with another, unless some fortuitous circumstance prevented.

The lamp raised and lowered upon one road is the signal to "back up;" upon a parallel line, not ten feet away, perhaps, it means "go ahead." Differences like these are suggestive. In considering the dangers resulting from diversity of practice, the question arises, how far is uniformity practicable?*

In the early history of railroads signals were unknown. As already mentioned, a candle placed in the station window was a signal for trains to stop; if absent from the window, the engineer proceeded. Upon one line the use of red lanterns was restricted to the higher officers of the company, and was intended as a badge of

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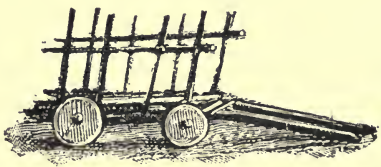
* While organizations of many other classes of railway officers and employes, formed for the purpose of reconciling differences and obtaining uniformity of practice in matters of joint concern, have been in existence in this country for a long time, it is only in later years that an association was formed among the officials in charge of the train service. Quite naturally one of the first subjects considered by this association was that of signals with a view to uniformity of practice; the rules adopted by it, with others, are embodied herein. Great progress has been made toward the adoption of uniform signals. There are, however, many roads still using devices of their own. So that only partial success has been attained. But even if uniformity should be secured on the railways of the United States as a whole, the reform would still be incomplete for the reason that those connected with its train service go elsewhere. We find them today in Canada, tomorrow in Mexico. 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 drew a code. This code was, in the main, the basis of that adopted shortly afterward by associations designed to facilitate train service. It is practically the code today, so far as uniformity has been attempted. M. M. K.

authority. The idea of using them as a signal had not been thought of. Appliances of every kind were crude. Flagmen were required in some instances to provide themselves with a long flagstaff, having a white flag three feet square attached to one end of it, and a red flag of the same size to the other. In some cases no flags at all were specified or provided. A chapter might be filled with a description of the quaint signal devices of early carriers. The men in charge of trains had no experience. Some had been sailors, others military men; some had been connected with the fire departments of cities. Men flocked to the service who had been employed by the stage companies. So far as they had any previous knowledge of signals they naturally endeavored to make them apply to their new calling. In those days traffic was light and the need of signals not greatly apparent. Railroads were widely separated and opportunities for consultation between officials few. Signals were invented and applied as needed, without regard to the usages of other companies. Some of them were ill adapted to the purpose they were intended for, but so long as no serious mishaps followed, the difficulty of changing, and the disinclination of the persons who introduced them to change, caused their retention. With growth of business, however, roads were brought each day closer together and lack of uniformity became more embarrassing. The hamlet that was proud of a single railway became a great and prosperous city, the center of a vast network of lines, each line operating its trains under a code of signals largely its own. In some cases the trains used common tracks, stations and yards, so that the force was called upon continually to observe daily two entirely different sets of signals. The danger arising from such a condition of affairs, while perhaps more apparent than real, nevertheless invited remedy. But how could it be brought about? Not by legislative action. That had been tried and failed. Nor could it be done by taking the signal code of a



Bulgarian Form of Carriage.

particular road. That would excite jealousy. And in considering this subject the difficulty and danger of making any change at all was not forgotten.

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; of stationary colored lamps and signs; of colored hand lamps and flags; manipulation of the hands and arms; strokes of the engine bell and gong; the whistle, torpedoes, fusees, and so on.

Considerable variety is possible in the form and appearance of permanent signals. Many improved devices have been invented. Old forms in use, however, can not be easily or quickly changed. This has been a deterring force. As a rule permanent signals are used to indicate the position of switches, or whether the track is clear or not. The semaphore is largely used for the latter purpose. It consists of an upright post with an arm hinged at or near its top so that it may be dropped on a line with the post or raised at any angle to it. The arm is most prominent when at right angles with the post. This position is therefore generally used as the position to indicate "danger" or "line blocked." The arm dropped on a line with the post indicates "all right" or "line clear." The arm is so weighted that, in the event of breakage or derangement of machinery, it will rise of itself to the position of "danger." Some authorities, however, insist that "all right" should be given by a positive signal, and not by the absence of a danger signal; they 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 a position of the arm intermediate between that for safety and that for danger to indicate caution. Still others are opposed to the use of a caution signal at all; they say that if the line beyond the signal is not entirely clear no train should be allowed to enter upon it until it is so, at least not without coming to a full stop and learning definitely the nature of the obstruction and receiving permission to proceed. The same principles apply to the use of other permanent signals. These differences of opinion afford partial explanation of the differences of practice that exist.

Night signals are confined mainly to red and green lights. White and yellow might be mistaken for other lights in general use near the track. Especially is this the case in cities where tracks are numerous or crooked 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 was intended.* The objection to blue and violet is that they can only be distinguished at a short distance. By daylight a greater variety of color may safely be allowed. It is generally recognized, however, that the signals used by night and by day should be closely related. It is not generally attempted to vary the colors used by day and by night, though white is sometimes substituted by day for green.

Red is the color generally used to indicate danger, but this signification does not attach to it universally; it is sometimes used to indicate merely possible danger, or caution. Green is

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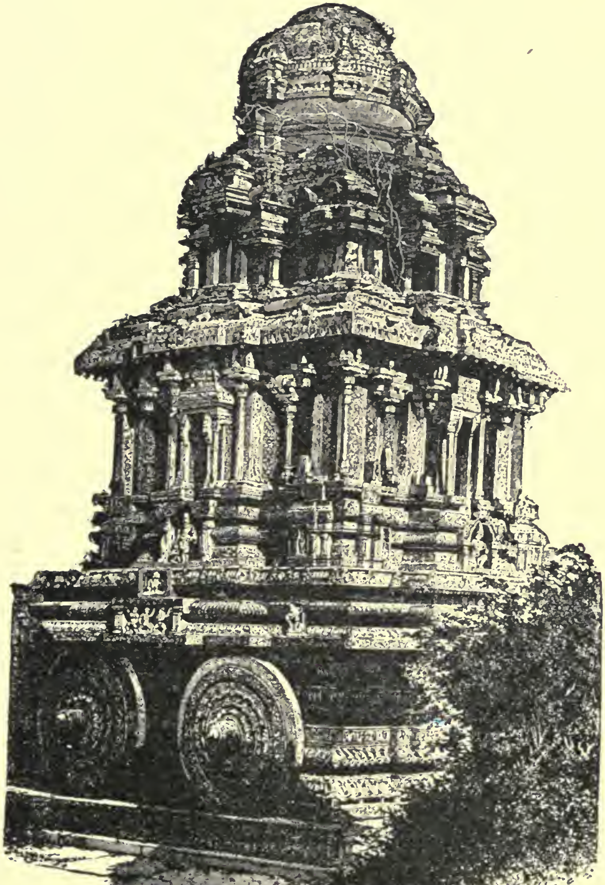
*Nevertheless, white is largely used in America to signify safety: it has also been generally used in England satisfactorily, but it has been remarked that signal lights in that country are displayed from taller posts than is the custom in America, hence there is less danger of confusion with other lights.

commonly used to indicate caution. Sometimes, however, one red light indicates "caution," and two "danger;" a lamp outside the rails means one thing, between the rails another. In all these matters, so far as practicable, it is desirable that there should be uniformity of practice among railroads.

The number of flags or lanterns which can be used effectively for a particular signal is very limited. Moreover, signals must be displayed in definite and prominent positions, such as the front or rear of a train, or on the station platform or at a considerable height above it. Intermediate positions are objectionable.

The movements of the arms and hands, also of lamps or flags that may be made available, are, 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 much restricted, though considerable latitude is possible in the case of the whistle by the ability to make long and short sounds or combinations of each. But where reliance is placed on the difference between short and long blasts, the distinction must be plainly made.

To make the fullest use of the limited materials at hand for signal purposes requires practical knowledge of the needs and workings of the service and great ingenuity. The best possible code, when framed, will not have a single signal to which some objection can not be made. With many the real objection will be that it is not

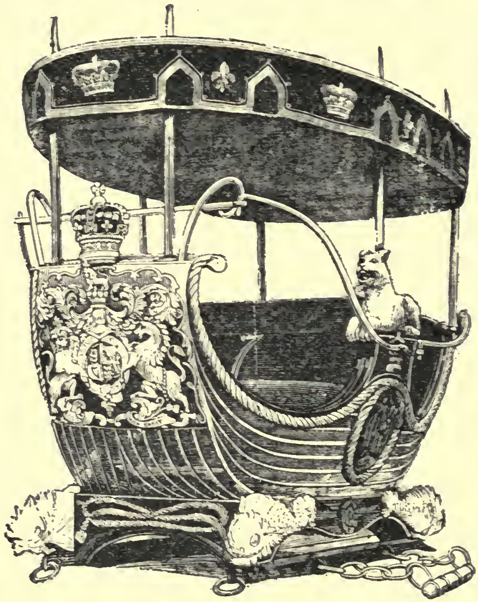


Car of Juggernath.

what they have been accustomed to. There will, however, be honest differences. One will say that the best system of signals should be the simplest; that on this account all visual signals should be generally similar; that as the semaphore signal to stop is the arm extended at right angles to the post, so the hand signal to stop should be the arm of the man in a similar position; 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 generally the arm placed at a position midway between those of danger and safety, so the same signal should be given by the hand by day, by dropping from the position of danger for a short distance, repeating the operation as may be necessary. The motion slowly given would be interpreted "go slow;" the same inference would be indicated by a similar gentle motion of the lamp at night. The signal for "all right, go ahead" would be given by the semaphore arm being dropped nearly or quite on a line with the post; the same might be given by dropping the arm of the man, but moving it on a level from side to side to make the order positive; a horizontal motion of the lamp by night would mean the same thing. The signal to back up is seldom, if ever, given by the semaphore. If desired, it might be done by raising the arm nearly perpendicularly above the post; the natural sequence would be the hand of a man by day or a lamp by night swung above the head to indicate the same order.

These would be the methods of one party. Other authorities would not attempt to harmonize permanent and hand signals, but might adhere to the principle that hand and lantern signals should be the same. That both should be simple, and while each should be distinct from the other, the transitions from one to the other should be easy and natural; that gentle motions of the hands should indicate gentle motions of trains, and thus swinging motions, horizontal and over the head, should be used for forward and back, both of course being easy at first; that as perpendicular motions are naturally energetic and imperative and also distinct, they should therefore be used for stop—the most important order and the one which must be most quickly obeyed.

Other authorities would urge that each signal should be the one best adapted to the particular purpose, without reference to other signals, except that it must 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; moreover, it can be done without danger of putting out the light and covers a wider range of vision than any other, and therefore is most likely to attract attention. For "go ahead" they would favor the lamp swung over the head, because it is the natural motion for all right, is easily seen and involves no danger of extinguishing the light; to back they would use the motion up and down as being plain, easily seen and giving, if necessary, an idea of the distance required.



Form of Carriage in Madras.

All authorities will agree, generally, as to the desirability of uniformity, but will not agree as to what is best. Compromise is, however, possible.

The signals to the engineer by strokes of the gong were adapted, it is said, from those in use upon steam vessels; one for "go ahead" or "stop;"

two for "back." This arrangement is still in more or less use. In practice, however, 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 train were stopped suddenly the detached portion was likely to come into collision with it. Consequently, many roads prescribe two strokes as the signal for stop.

As an illustration of the diversity of whistle signals that is possible, the only whistle signal practically uniform at one time was that of the engineer that he was about to back—three short blasts. Upon a large majority of the roads the signal to apply brakes or stop was one short blast, while the signal to release brakes was two blasts. Many roads prefer two blasts for "stop" and one for "let go," and give good reasons for their preference, some claiming, for instance, that the two blasts for "stop" is more distinct and likely to attract attention than one, and that the interval between the blasts may be made to intimate whether the train is to be stopped quickly or easily.

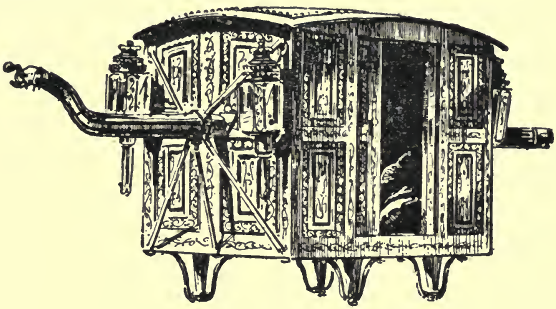
Noticeable diversity also exists in the signals used by engineers for highway crossings; some companies prescribing one long blast; others two long blasts followed by two short ones, and so on.

A great diversity is noticeable in other signals beside those governing the movement and safety of trains. Many of these do not in any way affect the safety of persons or property, their use being merely a matter of convenience or the saving of time. Uniformity in such cases is not important. It would, however, be valuable in a disciplinary way.

On some roads a certain combination or number of strokes of the gong or blasts of the whistle means one thing when the train is standing; another when running. This principle is valuable in framing a code of signals for general use.

In the use of whistle signals it should not be forgotten that frequent use of the whistle greatly 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, and carry us back to the time when, as children, everything about a railway was beheld by us with wonder and delight.

The uses of the whistle and bell may be briefly summarized: They should not be used except when absolutely necessary; they should not be used an instant longer than safety requires; they should be moderated as much as possible, the former being no louder than needed and the latter no harsher than the service requires; managers, moreover, should know that rules and regulations governing their use are carried out, in quiet villages as well as in great cities; neither deputations of citizens nor ordinances should be necessary to keep them advised. Undue use of the whistle and bell grows out of the desire of train men to make sure that everyone hears the warning; to be so definite that no one can say he did not hear. This feeling, while laudable, assumes in time the dogged persistence of a craze. Men may become monomaniacs on the subject. As a rule, the service will be benefited by restricting, rather than enlarging, the general use of the bell and whistle.



Form of Carriage in India.

The necessity for signals depends very much upon the frequency and speed of trains. But whatever the system, however limited, it should be comprehensive and intelligent and faithfully carried out.

Signals adapted to the nature of a country must be used. Thus, on a straight road in a level country, where the atmosphere is clear, the minimum plant will answer, while in countries like England where fogs are dense and frequent, a more elaborate system, including the use of torpedoes and fusees, is necessary.

Signals have two values: one positive, one negative. An objective point with every signal is to supplement the intelligence and care of operatives; to correct their mistakes; to call attention to oversights and omissions; to prevent men from doing what they might otherwise do thoughtlessly, to warn.

To attain all the objects the signals of a railroad ought to conserve, man's ingenuity has been exercised to the utmost; all known influences and forces have been brought into play.*

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*The following classification will indicate, though imperfectly, the means and agencies employed:

CLASSIFICATION ACCORDING TO MANNER OF INDICATION.
Visible, audible, visible and audible.

CLASSIFICATION ACCORDING TO 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, remaining 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.

CLASSIFICATION OF AUTOMATIC SIGNALS ACCORDING TO PRINCIPLES OF OPERATION.
Electro-mechanical, pneumatic, electric, atmospheric.

CLASSIFICATION OF AUTOMATIC SIGNALS ACCORDING TO USE.
Special signals, line block signals—absolute and permissive, etc.

The above is adapted from a classification by G. W. Blodgett.

Any system of signals that depends for its efficiency at any place or time upon man is defective, and those interested in such matters will never cease their efforts until they have devised something that eliminates him as a factor altogether; until they have introduced devices by which, if signalmen make mistakes or omissions, or men fail to observe a signal, an intermediary force, not dependent upon either, will correct the oversight or make it so strikingly apparent that further neglect can only arise from willfulness. The safety devices that accomplish this are very few at this time.

In considering generally the subject of signals it is not too much to expect of carriers that they shall use the best that come within their means. This requires that they shall keep themselves advised of what is best, and conform thereto as nearly as possible. Ultimately signals adaptable to the wants of roads of different grades will be evolved. The supply will follow the demand. Carriers may not at once be able to adopt new devices because better than something they have, 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; the inheritance of an earlier period; a prolific source of accident. All visual signals involve the risk of obscurity, omissions, color blindness, and so on. The sounding of a whistle or the ringing of a bell are also never to be depended upon in themselves. The reasons are too obvious to require enumeration. But all may be made useful as adjuncts to other signals and precautions. The French, in some cases, use a detonator in connection with their home signals; the detonator lying on the rail when the signal is at danger, and being mechanically withdrawn when the track is clear.

It has been suggested that locomotives should be supplied with an audible signal which would in every instance be sounded on passing a danger sig-

Carriage on the Tigris.

nal. It would be especially valuable in the case of tunnels and similar obscure places. Many accidents that have occurred emphasize the necessity of some mechanical device for warning the engineer when passing a danger signal. It is one of the great needs of the service. It would be especially valuable in tunnels, where great obstacles have to be overcome, such as obscurity of view arising from darkness, fog and smoke, limited space and the confusion and noise that attend the movement of trains under such circumstances. Both visual and audible signals are necessary in such cases, the one supplementing the other, and, so far as possible, acting automatically.

In the operation of trains the additional dangers to be met with at crossings, drawbridges, tunnels, curves and obscure places receive special attention in every instance.*

Of all the devices for signaling introduced up to this time, the semaphore (the extended arm or blade) is perhaps the most simple and, so far as visual signals are concerned, the most effective. It is 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 by an expert, will make it equally desirable by night.‡

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* When gates are used at highway crossings, the gatehouse for signaling is usually elevated when there is more than one track, so that the operator may have an uninterrupted view of trains in all directions.

† C. A. Hammond.

‡ Its provisions are:

"Horizontal and red—Danger; stop.
Horizontal and green—Caution; prepare to stop.
Inclined and white—Safety; proceed."

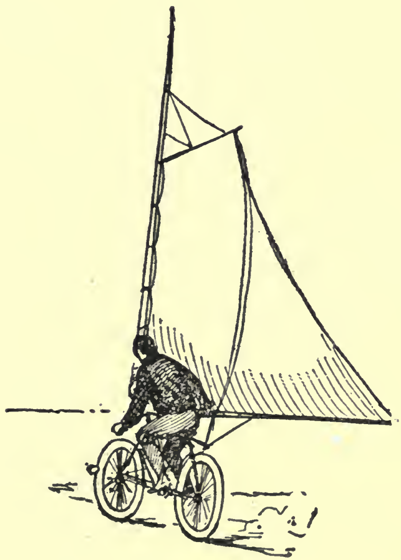
The parabolic semaphore, invented by Professor Koyr, renders the display of colors possible at night as well as by day.

An absolute requisite with every signal is that it should never indicate safety except through some premeditated act; that without the consummation of such act it should always indicate danger. Signals must, moreover, be simple and effective, and not easily disarranged, not requiring 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 perfect protection of trains, whether moving or stationary, it may be said in conclusion, is in process of solution. Each day adds something to our knowledge of the subject. This knowledge is used in perfecting old and in introducing new methods. While the block systems and other methods of early days are being improved, other and better systems are being introduced. Primitive methods depended entirely upon signals operated by man. Modern practice requires that devices shall be self acting, so that trains will be automatically guarded; shall be safe whether men sleep or wake, whether they are stupid, inexperienced or neglectful. How far such appliances can be perfected time only

*C. A. Hammond.

will tell. The disposition, however, is as manifest to introduce self acting machinery into the operations of trains as it is in the operations of manufacturers. The success attained by the latter justifies the belief that the principle of automatic action will, in time, be perfectly attained by railroads.



Carriage in Transcaspia.

CHAPTER XIII.

SIGNALS AND OTHER DEVICES FOR PROTECTING TRAINS—(PART TWO.)

For a long time the most perfect method of protecting trains from collision was that known as the block system. It was first introduced in Europe and grew in favor in America. It is designed for use upon roads having two or more tracks. But its advocates claim that it may be used effectively on a single track road by placing signals on both sides of the road just as if there were two tracks and making the blocks, or sections, extend from one side track to another. Many different methods are in course of perfection for protecting trains from front and rear collisions. Several of them I have already referred to. The highest types contemplate automatic action. The old fashioned block system is operated by signalmen. A road is divided into short sections or "blocks,"—hence the name block system. 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.

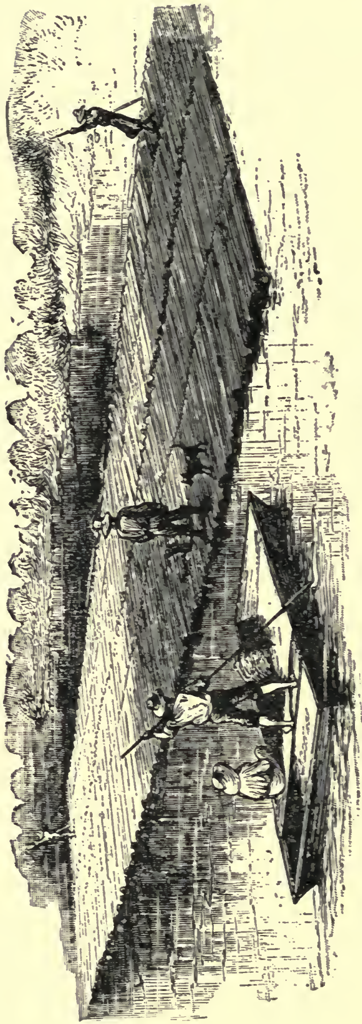
Under the former, one train only is allowed upon a block at a time; consequently a collision is impossible if every precaution is attended to. Under the other, two or more trains may be upon a block at the same time (under certain circumstances), but provision is made for notifying each train that enters a block whether it is occupied or not. When a train leaves a block, the fact is noted by the operator (signalman) and telegraphed back to the signalman at the other end; the latter then signals that the track is free for

Carriage in Mesopotamia.

the use of following trains; but until the receipt by the signalman of the notice that the block is vacant no train is permitted to enter it (unless the train disregards the danger signal) under the "absolute" system. Under the "permissive" system certain trains are allowed to enter after having been notified that the block is occupied. The block system I am describing was the first one invented; it contemplates keeping the train force advised whether the track is free or obstructed. Notwithstanding its great cost and the expenses attending its workings, such companies as were able hastened to adopt it upon sections where it was necessary. It is relatively more valuable on a road with two tracks than with four. The latter permits of a classification of trains and their assignment to tracks according to speed and character. However, in event of misunderstanding or omission, or if a car becomes detached, the danger is as great upon one as upon the other.

The block system properly systematized is designed to take cognizance of every attending circumstance; thus, if a train should break in two, and the forward part continues on its way, the loss should be observed by the operator and the block kept closed to succeeding trains until the obstruction can be removed. In theory the block system is perfect. As a matter of fact, it is efficient only according to the intelligence and care of the men in charge. The frightful disasters that have occurred under its operation prove it to be very defective. 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; something that protects trains automatically.

An obstacle to the general adoption of the original block system by American railways was the great cost. It entails an immense outlay for special telegraph wires and apparatus, and the numerous signals and towers it contemplates. Afterward it involves a large and continuous



Carriage on the Upper Mississippi.

outlay for maintenance and operatives. It was this latter partly that set ingenious inventors to work to produce something that would work automatically; that would warn trainmen of obstructions without the intervention of signalmen. Electricity and pneumatic pressure are the agents generally used in seeking this end. Some of the devices utilize the track rail as the conductor of the electric current. Others use wires connecting with signaling devices that are governed by the passage of trains. Others again are combinations of the two. One requirement generally recognized as essential is that in case of any derangement of the apparatus, the signals shall automatically assume the position of danger. And here another obstacle intervenes. If the apparatus is so complicated or delicate as to be subject to continual derangement (and thus give the danger signal frequently when no danger exists), it loses in value because of the delay and uncertainty it entails. It must, to be desirable, be simple, effective and easily maintained. At the present time study and experiment are confined almost wholly to the discovery and perfection of automatic devices,—devices not at all dependent upon the presence of mind of employes in emergencies or the care and watchfulness of trainmen.

They are, however, costly, complicated and liable to get out of order; nor, so far, are they infallible. However, it is probable that all these objections will be overcome except the first.

Mr. C. A. Hammond has been at considerable pains to classify and explain the limitations and jurisdiction of signals. He says:

"Signals may be divided 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 before it; and those intended to indicate near at hand the particular track which the train should take. In the first class are distant and home signals, masthead signals, block signals, drawbridge 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 engin when facing or running towards them, should for righthanded 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.

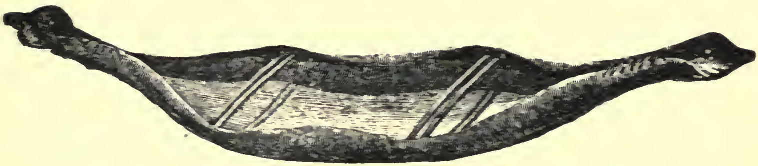
"No engine or train should be allowed to pass a caution signal (horizontal green) unless under full control, so that it can be safely brought to a quick stop within the distance say of three train lengths.

"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: Where the block limit overlaps its entrance signal, for the purpose of allowing 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



Primitive Form of Carriage.

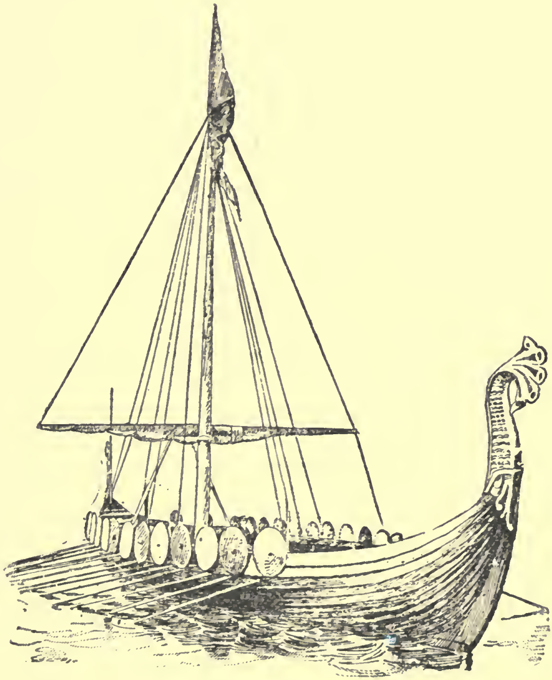
written orders, or under the protection of red and white flags or lights in the hands of the signalman."

In the operation of railroads signals are necessary and valuable for expediting business and conveying intelligence. But they are adjuncts merely. When they fail to operate properly, or are misunderstood or overlooked, something is required that will avert the danger that such a condition of affairs threatens. Something not dependent upon the action of man at the moment. It must be something provided in advance and intended to remedy man's mistakes and omissions.

It must be something that will divert any engine or train that would otherwise come into collision with another engine or train. Of all the needs of the present time perhaps the greatest, the most urgent, is some self acting device by which trains will be protected while standing on the main track at stations from being run into by other trains. Some apparatus not dependent upon signals or air brakes; something that will derail or divert any train approaching within a given distance; some device operated by the endangered train. Some device whereby a train, as it approaches a station, disconnects the track in its rear and also at the other end of the yard in advance; a device that as the train passes on its way and leaves the section thus protected, will automatically reconnect the rails.

In another chapter I have described some of the mechanical appliances that have been invented for protecting trains automatically and have pointed out some of the things wanting to make the protection complete. Electricity is a favorite means for the attainment of safety devices. Whether it will prove to be the best in the end, only time will tell.

For the information of those technically interested in such matters, one or two of the more prominent electrical devices that have been invented for the protection of trains may be mentioned here. One 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 insulated from those of the adjacent section. Weights with clockwork attachments are arranged so 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. Another contrivance governs the switches of the main line, another is so arranged that a car on a siding that may be too close to the main track for the safety of passing trains will throw the signal to danger on the block in which the siding is located. Another invention is known as the circuit system; under its operation 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. Another method is that known as the electro pneumatic system. The force used to operate the switches and signals is compressed air. The controlling power is electricity. This method provides for air compressing plants at convenient distances apart, usually in pairs, so that if one is out of order the other may be used; each signal is operated by a cylinder placed immediately below it, which, when the track is not occupied, is filled with compressed air, thus holding the signal at safety. It is claimed for this system that it is immediate in its action, definite, suited to any traffic, capable of diversified use, and that the cost of maintenance is relatively small. Every day adds to the number of electrical and other devices. One ingenious contrivance is intended, by means of the contraction of a brass cylinder placed within the lamp, to call the atten-



Carriage in Scandinavia, 9th Century.

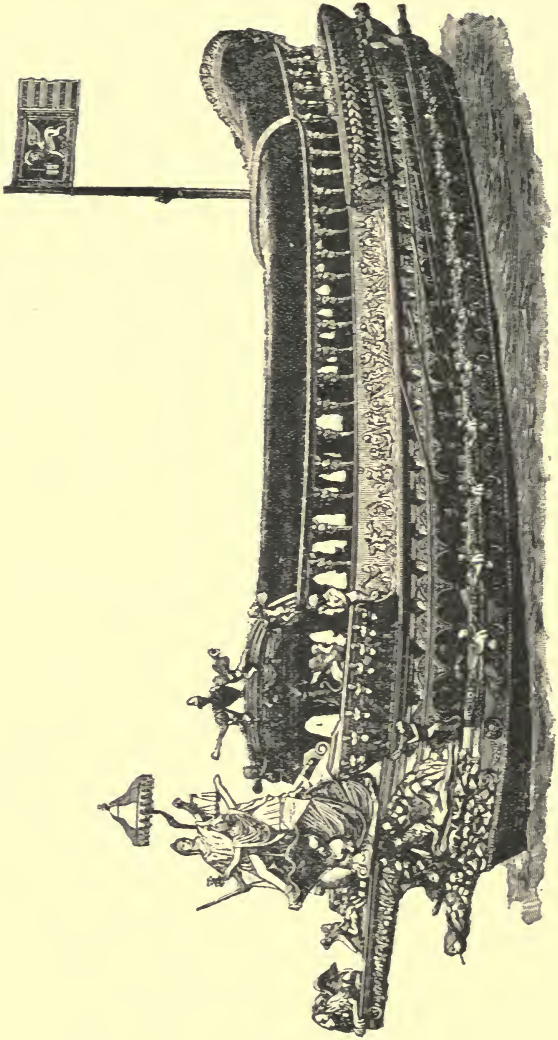
tion of the watchman to the fact if the light goes out. Another is designed to call the attention of the train dispatcher to the fact if a train runs past a station where another train is discharging or taking on passengers. Another announces the approach of trains by ringing a bell at crossings while the train is yet distant, and so on. Only those versed in such matters are able to keep track of the new appliances invented. Time only can demonstrate the value of these devices. Like all those heretofore in use, however, they are, so far as we are able to judge, still incomplete; still leave something yet to be desired; still leave trains subject more or less to the intelligence and care of employes, or the efficacy of brakes and similar appliances. So long as this is so accidents are inevitable.

CHAPTER XIV.

ORIGIN, DIVERSITY, EVOLUTION AND VALUE OF TRAIN RULES AND REGULATIONS.

In considering the subject of train rules the question comes up as to the practicability of adopting uniform regulations for all railroads. The question of uniformity of signals has already been discussed.

Among men trained under particuliar systems, who possess the strong individuality that characterizes railroad officers, difficulty will always be experienced in securing their acceptance of the ideas of others. In general, the methods of each railroad company are peculiar; this is beneficial in the main. But where such conditions possess no advantage, but, on the contrary, invite disaster, they should give place to uniformity. This last condition is thought by many to characterize matters affecting train rules and regulations. The desirability of uniformity in such matters has been a subject of discussion among railroad men for many years, and a code has been adopted which railroads have been asked to subscribe to. Only a part of them have done so, however, and these, individually, reserve the right to make changes when they think fit without the concurrence of others. Many necessary



Carriage in Ancient Venice.

rules have not been embodied in the code because of indisposition of parties in interest to conform thereto. Differences grow partly out of dissimilar needs and partly out of indisposition to make sacrifices to gain what is not thought material.

The same necessity does not always exist for particular rules or it entails disproportionate expenses and hardships. Hence the indisposition to conform to a complete code that meets the wants of the most exacting. It is not probable that these conditions will be different hereafter. The adoption, therefore, by all railroads of a uniform code is not likely. But out of the multiplicity of systems and methods that which is, generally, essential and best will be adopted, leaving room for such improvements as experience and business invention suggests from time to time. The carrier, the employe and the public will, on the whole, be benefited by such an arrangement. The possibility of accidents growing out of diversity in unimportant matters will be avoided, while enough freedom will be left to the discretion of individuals to stimulate thought and further advancement.

While no practical person can believe in the desirability of enforcing uniform methods of business, any more than he can believe in uniformity of intelligence, nevertheless, there are many mechanical matters wherein uniformity may be adopted without sacrificing anything. This is true in regard to mere signs, having no import or significance beyond the indication they convey.*

In promulgating train rules no sufficient attempt is made in many cases to explain the reasons underlying them. Delphic utterances, as obscure as those uttered by the ancient oracles, are oftentimes all that are vouchsafed. No attempt is made to instruct, to place the reader on a plane with the official. It can never be possible to operate trains with the highest efficiency so long as those in charge do not have as high a comprehension of the rules and regulations as the person making them. The subject is a growing one and its importance is enhanced by the fact that new rules are constantly being added to those already in vogue.

The disposition of those connected with the train service to give the rules and regulations governing them more careful study grows, it is probable, with each day's experience. But this is not enough; and it is likely that in the course of time those connected with the train service will be individually examined as to general fitness and acquired knowledge. This, it is probable, will be confined to new men coming into

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*Thus, it is suggested that everywhere the following signs shall mean the same, viz.:

* That the train runs daily.

† That the train runs daily, except Sunday.

‡ Daily, except Saturday.

¶ Daily, except Monday.

§ Sundays only.

‖ That the train stops for meals.

the service, and if carriers do not voluntarily in-introduce the custom, sooner or later the government will compel it. One great accident brought about because some one does not understand the rules, will be sufficient incentive.

In the absence of specific examinations it has been suggested that a particular person should be designated by each company whose duty it should be to answer all questions propounded to him by trainmen. The indifference of some and the pride of others sometimes prevent a thorough understanding of rules. Many who are ignorant of the true meaning of rules are too timid or too proud to ask explanation. If this explanation could be vouchsafed them without disturbing their sensibility, they would gladly ask it.*

In various books* the author has referred more or less fully to the financial affairs of railroads and the rules and regulations governing the collection, care and disbursement of money and the economical purchase, receipt, use and disbursement of material. They are filled with explanations intended to enable the reader to look at

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*To meet this difficulty the superintendent of one road places at various points on his line a "question box." Anyone wishing to ask a question writes it out and drops it into this box without signing his name. The reply is posted on the bulletin boards where all, including, of course, the person who made the enquiry, can peruse it.

*"Fiscal Affairs; Disbursements," "Fiscal Affairs; Collection of Revenue and the Principles Governing It," "Baggage, Express and Mail Business," "Passenger Business," "Freight Business," "Fiscal Duties of Agents and Conductors," "Fiscal Affairs."

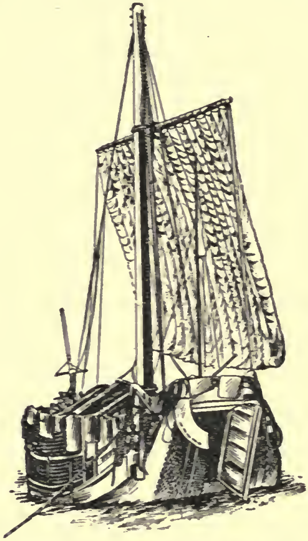
the subject from the standpoint of the manager. He is thus enabled not only to understand clearly the particular matter in question, but collateral questions also. A similar practice can be observed to advantage in many things connected with the rules and regulations governing the movement of trains. Much that I say in this book has this object in view. Such explanatory matter appears unnecessary to experts; to men of great experience. It must be remembered in this connection, however, that rules and regulations are most valuable to new beginners, and by

Carriage in Africa.

such persons explanatory matter, even of the most simple and rudimentary character, is eagerly sought. Neither explanations nor rules are written for the few men who comprehend them already, but for the multitude who require guidance.

Not only must rules be adequate and thoroughly understood by those whom they govern, but they must be obeyed. These emergencies necessitate inspection and supervision. Every other department of the service provides for supervisors, whose duty it is to see that rules and regulations are observed. The same rule is required in the train service. High efficiency is impossible without it. Men can not be expected to confess their ignorance unasked. There must be an inspector whose duty it is to seek them out and ascertain whether they understand and observe necessary regulations. Rules and regulations governing the movement of trains should be printed and supplied each person. They should be simply and clearly stated. Whenever a rule is transgressed it should be understood that the offense was voluntary and conscious; that the offender thoughtlessly, or criminally, disregarded it. Ignorance can not be assumed in so vital a matter. To do so would be to destroy the whole force of the code. After a rule has been embodied in a manual, attention should nowhere be called to it outside of or apart from such manual; thus, a circular should not be issued calling attention to a particular rule and the desirability of obeying it. To do so is to demoralize the force; to weaken all other rules.

Employes do not always attach the same significance to specific signals and rules. Especially is this so with signals. Acquaintance with the every day working of trains teaches employes that allowance must always be made for the ignorance, stupidity or thoughtlessness of others; they strive constantly to protect themselves and their trains from the fatal effects that attend misconstruction, neglect and oversight. Thus the engineer of an irregular train running under special instructions at the rate of sixty miles an hour, can not depend implicitly upon the accuracy of reports in reference to the location and intention of other trains. Doubtless the information he has is perfectly accurate; at any rate he ventures no comments. He has his orders



Carriage in Japan.

and has been trained to obey. Outwardly, he is unconcerned, but as he proceeds he scrutinizes the track 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 to orders may cost him his life and the lives of people who trust him and are as unconscious of danger as they are helpless to avoid it. Oftentimes the watchfulness of the engineer is of no avail; a sharp curve brings him face to face with an advancing train, an open switch, or a track torn up for repairs. Some necessary rule or order upon which his safety depends may be disregarded; a train that should have waited proceeds on its way, confident of making the desired siding, but a high wind, a slippery track, an engine that will not make steam, prevents, and so, suddenly, from out the darkness or fog it emerges, the whistles shriek, the brakes are put on, but without avail to prevent a collision of the opposing trains.

That disasters of this character are not of more frequent occurrence is attributable to the care and watchfulness of trainmen. They understand that a disregard of necessary precautions 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 comply literally with every order or rule, risking nothing, but their obedience is attended with unceasing watchfulness. To this latter and their loyal adherence to established rules, travelers owe their safety.

The more we inquire into the rules governing the train service of different roads, the more we are surprised at the differences that exist.* Many

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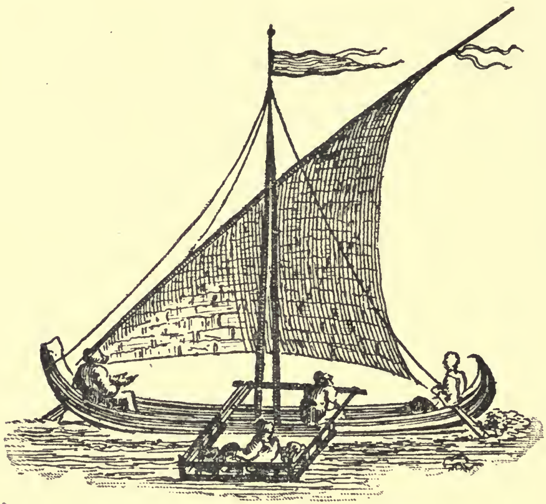
* These differences are not so great as formerly for reasons already explained.

of them are material. Others, again, are differences of form only. In many cases we can trace in the regulations enforced the peculiar traits of those who promulgate them. Thus the rules of one company will be exacting; those of another company will trust more to the discre-



Mexican Carrier, 16th Century.

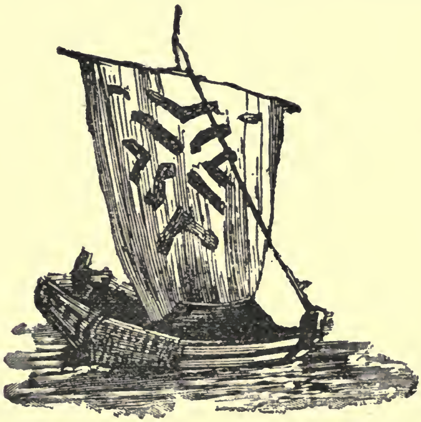
tion of employes. Much can be said in favor of each system; under one, employes act automatically; under the other more zealously, perhaps, but with less effectiveness. The first named system is, without doubt, best for the company; the last named more advantageous to the men as individuals.

Only those familiar with such matters are able to understand the reason for many of the differences that exist. Upon one line trains going south possess certain privileges over trains going north; they are entitled to the road for a certain number of minutes over and above the time allotted them in the time table, and connecting trains are required to keep out of their way. Upon a neighboring road trains going north will be the ones that are favored. It does not require a vivid imagination to picture the consequences of any mistake as to the rights possessed by a particular train, but as a mistake in this respect must involve misapprehension upon the part of both engineer and conductor, it may be said to be unlikely to occur. This lack of harmony in the practice of different roads is not the result of chance or caprice. The direction of business varies in different sections; in one section it will run north, elsewhere south. The discrimination mentioned arises in favor of the current of traffic most important to the carrier. It is the exercise of a shrewd discretion. Everywhere we find evidences of similar business sagacity.

A noticeable difference in the government of trains is that affecting working trains. Thus, one company will require its working trains to keep ten minutes out of the way of freight trains. These working trains employ hundreds of men, and whether the freight train is delayed or not, the loss to the company through the enforced idleness of the men 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. Under the latter regulation no time is lost unnecessarily by workmen, and in its practical working it is claimed to be safe.

The margin of time allowed trains of a superior class (which time must not be used by trains of an inferior order) is not alike 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 may render differences such as those enumerated necessary. The safety of trains, and especially those of a high grade, is of paramount importance, but due regard for this is not inconsistent with the expeditious and economical discharge of business where proper discipline is enforced, and if a margin of ten minutes is sufficient, to allow a longer time is to encourage wastefulness.

A close study of the rules and regulations of railways discloses strenuous efforts to make the most, economically, of every circumstance. That these efforts are sometimes ill directed and unfortunate is true, but such failures teach a lesson and are, therefore, in the end not wholly lost. In the operation of trains a particular company requires all detached engines to precede regular trains; another company, with a careful 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 the detached locomotive assist the loaded train when necessary. Now the danger to a train is generally greater from a following than a preced-



Carriage in Japan.

ing engine, but the opportunity of using the detached locomotive, as occasion requires, more than compensates for the risk run in the case of the latter company.

Not the least surprising of the differences that exist are those that have reference to the manner of conducting business upon double track roads. While to many it seems perfectly apparent that vehicles should turn to the left in passing upon a public highway, it seems equally clear to them that upon a railway where danger of collision does not exist, trains should take the right hand track. As the regulations of many lines require trains to run upon the left hand track, we must believe that there are weighty reasons why it should be so. One of the most weighty of these is doubtless the fact that long custom has made it most desirable upon the roads practicing it.

Similar diversity to that existing in the train rules of different companies is found in the telegraph department. Upon the lines of one company the signal "27" 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. Upon another circuit "27" possesses no signifiicance whatever, and its repetition would never still the struggle that is forever going on amongst operators. Upon another line the cabalistic sign "19" instantly hushes everyone. It is the signal of the executive, and woe to the unfortunate novice who ventures to break in upon its prerogatives. Upon still another line this number has no exceptional meaning, and its repetition would only excite profanity. Upon many, indeed every line, the most ingenious means are adopted to save time. Thus numerals are made to convey special information or lengthy interrogatories. When numerals have been exhausted, the alphabet is resorted to, and letters and combinations of letters are made to stand for words and sentences.

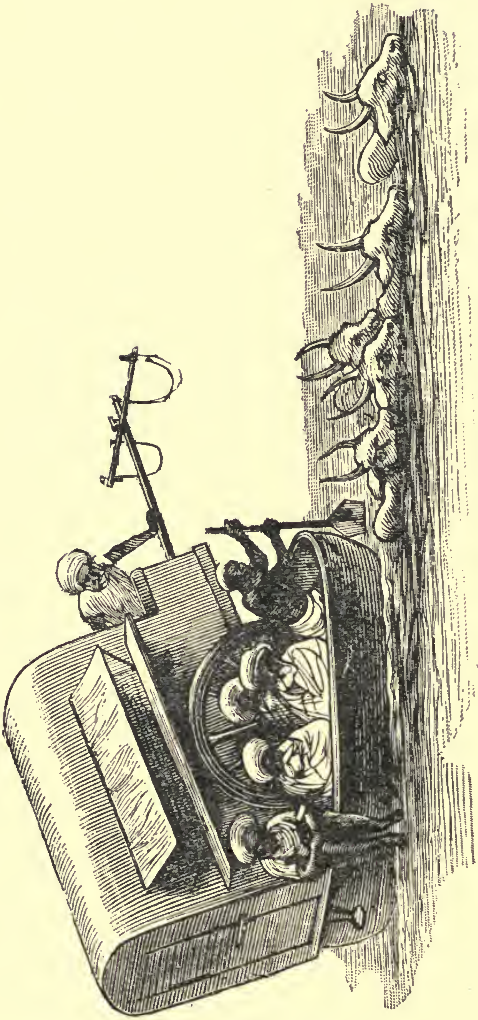
While the rules of no two railroad companies are alike, no code contains all the rules that possess positive practical value. But the methods of every company contain valuable hints and suggestions that may be profitably studied by other companies. It has been my aim to embrace in this book the salient features of all. I have been only partially successful. But in pursuing my studies I have never ceased to be surprised at the practical wisdom and adaptability of the managers of railroads as evinced in their train regulations. Each brings to the subject his quota of knowledge, sometimes original, sometimes adaptive. This last peculiarity is especially striking. Thus, one manager, who has given special attention to claims, directs his subordinates in cases of accident to report with other facts the names of witnesses; other companies note the provision and make similar requests; another manager warns his employes that his company will not be responsible for accidents to employes while coupling cars; another manager takes a rule common to all roads and, by adding a clause, gives it a completeness it did not before possess; other companies follow; another manager explains to the train force that they must not exceed fifteen miles an hour, and that, when running at that rate, they will pass seven telegraph poles a minute; another manager provides a system whereby trainmen may signal each other in the event a train should break into more than two parts; another manager is at great pains to define the rights possessed by an extra train, in the absence of special orders, if it can not reach the meeting point without trespassing upon the time of trains going in the opposite direction. A chapter would not be sufficient to describe the special rules of different companies suggested by the peculiar experiences of different managers and the wisdom and skill they evince in making them the basis of precautionary measures. Out of such experiences an effective code of rules is slowly growing.

CHAPTER XV.

DICTIONARY OF TRAIN TERMS AND PHRASES.

Not the least curious of the things in railway practice is the stock of phrases used. Many of them are adaptations. Others are evolved from the necessities of the service. While the vocabulary is not as copious as that of sailors, many of its phrases are quite as enigmatical and startling. Thus, when the manager issues his ukase that "flying switches" will not be tolerated, the inexperienced observer is justly puzzled. Nor is he more enlightened in regard to such phrases as "running switches," "shooting stations," "wild trains," "whistling posts," "taking side tracks," "turning on the Y," "making time," trains "clearing" each other, engines "slipping" their drivers, "setting" switches, guarding the "block," and so on.

The phraseology of English roads is radically different from that of American, but not more intelligible to outsiders. But an English railway employe who should attempt to explain the phrases he uses would be generally laughed at by railway men in that country because to them such phrases are a part of their mother tongue. Yet how many railway men in America are



Carriage in India.

there who know what a "scotch block"* or a "sprag"† is; or a "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.†† I append below a list of some of the phrases common among trainmen in America. The great bulk of them may be understood by the uninitiated, but others will be intelligible only to those trained in railway vernacular. It is necessary that they shall be understood by all in the service. The list might be greatly added to, and is receiving new accessions every day.

* 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' 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; in advance of its 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; when a train is late.

Block System.—A system devised for the expeditious discharge of business and the better protection of trains. Under the block system the track of a road is divided into sections called blocks; the purpose of the system is to protect trains from collision while on these blocks.

Brake.—In railway parlance an apparatus attached to engines and cars for the purpose of bringing them under more complete control, to be used when occasion requires in lessening their speed or stopping 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 phrases "setting the brakes," "set the brakes," "the brakes are set." Some brakes are worked by hand; some by steam; some by compressed air.

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* It is one of the most imperative and obviously necessary rules of all railway companies that no regular train shall *leave* a station ahead of its schedule time.

Cars.—The cars employed by a railroad may be enumerated as follows, viz.: In passenger trains: baggage, business, combination, dining, directors', drawing room, emigrant, express, hotel, mail, milk, officers', palace, passenger, first class; passenger, second class; parlor, pay, saloon, sleeping and smoking.* In freight trains: boarding, box, caboose, charcoal, coal, ditching, dump, excavator, flat, freight, fruit, furniture, horse boxes, mineral, oil, ore, paint, pile driver, platform, refrigerator, stock, way, wrecking, etc.†

Classes of Trains.—"Regular," "Extra," 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. As "clearing a train ten minutes."

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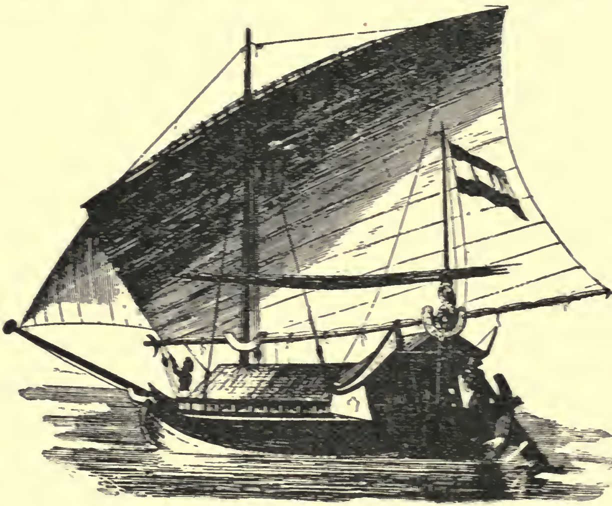
* Passenger cars are called coaches or carriages in England. In Europe the passenger cars are divided into compartments, with separate entrances on each side of the car. The compartments of first class carriages usually contain seats for eight, four on each side. In the lower classes there is no partition between the seats, and a greater number of passengers can consequently be accommodated. Passengers in different compartments of first and second class cars can not communicate with each other (the partitions extending to the ceiling) and are isolated from the officials in charge of the train. The water closet to be found in all our passenger cars is generally unknown abroad.

† Freight cars are called wagons in Great Britain.

‡ It will be noticed that the rules of the American Railway Association (general time convention) provide for but two classes, namely, regular, those shown on the schedules, and extra, those which do not appear on the schedule but are run from station to station under special orders. Under this classification all sections of a regular train, following it under the proper signals, are regarded as parts of such regular train.

Closed Switch.—When a switch is "closed" the principal, or main track, is uninterrupted, continuous, not diverted.

Construction Train.—A train employed exclusively in the transportation of material belonging to, and used by, a railroad company in connection with the improvement of its property, or the



Javanese Carrier.

building of new lines. It usually embraces trains engaged in hauling ballast, dirt, gravel, stone and timber, or employed in removing earth from ditches and cuts. Trains occupied in the work last described are frequently called ditching trains.

Drop off Flagman.—A man who gets off a train to protect its rear when the speed between stations is slackened so as to render it necessary.

Extra Train.—A train not expressly contemplated or provided for in the schedule. It is run for the purpose of expediting the business of the road; to accommodate the traffic that can not be hauled in the regular trains without delay.

Flying Switch.—The disconnecting of a portion of a train while in motion and just before reaching a switch, the forward part of such disconnected train accelerating its speed to such a degree as to enable it to reach and pass the switch in time for the person in charge thereof to divert the detached cars that are following, to some other track.

Grade of Trains.—The grade of trains varies upon different roads, but it may be stated, approximately, in order as follows: The first grade embraces the four classes of passenger trains, namely, express and through mail, local mail, suburban and accommodation. The second grade embraces the three classes of freight trains, namely, live stock, through and way. The third grade embraces the trains operated under special or telegraphic orders, including construction and wood trains.

Holding a Train.—Delaying a train for any reason. A train may be held for orders, until some other train arrives, until a brake can be repaired, etc.

Interlocking Switches.—Switches operated from a common point, by means of levers, by which a track is cleared for a train, the signals conforming thereto. Every switch and signal is locked so that the switches controlling the track over which the train is passing can not be thrown nor the signals changed; all collateral tracks are disconnected from such track and the signals belonging to same set at danger. No switch or signal can be moved, under the interlocking plan, except from the central tower. Various means are used for working the levers; in some cases they are worked by hand, in others by electrical, pneumatic or hydraulic force.

Irregular Train.—See "Wild trains."

Keep off the Time of a Train.—A direction not to obstruct the main track or attempt to occupy it when, according to the schedule, it rightfully belongs to another train.

Lost its Rights.—See "When a train has lost its rights."

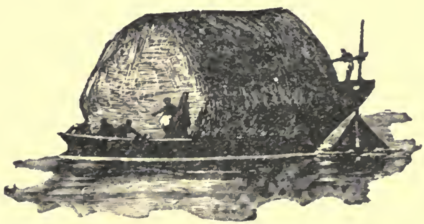
Lost Time.—The time that a train has lost, taking the schedule as a basis. If a train is behind time it may be said to have "lost time."

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

Making Time.—Signifies that a train is running in accordance with the time allotted it in the schedule; is not losing time. When a train is recovering the time it has lost, (generally by running faster than usual), it is said to be "making up its time."

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

Movement of Trains by Telegraph.—Telegraphic orders directing the movement of trains. The manipulation of trains from a central office through the medium of orders sent by telegraph. The substitution of special orders for the fixed time and rights allotted trains in the schedule and in the rules and regulations appertaining thereto. Directing what trains shall have the right to the road, and where and when they shall run without reference to the rights allotted them in the schedule.



Carriage on the Hooghly.

On Time.—Means that a train is conforming exactly to the time specified in the schedule; in accord with it.

Open Switch.—When a switch is "open" the main track from one direction is connected with a subsidiary or collateral track, while the main track from the opposite direction is not connected with anything. "Open a switch" is to disconnect a track and connect one part of it with some other track.

Overshooting.—Running past a point, as "overshooting" a station.

Passing Point.—A place where a train is overtaken and passed by another train going in the same direction.

Regular Train.—A train specifically named and graded in the schedule, as "Passenger train No. 3."

Right to the Road.—The right of a train to proceed on its course. The right to occupy the main track at a particular time and place, to the exclusion of all other trains of the same or inferior grade. In the absence of special orders to the contrary, trains of an inferior grade are required to keep out of the way of trains of a superior grade, *i. e.*, when a train of a superior grade is due according to the schedule, trains of an inferior grade must not occupy the main track until the superior train has passed.

Rights of a Train.—Certain rights that a train possesses as defined by the schedule and the rules and regulations governing the movements of trains. The right a train has to proceed according to the time allotted it in the schedule, when it can do so without impeding the course of a train of a superior grade, or when not otherwise ordered. The rights a train of a superior grade possesses over trains of an inferior grade. The rights under certain circumstances which a train going in one direction possesses over trains going in the opposite direction, etc.

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

Running Time of Trains.—See "Time."

Run Regardless.—A special or telegraphic order to run a train regardless of another specified train or trains. An order giving a train the right to the road against another train 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 or Time Table.—The schedule accurately fixes the grade of each and every regular train; it provides where trains shall meet or pass each other; it fixes the maximum speed of trains, and gives each regular train a definite number, and specifies the time of its arrival at and departure from stations.* The rules and regulations governing the movement of trains properly form a part of the schedule, and with these it is the chart that in the absence of special or telegraphic orders to the contrary governs the movements of trains.

Semaphore.—"An apparatus or piece of mechanism for exhibiting signals to convey information from a distance."—*Webster.*†

Setting a Switch.—Arranging a switch so as to connect certain specified 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

* The schedules published in the various railway guides are in form substantially the same as those used by trainmen. They, however, name only passenger trains, while the working time tables show both passenger and freight trains.

† A description of the ordinary form of semaphore will be found elsewhere herein.

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 so adjusted 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 each end by a switch. With unimportant exceptions, the freight cars required to transport the traffic of railroads are loaded and unloaded while standing upon these tracks; the tracks at the different stations vary in number and length with the business that requires accommodation. For the purpose of enabling trains to meet and pass each other upon the road, side tracks of varying length are required to be located at convenient points along the line. The terms familiar to railway men, "will take a side track," "will side track," mean, when robbed of the peculiar phraseology in which they have been clothed, that the train referred to will run upon and occupy a side track.

Sidings.—See "Side track."

Signals.—Train signals. The mediums by which under certain circumstances intelligence is conveyed quickly, and at a distance between employes at night and by day, through the agency of the human senses. The signals consist of motions of the arms and body; of fusees or torpedoes placed upon the track; of flags and other devices of different colors for use during the day; of lamps of varying color and significancefor use at night, and, finally, of information conveyed through the medium of the semaphore. Certain letters, figures and combinations are in common use as signals upon telegraph lines for the purpose of expediting business.

*Slipping the Wheels.**—When the wheels do not revolve (the engine or train being in motion) they are said to slip. Also, when the wheels revolve so fast that their adhesion to the rail is lost, often observed in driving wheels of engines when starting heavy trains.

Special Train. —A train provided for a special purpose. It is not named in the schedule, and is moved under the special orders of the superintendent. A wild train.

Trains of a certain character or grade, like suburban or way passenger trains, are designated as special trains upon some lines. Upon still other roads, what we have already classified as an extra train, is called a special train. A special train is an extra train in this, that it is operated for the purpose of meeting a want that the regular trains do not adequately provide for.

Spur Track.—A track connected only at one end with the main track; it sometimes runs parallel with the latter, the same as a side track. These tracks are usually constructed for the purpose of giving a company access to gravel pits, stone quarries, and outlying manufactories and business enterprises, etc.

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* It is termed "Skidding the Wheels" in Great Britain.

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

Holland Carrier.

side track located at an isolated point on the line possesses, in many important respects, the same significance as a station; a place where trains meet or pass each other.

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

"To turn from one railway track to another."—*Webster.*

Switching (called "Shunting" on English roads).—The transfer of a car from one track to another. The manipulation of cars in yards and elsewhere. The arranging and rearranging of cars in making up trains so as to get them in the order desired. The arranging of cars upon the arrival of trains at their destination or while en route.

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

Through Train.—A train designed to accommodate the through traffic, or (in the case of a pas-

* 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 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.

Carriage on the Thames.

senger train) the traffic between the large cities at which it stops.

Time.—The time allotted to trains by the schedule and by which their movements are governed. In some cases, though rarely, special orders are given to trains to run to a specified point in the event they can reach such point by or before a certain time named in the order.

Time Table.—See "Schedule."

Train Dispatcher.—An assistant of the Superintendent. The official who directs the movement of trains by telegraph. An expert.

Trains.—The trains operated upon our various railroads may be specified as follows, viz.: Ballast, coal, dirt, emigrant, excursion, express, freight, fruit, gravel, mail, milk, mineral, oil, ore, passenger, pay, stock, stone, timber, wood, work, wrecking,* etc. "Freight trains" embrace, practically, all trains engaged exclusively in transporting property for which a railway company receives pay.

Turn a Switch.—To "turn a switch" is to disconnect one track, substituting another track in its place.

Turn Out.—See "Side track."

Way Train.—A train that stops at the various stations and is occupied in doing the petty or local business of a company. An accommodation train. A way passenger train or way freight train stops at all regular stations. The duties of employes

* In England a wrecking train is called a "Breakdown Van Train."

on way freight trains are multifarious and arduous. In addition to the ordinary duties of trainmen they are compelled to handle much of the freight hauled in their trains. For instance, a freight car sometimes contains small parcels of freight for 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. The engines of way freight trains do the switching required at the small stations.

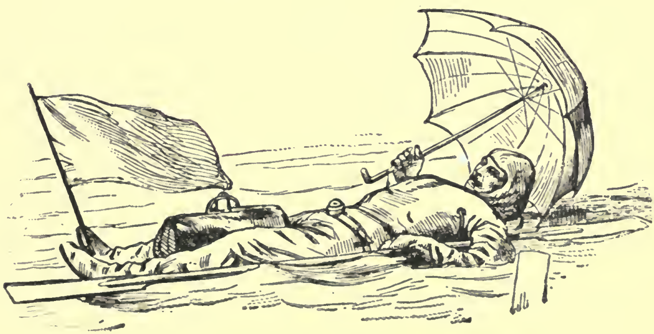
When a Train has Lost its Rights.—A regular train, when twelve hours behind time, usually loses its right to the road against all regular trains. It is no longer provided for by the schedule; it ceases to be a regular train, and becomes an extra or wild one. A train may lose its rights as against a particular train or trains, and still possess rights that are paramount over those of other trains. Upon a single track road a train of the highest grade going in a certain direction 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, and the opposing train must keep out of its way. Trains of an inferior grade can not proceed until trains of a superior grade that are due, or past due, have arrived, unless the latter are twelve or more hours behind time.

Whistling Post.—A post or board erected in the vicinity of stations and crossings. A signal to the engineman to sound the whistle of his engine.

Wild Train.—An irregular train for which no provision is made in the schedule. It is operated under orders, and is required to keep out of the way of regular and extra trains unless especially directed otherwise.

Wood or Fuel Train.—A train engaged in hauling the fuel required by a railway company for its own use.

Y.—A track of the general shape of the letter Y. A track connecting two tracks running at right angles with each other. This track, or combination of tracks, affords a convenient means of turning trains or cars.



Carriage on the Scheldt.

CHAPTER XVI.

PLAN OBSERVED IN COMPILING THE RULES AND REGULATIONS IN THIS BOOK.

The directions in this book governing the movement of trains have been compiled, as already stated, from rules and regulations in force upon the greatest, most thoroughly organized and best managed roads of America. In their compilation, the workings of the principal roads of Great Britain were also studied, and such rules and regulations as were thought applicable embodied. In many cases where present or former regulations are not directly or wholly practicable, they have nevertheless been inserted as foot notes for the purpose of illustrating other theories and peculiarities or for the information and instruction they afford. Many of the rules, however, are original with the author. In this compilation it has been necessary to decide between conflicting rules in many instances. In such cases preference has been given to those that seemed, taking all things into consideration, the most feasible, or to possess the greatest practical value. The object has been to form as perfect a code of rules as seemed possible.

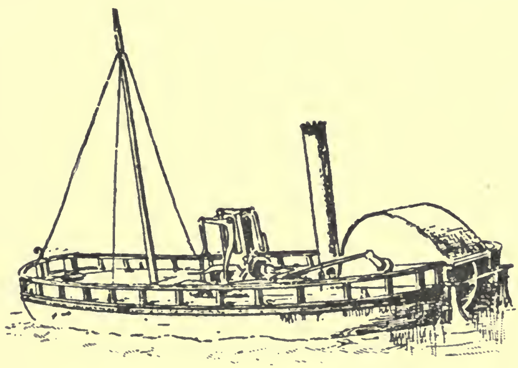
The compilation has not been made with the expectation of its adoption by any particular company. Wherever the rules are applicable or valuable to railway managers, either wholly or in part, they will in time be accepted; where they are not applicable or best, they ought not to be adoped, and will not be.

While it has been the aim of the writer to make the regulations practicable upon any line, it is true that many rules imperative upon one line are unnecessary upon another, or possess little relevancy. The double track road, for instance, does not require such elaborate rules as a single track road, still it is necessary to provide regulations sufficiently comprehensive to provide for the operation of a single track in the event circumstances should, temporarily or otherwise, so restrict a company's resources.

The company that can, without inconveniencing the public, allow twenty minutes between its trains, will possess rules that, while they are wise in their application by that particular company, would be cumbersome and impracticable upon a line where the business required trains to arrive and depart every five minutes.

The principal object of the compiler has been to place within the reach of railway men, of every grade and occupation, facilities for acquiring accurate knowledge of the extent and scope of the duties and responsibilities of train men under the American system.

An examination of the rules and regulations of the best managed companies makes it apparent that many seemingly trivial but really important things that employes should possess accurate knowledge of are nowhere mentioned; it being accepted as a matter of course that the employes possess the desired knowledge. And it is doubtless true that those familiar by experience with the practical working of trains do possess this knowledge, but the novice or student finds the omissions of a character not to be overcome except by experience or diligent and protracted en-



The First Steamship, "Charlotte Dundas," 1801.

quiry, which but few of them are able to prosecute successfully. The writer has, therefore, introduced new rules and explanations wherever he believed they would tend to a clearer understanding of the subject.

In reference to the construction of old rules adopted herein, he has altered and amended their purport or phraseology wherever greater efficiency or clearness could be secured thereby; the object being to frame a code of rules sufficiently comprehensive to cover great enterprises as well as comparatively unimportant or partially completed ones.*

* The more minute rules and regulations of the old fashioned block system having no general significance in the United States, and not being likely to have, are not embodied herein. The general regulations applicable to that system are, however, given in the chapter in relation to the operation of trains on English roads.

CHAPTER XVII.

RULES AND REGULATIONS APPERTAINING TO THE MOVEMENT OF TRAINS. (PART ONE.)

The signals and rules and regulations agreed upon by the American Railway Association are embodied herein. Much time was spent by the association in formulating these rules. The object sought was the securing of greater efficiency in the operation of trains upon roads where the block system was not in vogue, or only in a limited way. An examination of the subjoined rules in their entirety will suggest the difficulties railway representatives find in agreeing upon a standard that shall embrace all the rules necessary in connection with the movement of trains.

The rules that are printed solid are the rules of the American Railway Association. Those that are leaded are such as the author esteemed necessary to a complete code. As already intimated all the rules embodied herein are substantially those compiled by the author in his first book on train service published in 1878.

GENERAL RULES.

It is contemplated that every company will supply its employes with printed instructions governing the movements of trains; these will be contained partly in printed manuals, partly in instructions issued in connection with time tables, partly in special rules issued as circumstances require.

It is the duty of officials in charge to see that these instructions are properly understood and measures taken to secure obedience.

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

The fact that any person enters, or remains in, the service of the company will be considered as an assurance of willingness to obey its rules. No one will be excused for the violation of any of them, even though not included in those applicable to his department.

If in doubt as to the meaning of any rule or special instructions, application must be made at once, to the proper authority, for an explanation. Ignorance is no excuse for neglect of duty.

First Railway Coach.

All employes will be regarded as in the line of promotion, advancement depending upon the faithful discharge of duty, and capacity for increased responsibility.

If an employe should be disabled by sickness or other cause, the right to claim compensation will not be recognized. An allowance, if made, will be a gratuity justified by the circumstances of the case and the employe's previous good conduct.

Every employe, while on duty connected with the trains on any division of the road, is under the authority, and must conform to the orders of, the superintendent of that division.

Employes must wear the prescribed badges or uniforms while on duty.

Mail agents, express messengers, parlor and sleeping car conductors and porters, news agents, and persons in charge of individual cars are subject, while on duty, to the rules governing employes of the company.

Conductors, engineers and telegraph operators should pass an examination in the rules and regulations before being set to work.

Such notice should be taken of disobedience of orders, neglect of duty, or inefficiency, as the interests of the company require.

Each person in the employ of the company should devote himself exclusively to its service, and may not engage in any other business, except on permission from a duly authorized official.

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

All 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 all cases of damage to persons or property.

Persons whose pay is garnished should, in the discretion of officials in charge, be subject to such deductions of pay as may be necessary to reimburse the company for expenses incurred.

The use of intoxicating liquors on the part of employes can not be allowed.

An employe discharged from one department can not be re-employed by another without permission being first obtained.

Minors can not be employed in the train service except under special arrangements.

All communications concerning the safety of trains, track or buildings should, when possible, be made in writing.

An employe can not become familiar with his duties except by acquiring knowledge of the duties of others. This knowledge can not be acquired without studying all rules and regulations; he will find something that interests him under all the headings and sub-headings; it is impossible to accurately classify under different headings the duties of the various employes without endless reiteration. All rules and regulations pertaining to the service should therefore be studied.

One of the tests of an employe's fitness is the extent and accuracy of his information as to train and station service; this is particularly the case with train and station officials. Each train official should be especially familiar with the duties of the various servants of the company connected with the train service. so that in the event of accident he may be prepared to perform their functions. The same rule holds good in regard to employes at stations.

Employes should be sober, temperate men; * they should not accept gratuities; † they should attend diligently to their duties during prescribed hours and should reside wherever the interests of the company require.‡

All property they may find or which may come into their possession should be turned over to the authorized officer of the company.‖

Employes should obey promptly instructions received from persons placed in authority over them.

Disobedience, negligence, incompetency or immorality renders a person unfit for retention in the service, and is sufficient cause for immediate dismissal; but suspension from duty may be substituted at the discretion of the proper officer.§

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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."—1854.

† "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."—1854.

‡ "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 immediately 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."—1854. "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 enquiry."—*Great Northern Railway, England.*

§ "Persons who disapprove of the regulations adopted, or are not disposed to aid in their enforcement, are requested not to

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

All orders and instructions should be filed for future reference.

Employes should exercise a wise discretion and economy in the use of the company's material intrusted to their care.†

Employes intrusted with keys to switches or cars should receipt for them, and not let them go out of their possession.

Employes should be held responsible for injuries to persons or property occasioned by their negligence or misconduct, also for all moneys that may come into their possession. The company reserves the right to reimburse itself for any expense it may be put to in consequence of the negligence, misconduct or improper action of an employe, by withholding the pay of the person in fault.‡

Employes of the company are forbidden, while upon duty, from entering into altercation with other persons, no matter what the provocation.

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remain in the employment of the company."—1854. "And they will enquire 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 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 volume "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

The pay of employes absent from duty will be stopped, unless otherwise directed by the proper officer.*

When instructions are not 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 the lives of passengers or others, seeking of the proper officer, on the first opportunity, the explanations they require.

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

STANDARD TIME.

Observatory standard time is the only recognized standard, and will be transmitted from .... Observatory to the designated offices.

The standard time will be telegraphed to all points from the designated offices at 4 p. m., Central time, daily.

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

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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 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.*

Certain clocks will be designated on each division as standard clocks.

Where station clocks are provided, station agents must see they show correct time; but trainmen and enginemen must not take time from such clocks unless they are also designated as standard clocks.

Each conductor and engineman* must have a reliable watch which has been examined and certified to on the form attached hereto, by a responsible watchmaker, and must file such certificate with the proper designated officer before he is allowed to take charge of a train or engine. Watches must be examined and certificates renewed every six months.†

(*Form of Certificate.*)

WATCHMAKER'S CERTIFICATE.

This is to certify that on ...., 189..
the watch of ....
employed as ....
on the .... R..........
has been 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) ....
Watchmaker.
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.]

Each conductor and engineman must regulate his watch by the designated standard clock before starting on each trip, and register his name and the time at which he regulated his watch on a blank form (or in a book) provided for that purpose.

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

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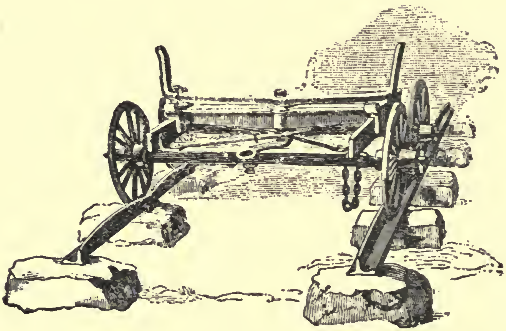
*The term "Engineman" embraces locomotive engineers and firemen.

†Some companies require this examination to be made at more frequent periods.

The minimum standard of excellence for watches should be of a grade equal to what is generally known among American movements 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 can not be passed upon by another, except 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



Primitive Iron Railway and Truck, A. D. 1800.

should be at liberty to do so. The watch he carries during the time his own is being cleaned or repaired, however, must be examined by the company's examiner, and for this examination the employe should pay the necessary fee.

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

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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.

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.

TIME TABLE.

A time table is the general law governing the arriving and leaving time of all regular trains at all stations. Time tables will be issued from time to time. as may be necessary. The times given for each train on the time table is the schedule of such train.

Each time table, from the moment it takes effect, supersedes the preceding time table, and all special instructions relating thereto; and trains shall be run as directed thereby, subject to the rules. All regular trains on the road running according to the preceding time table shall, *unless otherwise directed*, assume the times and rights of trains of corresponding numbers on the new time table.

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 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 other 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 is called to it by ———.

[NOTE.—The committee recommend that each company adopt such method as it may prefer in filling the above blank as to the manner of calling attention to such meeting or passing points.]

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

On the employes' time table the words "daily," "daily, except Sunday," etc., printed at the head and foot in connection with a train, indicate how it shall be run. The figures given at intermediate stations shall not be taken as indicating that a train will stop unless the rules require it. 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 committee recommend that odd numbers shall be given to west or south bound trains, and even numbers to east or north bound trains.]

SIGNAL RULES.

SIGNALS.

Conductors, enginemen, firemen, brakemen, station agents, telegraph operators, switchmen, switch tenders, track foremen, road and bridge watchmen, and all other employes whose duties may require them to give signals, must provide themselves with the proper appliances, and keep them in good order and always ready for immediate use.

If in any emergency the 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, and lamps of the proper color by night or whenever from fog or other cause the day signals can not 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.*

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 used by car inspectors.

An explosive cap or 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 is a signal to *reduce speed* immediately, and look out for a danger signal.

A fusee is an *extra* danger signal, to be lighted and placed on the track at night, in cases of accident or emergency.

A train finding a fusee burning upon the track must come to a stop, and not proceed until it is burned out.

A flag or lamp swung across the track, a hat or any object waved violently by any 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 them in such a manner as to be readily understood. The utmost care should be exercised by

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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 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.

trainmen to avoid taking the wrong signal, when two or more trains are passing each other at stations or in yards. Unless both the conductor and engineer are positive that the signal given is for them, they should not move their trains until communication is made by word of mouth.

Engineers, conductors and brakemen of all trains, also station, track, bridge, signal and switchmen, should carefully observe all passing trains by day and night to see if they flag following trains, and in case signals are shown on any engine should govern themselves accordingly.

"Every guard, signalman, enginedriver, 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 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 upwards) 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." *

Should a third torpedo be exploded at the regulation distance (600 yards) from the first two, the train should be stopped 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 dotonators 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.

Each 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.*

Each 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. In the absence of an equivalent appliance, a bell cord must be attached to the signal bell of the engine, passing through or over the entire length of the train, and secured to the rear end of it.

Two green flags by day and 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 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 the end of a car, denote that car inspectors are at work under or

* "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.* Several 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.*

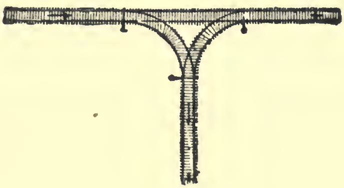
‡ "A special train to follow is indicated by the preceding train carrying on the last vehicle a red board or a red flag by day and an additional red tail lamp by night, but as special trains or engines have frequently to be run without previous notice of any kind, it is necessary for the staff along the line to be at all times prepared for such extra trains or engines."—*English Standard.*

about the car or train. The car or train thus protected must not be coupled to or moved, until the blue signal is removed by the car inspectors.

When a car or train standing on a siding is protected by a blue signal, other cars must not be placed in front of it so that the blue signal will be obscured, without first notifying the car inspector, that he may protect himself.

[NOTE.—The committee find on investigation that the combined green and white signal denoting an irregular train following, as suggested by the "Committee on Uniform Train Signals" in their report of October 11, 1883, and adopted by the convention of October 9, 1884, is unsatisfactory and is used by a very limited number of roads. As your committee have found it impracticable to suggest any combination of signals, sufficiently distinct from other signals, they do not recommend the carrying of any signal denoting an irregular train following, and have therefore omitted the signal from the rules.]

Two green and two white flags (one of each kind on each side) by day and two green and two white lights by night indi-



Y Track.

cate 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.

A yellow flag or lantern carried in front of an engine denotes that the telegraph line is out of order, and the track men 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 is the signal for approaching stations, railroad crossings and junctions (thus, ——).

One *short* blast of the whistle is the signal to apply the brakes —stop (thus, –).

Two *long* blasts of the whistle is the signal to throw off the brakes (thus, —— ——).

Two *short* blasts of the whistle is an answer to any signal, except "train parted" (thus – –).

Three *long* blasts of the whistle (to be repeated until answered, as provided) is a signal that the train has parted (thus,—— —— ——).

Three *short* blasts of the whistle, when the train is *standing* (to be repeated until answered, as provided), is a signal that the train will back (thus, – – –).

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 is the engineman's call for signals from switch tenders, watchmen, trainmen and others (thus, – – – –).

Five *short* blasts of the whistle is a signal to the flagman to go back and protect the rear of the train (thus, – – – – –).

One *long* followed by two *short* blasts of the whistle 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 (thus, —— – –).

[NOTE.—In order to avoid duplicating signals the committee have recommended that the above named signal be substituted for the three short blasts now used, with which much dissatisfaction has been expressed. In the opinion of some of the committee this rule is unnecessary.]

Two *long*, followed by two *short*, blasts of the whistle is the signal for approaching road crossing at grade (thus, —— —— – –).

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.*

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* "Every guard, when traveling, must keep a good look out and should he see any reason to apprehend danger, he must use

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 has 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.

LAMP SIGNALS.

A lamp swung across the track is the signal to stop.*

A lamp raised and lowered vertically is the signal to move ahead.

A lamp swung vertically in a circle across the track, when the train is *standing*, is the signal to move 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 as soon as dusk commences, and during the interval between daylight and dark, both day and night signals should be used.†

Hand lamps and flags, when used as signals, should be held in the hand, unless otherwise directed.

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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."—*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 right' is shown . . . by holding the right arm in a horizontal position pointing across the line of rails."—*Great Northern Railway, England.*

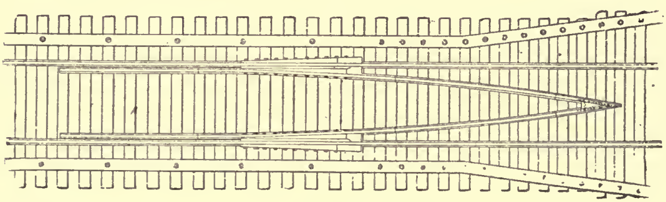
† English Clearing House Standard.

FIXED SIGNALS.

Fixed signals are placed at junctions, railroad crossings, stations and other points that require special protection. Special instructions will be 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 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 can not 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.



Bridge Guard.

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 the whistle is prohibited; when necessary in shifting at stations and in yards the engine bell should be rung, and the whistle used only when required by rule or law, or when necessary to prevent accident.

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* "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.*

† "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.

The whistle must not be sounded while passing a passenger train, except in cases of emergency or danger, or when required by the rules.

When a danger signal (except a fixed signal) is displayed to stop a train, it must be acknowledged as provided.

The engine bell must be rung before starting a train, and when running through tunnels and the streets of towns or cities.

The engine bell must be rung for a quarter of a mile before reaching every road crossing at grade, and until it is passed; and the whistle must be sounded at all whistling posts.

When two or more engines are coupled to the head of a train, the leading engine only shall display the signals as provided.

One flag or light displayed as a classification signal will be regarded the same as if two were displayed; but conductors and enginemen will be held responsible for the proper display of all train signals.

When a train is being pushed by an engine (except when shifting and making up trains in yards) a white light must be displayed on the front of the leading car at night, or when the train is obscured by fog or other cause.

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 track is clear and the train has stopped, and 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 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.

White signals must be used by watchmen at public road and street crossings to prevent persons and teams from crossing when trains are approaching. Danger signals must be used only when necessary to stop trains.

Torpedoes must not be placed near stations or road crossings where persons are liable to be injured by them.

All signals must be used strictly in accordance with the rules, and trainmen and enginemen must keep a constant lookout for signals.

[NOTE.—In connection with the subject of signals the committee recommend that no cross arms or telegraph poles placed along the lines shall be permitted to be painted red or green.]

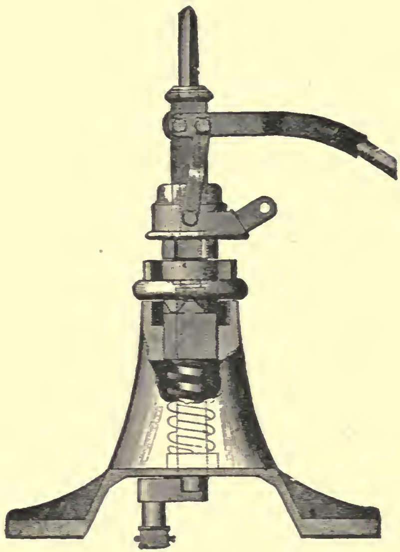
A red lantern should be kept lighted, ready for use at night or in foggy weather, in the rear car of trains, also upon engines.

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.

The cylinder cocks of engines should be closed when trains are waiting on turnouts, clear of the main track.

When upon duty each trainman should carry three torpedoes in his pocket. Trains should also be provided with fusees

No new signal should be brought into use, nor alteration made in the position of use or any signal, without the authority of the proper officer.



Automatic Safety Switch Stand.

TRAIN RULES.

CLASSIFICATION OF TRAINS.

All trains are designated as regular or extra. Regular trains are those represented 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. An engine without cars, in service on the road, shall be considered a train.

All 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 the second and all succeeding classes, and trains of the second class being superior to those of the third and all succeeding classes, and so on indefinitely. The terms passenger, freight, or mixed are descriptive and do not refer to class.

Extra trains may be distinguished as:—

Passenger extra, or special;
Freight extra;
Work train extra.

All extra trains are of inferior class to all regular trains of whatever class.

MOVEMENT OF TRAINS.

A train of inferior class must in all cases keep out of the way of a train of superior class.

On single track, all trains in one direction, specified in time table, have the absolute right of track over trains of the same class running in the opposite direction.

[NOTE.—It being represented to the committee that some of the roads represented in the convention will be unable, on account of limited telegraph facilities and other local causes, to carry out this rule in its literal meaning and full scope, it is suggested by the committee that such roads may issue regulations to arrange this matter in some other way. The committee believe, however, that a test of the rule, as approved by the committee, and its literal enforcement, will result to the entire satisfaction of those using it.]

When trains of the same class meet on single track, the train not having right of track must take the siding and be clear of 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 out in the direction of the opposing train.

[See note under following rule.]

When a train of inferior class meets a train of superior class on 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.

[NOTE.—The committee recommend in case grades or other conditions are such that on any line or parts of line greater protection is necessary, the second preceding rule should require a clearance of *five* minutes, and the preceding rule *ten* minutes.]

A train must not leave a station to follow a passenger train until *five* minutes after the departure of such passenger train, unless some form of block signal is used.

Passenger trains running in the same direction must keep not less than *five* minutes apart, unless some form of block signal is used.

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 some form of block signal is used.

[See note under next rule.]

No train must 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 full schedule time to make the meeting or passing point, or unless it has the full time allowed between stations (which may be shown on the margin of the time table) to make the meeting or passing point, and clear the track by the times required by the rules.

[NOTE.—The committee recommend, 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 right of track must be entirely clear of the main track by the time it is required by rule to clear an opposing train or a train running in the same direction: failing to do so it must be immediately protected, as hereafter provided.

Except at meeting or passing points, as provided, no train must arrive at a station in advance of its schedule arriving time, when shown.

No train must leave a station in advance of its schedule leaving time.

All trains must *stop* at schedule meeting or passing points on 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. The point at which a train should *stop* is 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 train having right of track must approach all sidings prepared to stop, until the expected train is met or passed.

All trains must approach the end of double track, junctions, railroad crossings at grade, and drawbridges prepared to stop, and must not proceed until the switches or signals are seen to be right, or the track is plainly seen to be clear. Where required by law, all trains must stop.

No train must leave a junction, a terminal, or other starting point, or pass from double to single track, until it is ascertained that all trains due, which have the right of track against it, have arrived.

When a passenger train is detained at any of its usual stops more than ——— minutes, the flagman must go back with danger signals and protect his train as provided: but if it stops at any unusual point, the flagman must immediately go back far enough to be seen from a train moving in the same direction when it is at least ——— from the rear of his own train, and if the stop is over ——— minutes he must be governed by the rule relating to trains stopped by accident or obstruction. When it is necessary to protect the front of the train, the same precautions must be observed by the fireman. If the fireman is unable to leave the engine, the front brakeman must be sent in his place.

[NOTE.—The committee, on account of the existing great diversities of grades, amount of traffic and other local circumstances, have left blanks in this rule for each company to fill out, after determining what times, if any, are necessary, either for its road as a whole or for each division.]

When a freight train is detained at any of its usual stops more than ——— minutes, where the rear of the train can be plainly seen from a train moving in the same direction at a distance of at least ———, the flagman must go back with danger signals not less than ———, and as much farther as may be necessary to protect his train; but if the rear of his train can not be plainly seen at a distance of at least ———, or if it stops at any point that is not its usual stopping place, the flagman must go back not less than ———, and if his train should be detained until within *ten* minutes of the time of a passenger train moving in the same direction, he must be governed by the rule relating to trains stopped by accident or obstruction.*

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*This rule seems unnecessary except upon a double track road where freight trains move without much, if any, reference to the rights of other trains under the schedule. It is impossible that signals should in all cases be sent out as directed at the various regular stopping places of freight trains. To do so would require an enormous train or station force, and besides, if the freight train is not trespassing upon the rights of other trains, such precautions are unnecessary. If it is in the way of trains having the right to the track, then the precaution provided by this rule is necessary, otherwise it is not. The regulations require that officials in charge of extra or wild trains, or delayed trains of inferior grade, must approach stations carefully, expecting to find other trains at such stations. If trains of an inferior grade trespass upon the rights of trains of a superior grade, then they should be protected in the manner provided. Upon a double track road it would not of course be necessary to send the signals in advance, as provided in the rule, unless the opposite track was obstructed. I find the following rule, in the regulations of a prominent road, worthy of incorporation here: "Should it be necessary for a first class train to occupy the main track at a station or turnout, in the time of any train of the same class, which by the time table should either stop or pass any first class train at such station or turnout, no signal shall be given to such approaching train, but it must be distinctly understood that when any train occupies the main track at any station or turnout, in the time of any other train of the same class, which by the time table does not stop at such station or turnout, the proper signal must be sent out to prevent accident."

When it is necessary to protect the front of the train, the same precautions must be observed by the fireman. If the fireman is unable to leave the engine, the front brakeman must be sent in his place.

[NOTE.—The committee finding that the distances and times necessary for flagmen to go back differ so much on account of grades, amount of traffic and other local circumstances, have left blanks for each company to determine what distance and time is necessary, either for its road as a whole, or for each division.]

When it is necessary for the flagman to go back to protect the rear of his train, the next brakeman must immediately take the flagman's position on the train and remain there until relieved by the flagman; and on passenger trains the baggagemaster must take the place of the front brakeman whenever necessary.

When a train is stopped by an accident or obstruction, the flagman must immediately go back with danger signals to stop any train moving in the same direction. At a point ——— from the rear of his train he must place *one* torpedo on the rail; he must then continue to go back at least ——— from the rear of his train and place *two* torpedoes on the rail, ten yards apart (one rail length), when he may return to a point ——— from the rear of his train, and he must remain there until recalled by the whistle of his engine; but if a passenger train is due within *ten* minutes, he must remain until it arrives. When he comes in, he will remove the torpedo nearest to the train, but the *two* torpedoes must be left on the rail as a caution signal to any following train. If the accident or obstruction occurs upon single track, and it becomes necessary to protect the front of the train, or if any other track is obstructed, the fireman must go forward and use the same precautions. If the fireman is unable to leave the engine the front brakeman must be sent in his place.

[See note under third preceding rule.]

Freight trains having work to do on any other track may cross over if no passenger train is due, provided no approaching freight train is in sight; and also provided that a flagman has been sent with danger signals, as provided, not less than ——— in the direction of the expected train.

[See note under fourth preceding rule.]

When a freight train on double track turns out onto the opposite track to allow a passenger train running in the same direction to pass, and, while waiting, a passenger train from the opposite direction arrives, the freight train may cross back and allow it to pass, provided the other passenger train is not in sight; and also provided that a flagman has been sent with danger signals, as provided, not less than ——— in the direction of the expected train.

[See note under fifth preceding rule.]

When it is necessary for a freight train on double track to turn out onto the opposite track to allow a passenger train running in the same direction to pass, and a passenger train running in the opposite direction is due, a flagman must be sent back with danger signals, as provided, not less than ——— in the direction of the following train, and the freight train must not cross over until one of the passenger trains arrive. Should the following passenger train arrive first, a flagman must be sent forward on the opposite track with danger signals, as provided, not less than ——— in the direction of the overdue passenger train before crossing over. Great caution must be used, and good judgment is required, to prevent detention to either passenger train. The preference should always be given to the passenger train of superior class.

[See note under sixth preceding rule.]

[NOTE.—In regard to backing trains upon the main track or crossing over on double track to move in the wrong direction to avoid obstructions, the committee believe that owing to the different conditions of the train service, etc., on the various roads, it is impossible to formulate a rule which can be generally adopted, and therefore recommend that each company issue such special instructions to cover this case as its circumstances may require.]

If a train should part while in motion, trainmen must use great care to prevent the detached parts from coming into collision. Enginemen must give the signal as provided, and keep the front part of the train in motion until the detached portion is stopped. The front portion will have 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, and running with great caution, at a speed not exceeding four miles per hour. On single track all the precautions required by the rules must also be taken to protect the train against opposing trains. *The detached portion must not be moved or passed around until the front portion cames back.* This rule applies to trains of every class. An exception will only be made to the above when it is known that the detached portion has been stopped, and when the whole occurrence is in plain view, no curves or other obstructions intervening, so that signals can be seen from both portions of the train. In that event the conductor and engineman may arrange for the recoupling, using the greatest caution.

[See note under seventh preceding rule.]

If the engineman of a train can not 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 ten minutes, signal his engine back to the rear portion of his train, presuming that it is still in motion, taking great 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 not to stop any part so as to permit of collision with it. When stopped, each portion should be protected by signals.*

When a train is being pushed by an engine (except when shifting and making up trains in yards) a flagman must be stationed in a conspicuous position on the front of the leading car, so as to perceive the first sign of danger and immediately signal the engineman.

A train starting from a 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, and the overdue train will run as provided.

A train which is delayed, and falls back on the time of another train of the same class, does not lose its rights.

Regular trains twelve hours or more behind their schedule time lose all their rights.†

A train overtaking another train of the same or superior class, *disabled so that it can not move*, will run around it, assuming the rights and taking the orders of the disabled train, to the next telegraph office which is open, where it will report to the superintendent. The disabled train will assume the rights of the last train passing it, till the next telegraph office which is open is reached.

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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.*

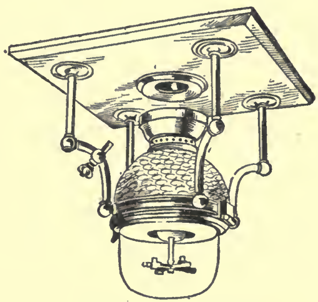
† Until, therefore, a regular train is twelve hours or more late it is only necessary for it, as it proceeds, to keep off the time of regular trains, of the same or superior grade, until the expiration of the time stated; extra or special trains must keep out of its way.

All messages or orders respecting the movement of trains or the condition of tracks or bridges must be in writing.

Passenger trains must not display signals for a following train without an order from the superintendent; nor freight trains without an order from the yardmaster.

Extra trains must not be run on single track without an order from the superintendent.

When signals displayed for a following train on single track are taken down at any point before the following train arrives, the conductor must inform the superintendent promptly by telegraph, and also the operator or switchtender; and the latter, unless there is some other provision for the purpose, must notify all opposing trains of the same or inferior class leaving that point before the train arrives for which signals were displayed.



Car Gas Burner, "Pintsch" (Equal 44 Candles).

If signals are taken down at a point where there is no operator, switchtender, or other provision for the purpose, the conductor must notify all opposing trains of the same or inferior class until he reaches the next telegraph office, when he must inform the superintendent; and the operator, unless there is some other provision for the purpose, must notify all opposing trains of the same or inferior class until directed otherwise by the superintendent.

If the train for which signals were displayed leaves the main line at a point where there is no operator, switchtender, or other provision for the purpose, a flagman must be left to notify opposing trains that it has arrived.

Work trains will be run as extras under special orders, and will be assigned working limits.

Great care must be exercised by the trainmen of a train approaching a station where any train is receiving or discharging passengers.

Enginemen must observe trains on the opposite track, and if they are running too closely together call attention to the fact.

No person will be permitted to ride on an engine except the engineman, fireman and other designated employes in the discharge of their duties, without a written order from the proper authority.

Conductors will be held responsible for the proper adjustment of the switches used by them and their trainmen, except where switchtenders are stationed.

Whoever opens a switch shall remain at it until it is closed, unless relieved by some other competent employe.

When there is more than one train to use a switch it must not be left open unless one of the trainmen of the following train is at the switch and takes charge of it.

Accidents, detention of trains, failure in the supply of water or fuel, or defects in the track or bridges, must be promptly reported by telegraph to the superintendent.

No train shall leave a station without a signal from its conductor.

Conductors and enginemen will be held equally responsible for the violation of any of the rules governing the safety of their trains, *and they must take every precaution for the protection of their trains, even if not provided for by the rules.*

In all cases of doubt or uncertainty, take the safe course and run no risks.

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, if the train does not arrive by the time specified.

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 ——— from the train. The fusee should not be lighted until the signalman is recalled.*

Where a mixed gauge is used, torpedoes should be placed on each rail, both for broad and narrow gauge trains, or on the rail which is used for both.

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,

* This distance will vary according to the topography of the road, condition of business, etc.

using the proper danger signals to stop any following train, until assistance arrives or the train is sidetracked.

When a train is stopped upon the main track in consequence of the signals referred to in the preceding rule, the conductor should in turn protect his train with signals, in the manner described, from any train that may be following him, thus relieving the signalman previously upon duty.*

Should anything occur to detain an engine, not attached to a train, upon the main track, it should be protected by signals in the manner described.†

In the event of any obstruction or accident to the line, not expressly provided for in the rules, signals should be placed in both directions to warn approaching trains. These signals should be placed in the manner described.

Signal Lamp, A. D. 1861.

In the event of any obstruction or accident to 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

* "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.*

† 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.

flagmen in each direction from the accident; but the first duty of employes is to protect approaching trains from any possibility of disaster.*

In the event any accident occasion the obstruction of, or be dangerously near to, any track used by trains moving in the opposite direction, signals should be placed upon such line, and it should otherwise be protected in the manner contemplated by this rule.

Should a train or engine stop at any unusual point on the road (*i. e.*, at any point that is not a regular stopping place for such train or engine), it should be protected as provided.

If inferior trains are, at any time, contrary to rules, obliged to keep the main track in passing superior trains, signals should be sent twelve hundred yards, in the direction of the expected train, to give suitable warning for it to approach carefully; 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 great care to prevent accident occurring from the obstruction of the main track.† Engines or cars should not be permitted to stand upon the main track, except when switching within the

* "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 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

limits of the various yards. When it is necessary to use the main track at any other point, signals should be placed for the protection of approaching trains as required by this rule.*

Should any vehicle in a train be on fire, the train should be stopped, and protected in the following manner: The brakeman or fireman should detach the cars in the rear of those on fire, and the burning cars should be drawn forward to a distance of fifty yards at least, and then be uncoupled, and left until the fire can be extinguished, to effect which every effort must be made.

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 should be set and the wheels securely blocked.‡

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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.*

* "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."—*Regulations New York Road, 1854.*

‡ "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 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 possi-

When it is necessary to back a train (*i. e.*, when it is necessary to move it in a contrary direction upon the line) danger signals should be sent not less than one mile in advance of the moving train. A train should only be backed to the first siding; while it is in motion the whistle should be sounded at short intervals. The speed of the train should not exceed four miles per hour, so that the signalman may be able to keep the required distance in advance.

In the movement of trains, trainmen should take into consideration the state of the weather, the condition of the track, and the weight of the train.

Trains should run with great care during and after severe rains, and at reduced speed when the track is in bad order, or when crossing long bridges or trestle works.

Trains should carefully approach places or yards where engines use the main track in switching. Stations and switches should also be approached with care.

Upon a single track road when an order is given a train to proceed with caution, keeping a careful lookout for a particular train, it is the duty of the conductor in such cases to send signals in advance as the train approaches curves and obscure places in the track.

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, being kept under control until the opposing train is clear of the main track, and the switches are properly 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. The conductor of the slow train should not proceed until the faster train has passed, without special orders.

When a train is overtaken and passed by a train carrying signals for other trains (having the same rights as the train

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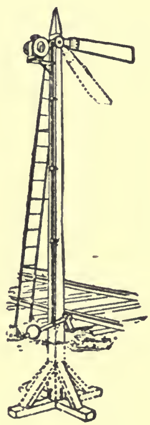
bility of the wagons moving away. The number of sprags must be regulated by the steepness of the gradient, the number of wagons, their loads, and the state of the weather and rails."—*English Standard.*

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 the application of this rule, terminal stations are considered the same as other stations on the road.

If an inferior train falls behind its time, as fixed in 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 named train should be protected



Semaphore.

by signals from all chance of rear collision, and yield the road at the first station after the following train has overtaken it.

Trains should approach stations and yards where switching engines are located with extreme caution.

When approaching stations and sidings, enginemen should observe whether the switches are set right, and should always be on the lookout for signals.

An engineer approaching a station where signals should be shown and failing to observe them, should stop the train and the

* Or, in other words, it must not proceed until all the *extra* trains have passed.

conductor should go at once to the office and learn the cause of the failure. Absence of signals where they should be shown indicates *danger.* All omissions of this kind should be promptly reported by conductors to the proper officer.*

Enginemen of delayed trains, or trains moved by special order, and of all extra or special trains, should approach stations with extreme caution upon the supposition that another train will be overtaken or met; or that the main track will be obstructed or occupied.

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 should be stopped before reaching such passenger train, and not go forward until it moves ahead or signal is given to the first mentioned train to move on.†

Any train following another train or engine should proceed with caution, keeping at least one mile in rear of it, and should approach all stations and fuel places with care, expecting to find

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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.*

†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, can not 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.

the preceding train taking fuel or water at such station, whether it may be a stopping place for that train or not.*

When one or more trains are followed, such train or trains should never be stopped between stations where the view from the rear of the train is not clear for a distance sufficiently great to stop a train after it has come in sight.

When following other trains a sharp lookout should be kept for the train immediately preceding, especially when running around curves and approaching stations.

In the event one or more trains are united and run as one train, notice of the fact should be given agents, also conductors and enginemen of trains that are met or passed. The proper officer should be advised at the first telegraph station of the consolidation of the trains.

A train of an inferior grade, running ahead of a train of a superior grade, should keep ten minutes off the time of such superior train.

Except when otherwise specially provided, extra trains should keep ten minutes off the time of all trains.

Upon a single track road, in the event a train or engine is delayed between stations and loses its right to the road, the conductor of such train (or in his absence, the engineman) should, when the train or engine is ready to move, send danger signals not less than one mile in advance in the direction in which the train or engine is to be moved. The delayed train or engine should only run to the next siding, and while in motion the engineman should frequently sound the whistle, and not exceed a speed of 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 (no matter which way it may be going), and the train having the right to the road can not pass the delayed train, then the latter should proceed to the

* 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.

† 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, in that case, it has not lost its right (unless it is twelve hours late), and it may proceed directly to such telegraph station without being signaled, as directed above.

first siding in advance, carrying signals for the following train. At the first siding it should allow the train having the right to the road to go ahead, after which time both the trains should be governed in all respects as in other cases where one train is met or passed by another.

In extreme cases, in which enginemen find it impossible to make their time in running to stations at which they should by schedule meet another train, they may disconnect their engine, leaving the train under proper danger signals, as required by rule, and run to the next station and notify the aproaching train, and then return for their own train.* But before proceeding to carry out this rule the engineman should have the authority of the conductor to detach the engine and proceed as directed.

When a train is delayed agents and switchmen should report the facts to trains that may be following when the latter stop at their stations.

When 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 following a regular train and properly signaled by it, should always be taken and considered to be a part of and to have all the rights of the regular train and no more.

An engine of a regular train should not carry a signal for any train, excepting of its own grade, unless in such cases as are specifically provided for.

When it becomes necessary for a train of an inferior grade to follow a train of a superior grade, under signals, then such following train should for that time be taken to be of the same grade with the preceding train.

When a train is ordered to carry signals for an extra or following train, the conductor and enginemen of each of the trains affected by the order should be notified. It is the duty of conductors of trains carrying signals to notify conductors whom they meet or pass of the fact. They should also notify agents and switchmen at places where they stop.

Trainmen and others should carefully observe whether signals are carried by passing engines.

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* 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 that it has left.

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 train ahead on approaching a station where a train is to be met, in order that the opposite train may have as little detention as is consistent with safety; in all other cases the distance between the two trains should never 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 can not make time, it should run upon a side track, and let the fol-

Automatic Signal, A. D. 1894.
(When at danger the white disc is replaced by a colored one.)

lowing train go ahead. The conductors and enginemen should, in such cases, see that the train which takes precedence carries the proper signals, and all special orders affecting the movement or safety of either train must be exchanged. Conductors should report the occurrence to the proper officer at the first telegraph station and also notify all trainmen they may meet and the agents at stations as well.

No engine or train should carry signals for an extra engine or train without orders from the proper officer, except as provided

* The distance apart will not be the same for every road.

in the following rule: Should a train be held 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 should report to the proper officer for orders; but the conductor of a freight train should 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 signaled by another, in accordance with the foregoing rule, possesses exactly the same rights as the second section of a train already described.

When a train is held between telegraph stations and can not 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.*

Whenever it is necessary to send an extra engine over the road, it should in all cases precede and run on the time of some regular train; it will be entitled to all the rights thereof, and carry proper signals therefor. In such cases the regular train should run five minutes behind its schedule time.†

CONSTRUCTION AND FUEL TRAINS.

When a construction train is going to or coming from work it should proceed with the utmost caution;‡ it should never be on the road within ten minutes of the running time of other trains.

When permission is given by the proper officer, the conductor may keep at work in respect to freight trains only, until the

* 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.

‡ They should know before starting that all trains that are due have arrived.

arrival of such trains, but he should in all cases station the proper signals, twelve hundred yards in each direction when upon a single track, or in the rear only when upon a double track, unless the same is obstructed. The signal man of the construction train should continue on the watch until the freight train arrives. On the arrival of the expected train, the construction train should immediately proceed to the siding in advance of such train.

Conductors and enginemen of fuel trains should be governed by the rules given for construction trains.

When freight trains are thirty minutes late, construction and fuel trains may occupy the main track, but should keep signals not less than twelve hundred yards in the direction of the expected train. Upon the arrival of the expected train, the construction or fuel train should at once proceed to the siding.

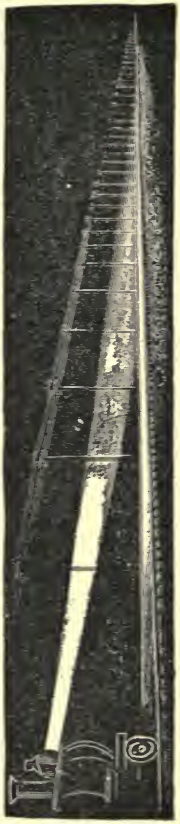
No construction train should be allowed to run beyond its given limits without orders, except in cases of great emergency. Under such circumstances, a construction train or engine may run beyond its limits; but such train or engine should not only keep off the time of regular trains, but conductors and enginemen should signal all curves carefully, and look out for special or extra trains. They should also report the fact of being off their limits, and the reason therefor at the first telegraph station, or if there is no telegraph station, a report should be sent to a telegraph office by the first train, or by special messenger if there is no train.

Two construction trains should not be allowed to run or work within the same limits except in cases of great emergency; in such cases special orders should be given by the proper officer.

A special order allowing two construction trains to occupy the same limits does not relieve the conductor and engineman of either train from the responsibility of signaling all curves carefully while running, and otherwise protecting their trains properly while at work on the main track.

Before leaving stations for the day's work, conductors of fuel and construction trains should report to the proper officer the exact location where they intend to work, and they should not leave the station until they have received a permit from him.

Conductors of construction and fuel trains should leave with the station agent at the starting point a memorandum stating where their trains will be operating for the day; this memorandum should be entered in a book kept for that and similar purposes. This book should at all times be open to the inspection of trainmen,



Electric Headlight, A. D. 1894.

Conductors and enginemen of construction trains should stop at all telegraph stations and register time of arrival and departure and direction of their trains, and ascertain if any extra or special engines or trains are on the road; also the limits of other construction trains that may be at work on the same division.

Conductors of construction trains should keep themselves informed as to where 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 should only embrace stated hours, and the train should not occupy the main track within its limits before or after the hours specified.*

Upon a single track road, signals, as provided by rule, should always be placed at a distance of not less than twelve hundred yards on either side of the place where construction or fuel trains are at work, and a man should remain with such signals. Upon double track roads, signals need only be placed in the direction from which trains naturally arrive.

In the case of a double track road, if the opposite track is obstructed, then signals should be placed in both directions.

Conductors and enginemen of construction and fuel trains should be held responsible for the observance of rules governing signals, and they should be expected to use every additional precaution which may be necessary.

Fuel or construction trains should not have signals carried for them by regular trains, nor should they carry signals for other trains; but if circumstances arise compelling them to follow a regular train carrying signals for another train, they should carry signals for the train following.

Conductors of trains unloading ballast or material of any kind along the line, should see that it is so arranged as to be out of the way of passing trains before leaving it. 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

* "Ballast trains must not work on the main line in a fog, except when authorized under special circumstances."—*English Standard.*

† These regulations express generally the practices of one of our greatest as well as one of our most carefully managed roads.
M. M. K.

allow trains of a superior class running in the same direction to pass them.

A half-way post is placed in the center of each middle siding: trains in either direction may run to the half-way 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 in all cases when the backing of either train from the siding onto the main track can be avoided.

All trains should use middle sidings with great care: they should invariably run expecting to meet an opposing train, whether opposing trains are due or not.

MISCELLANEOUS ORDERS RELATIVE TO TRAINS.

When trains are delayed, the lost time should, so far as possible, be made up by shortening the stops at stations. No risk must be incurred for the purpose of making up lost time.*

Mail trains should not be run at such speed as to prevent the mails being exchanged at places provided.

A speed of fifteen miles per hour will pass, approximately, seven telegraph poles per minute.†

If an obstruction or accident makes it necessary to move an engine or train in the wrong direction on a double track road, or to cross over to the opposite track to pass around such obstruc-

* "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."—1863. "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."—1853.

† U. S. Road. The number will not be uniform.

tion, obstructed trains or engines may do so, but the utmost caution should be used. The conductor of the obstructed train (or, in his absence, the engineman), before the train is moved, should send danger signals not less than one mile in advance, in the direction in which the train is to be moved. The train or engine thus moved should only be backed or run to the next crossing, and, while moving, the engineman should frequently sound the whistle, and not exceed a speed of four miles per hour, to enable the signalman to keep the required distance in advance.

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 should not take the time or assume the rights of another train, except as provided for by rule, without orders from the proper officer.

Upon a double track road, no conductor should assume the rights or take the time of any other train without special orders except as provided by rule.

Should a train, which has been telegraphed as having entered a tunnel, not emerge therefrom within a reasonable interval of time, the signalman toward whom the train is approaching should prevent any train in the opposite direction entering the tunnel, through which there is a double line of rails, until he has ascertained that the line on which it has to run through the tunnel is clear.

Should an engineman observe anything wrong on the line of rails opposite to that on which his train is running, he should sound the whistle and exhibit a danger signal to any train or engine he may meet, stopping if necessary to signal the train or engine. He should also stop at the first station and report to the person in charge what he has observed.

Upon a double track road, when a portion of a train is left upon the main line, the engineman should not return for it on the same line except by written instructions from the conductor, but should go on the proper line and cross at the nearest point behind the part left (unless there is a crossing in its immediate front), which he should push before him till convenient to go in front again with the engine. If the engineman finds it necessary to return to the rear portion of his train on the same line, he should, before starting with the front portion, send his fireman back to the conductor to obtain written instructions authorizing him; if he gives such instructions, the conductor should continue to protect his train in the rear and prevent a following train pushing it ahead, except upon inclines worked under special rules.*

Trains should not pass a junction of two lines nor pass from a double track line to a single track line until the officials in charge of the train have examined the register, kept at such place, for the purpose of ascertaining whether trains due or past due have arrived, except in those cases where they have a special, order from the proper officer to proceed without stopping.

Regular trains should be run in accordance with the schedule except when otherwise ordered by the proper officer.

No passenger train should be stopped at a station where it is not timed to call, for the purpose of taking up or setting down passengers, without special authority.†

* "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 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."—*New York Road, 1854.*

† "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.*

Trains should be run uniformly and steadily between stations, and delayed as little as possible for fuel. water, and the transaction of station business.

Passenger trains should be drawn, not pushed, except in case of accident or other emergency, and in case 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 next to the engine.

No train should start without a signal from its conductor, and conductors should not give the signal until they know that the cars, including the air brake hose, are properly coupled.

At junctions and other points where registers are kept, or where train boards or indicators are located, it is the duty of those in charge to see that the arrival and departure of trains are accurately and promptly noted thereon, the grade of the train being given in each instance; and it is the duty of trainmen to carefully examine the same before proceeding.

Pieces of wood or coal should not be thrown from an engine or train when in motion, lest sectionmen or others be injured thereby.

Flying switches should not be made, except at places or by persons authorized by the proper officer. In the absence of such authority a switch rope must be used.†

No person should be permitted to ride on an engine or tender without an order from the proper officer. except employes in the discharge of their duties upon their respective divisions, and trainmen, in case of accident, or whenever necessary.

Employes should be under the authority and conform to the orders of the superintendent of the division upon which they work.

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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.*

† "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.*

In order to insure uniform time being kept at all the stations on the line, to which time is not telegraphed, the following regulations should be strictly observed:

Each conductor should, before starting on his journey, satisfy himself that his watch is correct with the standard clock, and again compare it, and regulate it, if necessary, at the end of his journey, before commencing his return trip.

The conductor in charge of the first passenger train stopping at all stations on the portion of the main line, or branch over which it runs, 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; in the event the time given by the conductor differs from that of the station clock, the latter must be corrected.

Agents should be held responsible for keeping their clocks properly regulated in accordance with this order, and should at once report to the proper officer any serious defects that may occur in their working, in order that the necessary steps may be taken for their immediate repair.

Conductors of trains running at night, upon a single track road, should report in person to the operator at every night telegraph office at which they stop.

At night the conductors of freight trains should make and sign duplicate statements (memorandum cards) of the time of leaving each station, and give such statements 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 should hand the copy to the engineman of such train. Enginemen should be on the lookout to receive such notices as they pass stations. At stations where train registers are kept for the information of trainmen, this rule need not be observed.

All accidents, detention of trains, failure in any way of engines, or defects in the road or bridges, 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 passing trains, sectionmen should place danger signals upon the track, as required by rule.*

* "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

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.*

In case of accident to trains the nearest section foreman should at once take his whole force to the assistance of the train, even if it is not on his own section.

In case of a wreck, foremen should at once appoint necessary watchmen to prevent property from being stolen.

On receiving notice of a wreck or accident roadmasters should at once proceed to the place and take full charge and control of all track forces and construction trains; put the track in condition for the safe passage of trains; and remove the wreck with the quickest possible dispatch.

No notice is given trackmen of the passage of trains, and they should 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.

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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.*

† "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.*

Signal Torch.

" 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 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."*

RULES FOR THE MOVEMENT OF TRAINS BY TELEGRAPHIC ORDERS.†

Special orders, directing movements varying from or additional to the time table, will be issued by the authority and over the signature of the superintendent. They are not to be used for movements that can be provided for by rule or time table. They must not contain information or instructions not essentially a part of them. They must be brief and clear, and the prescribed forms must be used when applicable and 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 may be substituted in the above rule. The 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. Preferably an order should include but one specified movement.

Orders will be numbered consecutively for each day as issued, beginning with No. 1 at midnight.

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,

* English road.

† 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 as high a state of perfection as at the present time. M. M. K.

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 superintendent's office; and 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; and the train dispatcher's initials. These records must be made at once on the original copy, and not afterward, from memory or memoranda.

[See note under fifth preceding rule.]

The terms "superior right" and "inferior right" in these rules refer to the rights of trains under the time table and train rules, and not to rights under special orders.

When an order is to be transmitted, the signal "31" (as provided), or the signal "19" (as provided), meaning "Train Order," will be given to each office addressed, followed by the word "copy" and a figure indicating the number of copies to be made, if more or less than three—thus, "31 copy 5," or "19 copy 5."

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, and 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 out 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," 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 re-

* 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.

tained by the operator, and he will send their signatures to the superintendent. The response "complete," with the superintendent's initials, will then be given, when authorized by the train dispatcher. 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, except enginemen, and each must read his copy aloud to the operator. The copy for each engineman must be delivered to him personally by———, and the engineman must read it aloud and understand it before acting upon it.

[NOTES.—The blank in the above rule may be filled for each road to suit its own requirements. On roads where the signatnre of the engineman is desired, the words "except enginemen" and the last sentence may be omitted. See also note under first rule in this section.]

[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," "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.]

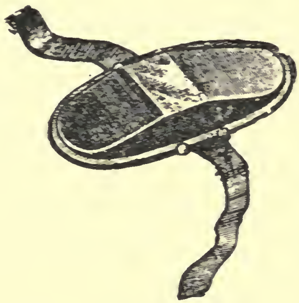
When an order has been transmitted, preceded by the signal "19," operators receiving it must (unless otherwise directed) repeat it back at once from the manifold copy, and in the succession in which the several offices have been addressed. Each operator repeating must observe whether the others repeat correctly. After the order has been repeated correctly, the response "complete," with the superintendent's initials, will be given, when authorized by the train dispatcher. 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. See also note under the first rule in this section. The committee has recommended two forms of train orders—the "31" order and the "19" order," 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



Torpedo Signal.

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 superintendent.

[See note under first rule in this section.]

Orders used by conductors must be sent by them daily to the superintendent.

Enginemen will place their orders in the clip before them until executed.

For orders delivered at the superintendent's office the requirements as to record and delivery will be the same as at other points.

[See note under first rule in this section.]

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 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 he must deliver 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.

[See notes under the twelfth preceding rule.]

When a train is named in an order, all its sections are included unless particular sections are specified, and 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. When it can not 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. 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. Orders held by or issued for a regular train which has lost its rights, as provided by rule, are annulled 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 superintendent from the next open telegraph office. When a semaphore is used. the arm means red when horizontal and white when in an inclined position. A fixed signal must be used at each train order office, which shall display red when trains are to be stopped for orders. When there are no orders the signal must display white. When an operator receives the signal "31," or "19," he must *immediately* display red, and *then* reply "red displayed." The signal must not be changed to white until the object for which red is displayed is accomplished. While red is displayed, all trains must come to a full stop, and any train thus stopped must not proceed without receiving an order addressed to such train, or a clearance card on a specified form stating over the operator's signature that he has no orders for it. 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 superintendent from the next open telegraph office. When a semaphore is used. the arm means red when horizontal and white when in an inclined position.

[NOTE.—The committee have recommended two forms of the above rule, leaving it discretionary with the roads to adopt one or both of these forms according to the circumstances of their traffic.]

Operators will promptly record and report to the superintendent 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.

[See note under first rule in this section.]

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 committee see no objection to their doing so.]

The following signs and abbreviations may be used:

Initials for superintendent's signature.

Such office and other signals as are arranged by the superintendent.

[See note under first rule in this section.]

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.
The usual abbreviations for the names of the months and stations.

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 made definite and conclusive and be first sent to the conductor having the right to the road.

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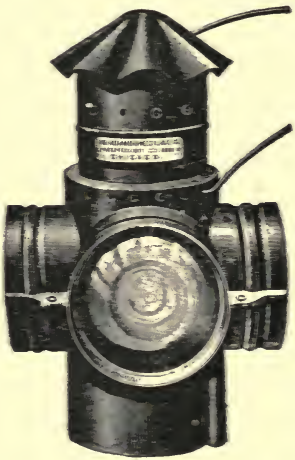
* This regulation requiring that the operator at the station where the trains are to meet shall be notified, is not deemed necessary by many experts in such matters. Indeed, many dispatchers only send the order to the train that would not otherwise move. Thus, if a dispatcher desires a train moving under 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.

If it is desired to give a train the right to run against a passenger train, the order should first be sent to the conductor of the latter, and no order be given the opposing train until the receipt of a satisfactory reply from the conductor of the passenger train. In the same way, before giving a passenger train the right to the road over a train possessing such right, the order should first be sent to the train having the right to the road; when a satisfactory reply has been received from the conductor of such train the order may be transmitted to the other train.



Signal Lamp.

A train of an 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, can not 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 an 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 into the office for the purpose of receiving the orders necessary before proceeding.

Conductors and engineers should not go to meals, or delay their trains from any cause, after receiving an order allowing them to proceed, without asking for and obtaining express permission to do so. If a train has work to do, in such cases the conductor should at once notify the dispatcher of the probable length of time before he can be ready to leave. When such permission is received, he should report when he is ready to go, and ask if there are any further orders.

A full record of the movement of all regular and special trains, showing hour and minute of leaving each station, as reported at the time by operators, should be kept by the dispatcher.

Safety demands that all persons connected with the movement of trains by telegraph should use the utmost care and watchfulness.

Orders should be written in a clear and legible manner, without erasures, alterations or interlineations, and conductors and engineers should be forbidden to receive or proceed on any order which they can not readily read and understand.

After the reception of an order it should be strictly obeyed, unless canceled by another formal order from the same or a superior officer.

In the transmission of orders by telegraph no abbreviation should be used except those provided for by the rules and regulations. Figures when used should be written with especial care. Where there is any possibility of mistaking one train for another the engine number should be given as well as the number of the train.

The train order signal, or the signal to stop, should be promptly removed when the object for which it is displayed has been accomplished.*

Operators should, upon receiving telegraphic orders for an expected train, immediately exhibit the proper signal directing it to stop. The signal should not, however, be relied upon exclusively to hold the train. Operators must watch for it closely and use all necessary means to stop it.

When the signal to stop is shown, the approaching train should be brought to a full stop (and in such cases it is the duty of operators to see that trains are so stopped), and the conductor should go to the telegraph office to receive and acknowledge such orders as may be awaiting the train.

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 that train until the order is approved and delivered. A train order is not complete and a train can not move under its direction until it is approved by the dispatcher.

Operators should not receive or receipt for an order until they know positively that none of the trains named in it has already passed their station; or, if at their station, they should know to a certainty that none of them is beyond reach, and should at once hold them by getting the acknowledgment from the conductor. If in doubt they should not acknowledge receipt of the order until they get the signature of the conductor.

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

* 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.

until that official has personally signed the same, after it has been carefully read to him, as directed.*

In cases of threatened storm, or any probable failure of the telegraph 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 as practicable afterward.

A conductor receiving an order should, as soon as it is approved, personally deliver to his engineman a copy thereof, retaining a copy for himself, which latter he should read aloud to the engineman, who should closely scrutinize his own copy and see that it is the same in all respects. An engineman should not, under any circumstances, start from a station at which an order is received for his train without a copy of the order in his possession.†

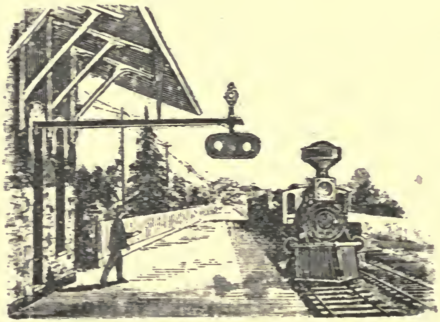
Night telegraph stations should have signals burning all night. Day telegraph stations should have them burning from dark until offices are closed.

* The regulations in regard to repeating train orders are not uniform on all lines. In many cases the order is not repeated by the operator until the conductor has arrived and his signature has actually been obtained to the understanding. On other lines it is the practice (though probably not in accordance with the printed regulations) for the operator to repeat the order as soon as received, with the names of the conductor and engineer, though the latter could not possibly have had time to read or sign it, and perhaps have not yet arrived at the station. I think 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 will expedite the movement of trains. In train dispatching every moment is of value, and a gain of a few seconds will oftentimes permit trains to move forward that might otherwise be greatly delayed. However, the 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 signature of the conductor has been actually obtained and been transmitted to the dispatcher and the approval of the latter received. M. M. K.

† The rules of many roads require that the engineman, as well as the conductor, shall go to the telegraph office and sign the understanding of the order in person. If the rule as herein given is strictly observed (and if it is not, it is not likely that the other would be) it answers every requirement of safety. The engineman can do more for the protection of his train while waiting at stations by remaining at his post and looking over his locomotive to see that everything is in good shape than he can by accompanying the conductor to the telegraph office. M. M. K.

Operators should keep a red flag by day and a lighted red lantern by night, and also a supply of torpedoes ready for instant use.

No train should pass a telegraph station where the schedule requires it to stop, whether train order signals are exhibited or not, until the conductor has gone to the telegraph office and handed the operator a printed form, duly signed, inquiring whether there are any orders for him. If there are no orders the operator should deliver him a similar blank, duly signed, stating that he has no orders of any kind for him. This does not relieve operators from the duty of promptly displaying the necessary signals whenever they have orders for trains, or making such other efforts to stop them as may be necessary. At night, after



Station Signal.

day telegraph offices are closed, this rule applies only to night telegraph offices. Conductors should in all cases inquire for orders as directed at terminal starting points.*

* 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. 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 M. M. K.

When trains are running upon special orders each should approach with great care every station where another train may possibly be, expecting that the main track may be occupied at such station. This, however, does not relieve any train from compliance with other rules and regulations governing such cases.

Special orders should only be used by the trains to which they are addressed. They should be used only against such trains as are expressly named therein. An order to run on the time of any particular train should not be taken to run on the time of any other train. All other trains should be treated according to the time table rules and regulations.

When an order is sent to a train which may be carrying a signal for a train, such order will not, unless expressly so stated, cover the train that may be following, and in no case should the train for which the signal is carried avail itself of any special orders which the train bearing the signal may receive without a written order to that effect. When orders are duplicated to following trains the understanding of each conductor should be separately signed and be responded to by the dispatcher. In no case should signals be removed by operators until all trains have passed for which the order is intended.

Under the system of moving trains by telegraphic orders, trains may be expected upon any part of the road at any time. This fact should be kept constantly in mind by employes.

In the event it is impossible or undesirable at any time to move trains by telegraphic orders, then trainmen should conform to the schedule and the rules and regulations governing the movement of trains incident thereto.

If conductors or enginemen change off before the completion of their trips, they should exchange all orders they may have, and each should know that these are perfectly understood by the other. No change of this kind should be allowed without the consent of the proper officer.*

* Forms of train orders, for the movement of trains, will be found in Appendix B.

CHAPTER XVIII.

RULES AND REGULATIONS APPERTAINING TO THE MOVEMENT OF TRAINS.—(PART TWO.)

GENERAL INSTRUCTIONS TO CONDUCTORS.

The general direction and government of a train from the time it is made up until its arrival at its destination is vested in the conductor; he is held responsible for its safety and proper care; it is his duty to see that all rules and regulations and orders affecting it are carried out.*

Conductors are responsible for the conduct of men employed upon the trains,† and for the signals, lamps, tools and other property entrusted to their care. They should report any defect in brakes, specifying the number of the car or engine on which it occurs; they should invariably require the brakes to be tested, and also have the engine signal bell rung from the rear car before leaving a terminal station.

They should be provided with a reliable watch, which they should keep regulated by the standard clock of the company.

* "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.*

† "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.*

They should compare time with the engineer before starting.* and know that he is provided with a schedule and a complete set of signals and tools.

They are required to see that their trains are supplied with a full set of signals, and, when upon the road, they should see that such signals are used in accordance with the rules.

Should a vehicle be attached to, or detached from, the rear of a train at an intermediate station, the conductor should see that the signals are removed to their proper places on the train.

Each train should be supplied with not less than six fusees, twenty-four torpedoes,† and such signal lanterns and flags as the rules and regulations require in the operation of trains, also with switch rope, axes, saws, crowbars, chains, spare links and pins, buckets, oil, and such other tools and supplies as may be necessary for daily use, or in the event of accident or delay to the train.

If compelled by accident or other cause to move at unusually slow speed, or stop their train on the main track, they should take immediate action to signal any trains that may be approaching in either direction, as required by the rules. They should keep in mind the fact that nothing justifies a collision, and that the prompt use of signals in the manner directed will, under all ordinary circumstances, prevent it.

Conductors and brakemen when meeting or passing other trains, or when approaching or passing a station, should be on the lookout for signals, and be prepared to do anything which the expedition of business or the safety of their train requires.

Conductors should give personal attention to switches used by their engines or trains, and they are held responsible for the proper adjustment of the switches used, except where regular switchmen are stationed. When more than one train uses a switch, conductors should not leave the switch open for the following train unless the conductor of such train is at the switch to take charge of it.

Conductors should see that road crossings are not obstructed by their trains. They should be particular when at junctions to see that no part of their train is allowed to stand on the crossings of other railways.

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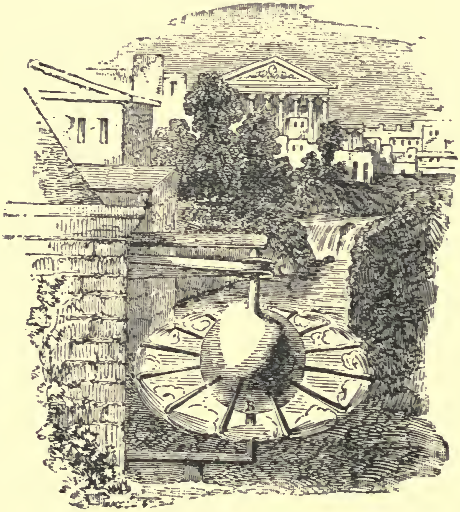
* "The guards are provided with timepieces. It is their duty to inform the enginemen of the hour at every chief station or junction."—*Great Northern Railway, England.*

† The earlier regulations governing the protection of trains have no reference to the use of torpedoes.

In the event a train is fifteen minutes or more late at any point, the fact should be telegraphed by the conductor to the proper officer from the first telegraph station.*

Conductors should visit the telegraph office before leaving terminal stations† to see if orders await them.‡ Conductors of freight trains should at the same time report to the proper officer the number of the engine and the number of empty and loaded cars in their trains. A similar report should be made by them upon their arrival at their destination.



Hero's Engine, 250 B. C.

* Where operators report the passage of all trains immediately upon their arrival or departure, this rule is unnecessary.

† A terminal station is a station where a train is made up: upon a long line there will be several terminal stations: they are usually at the end of divisions or subdivisions.

‡ "Every guard, before starting with his train, must examine the notices to see whether there is anything requiring 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.*

Conductors should call the attention of the repairer of cars, or of the agent in his absence, to any damage which may have been done to cars, or to any defects which may come to their knowledge, so that the same may be repaired.

Should complaint be made of the running of any car, the conductor should report it to the first car repairer, and enter the particulars on his report, giving the number and class of car; but if the conductor have reason to apprehend danger from such car before it can be inspected, he should have it detached.

Conductors should report to the proper officer any neglect of car repairers to inspect each car that may pass such car repairers' stations; any neglect to examine the running gear and brake fixtures of cars, or make such repairs as may be required; any neglect to give special attention to passenger, baggage, mail and express cars. Repairers should not permit cars to leave their stations that are not in good running order; it is also their duty to see that passenger cars are properly washed, and that interior fixtures are kept clean and in good repair.*

When the wheel of a car or engine breaks, the conductor in charge should ascertain, by personal examination, the name of the manufacturer, and the date and number of the wheel. This information should be forwarded to the proper officer, and noted in the train report.

In the event trainmen discover any defect or break in the telegraph, they should report the fact to the operator at the next station.

Conductors should advise the proper officer of any dilatoriness or lack of attention upon the part of agents or others whose duties require their co-operation in the movement of trains.

Conductors, or their subordinates, should not, under any circumstances, undertake to carry or take charge of valuable packages, or make collections for individuals, unless authorized to do so by the proper officer.†

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* "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.*

† "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

They should report, at the end of each trip, the number of each car in their train; its initials; the point from which taken; the place where left; whether loaded or empty; and its class.

It is important that letters, way bills and dispatches should be delivered promptly.

When a trainman or other employe is returning to the station at which he resides, by a train other than that he is appointed to work, he should render all assistance in his power in the working of the train by which he travels, and obey any instructions received from the conductor of such train.*

PASSENGER CONDUCTORS.†

Passenger conductors should make themselves acquainted with the duties of enginemen, baggagemen,‡ brakemen, express

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agents confine themselves strictly within the limits of their contract."—1854. "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.*

* "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.*

† "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."—1853. "When on duty, conductors must be respectably dressed. Every man on passenger trains and at stations must appear on duty clean and neat."—1854. "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.*

‡ "They [baggagemen] will consider themselves to be, and act as, brakemen when their train is in motion."—1853.

Discovery of the means of utilizing steam by Marquis of Worcester,
in the Tower of London, A. D. 1653.

messengers, mail agents, sleeping car conductors, porters and news agents, and rigidly enforce the rules and regulations applicable to them upon their trains, reporting to the proper officer any insubordination, neglect of duty, or misconduct upon the part of such men.

"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."*

Conductors should not permit drunken or disorderly persons to get upon their trains.

They should see that the doors of cars are properly closed, and in case of any unusual stoppage on the road, request passengers to keep their seats, except when necessary to alight.†

Smoking in cars, except in those specially set apart for that purpose, should be strictly forbidden.

Conductors should not permit beggars, peddlers or gamblers to pursue their vocations upon the trains.

Immediately after leaving a station they should cause the brakemen to announce in each car the name of the next stopping place. This announcement should be repeated immediately before the stoppage at the place thus announced.‡

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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.*

‡ "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.*

They should not signal their trains to start while passengers are getting on or off the train.*

When the signal is made, the conductor should stand near the front end of the forward passenger car.†

Conductors should report every instance of agents failing to give passengers an opportunity to procure tickets, reporting any neglect of an agent to open the ticket office of his station before the arrival of trains, when the rules require it.

They should know that the cars in their trains have been inspected at terminal and other stations, as required.‡

They should wear the prescribed uniform, and never appear on duty without it.

Upon the arrival of a train at its destination, the cars in which passengers have ridden should be searched by the conductor,§ any articles found should be delivered to the agent at the terminal station. The articles should be sent by such agent to the proper officer, if not called for within forty-eight hours.

FREIGHT CONDUCTORS.‖

"The guard in charge of the train must satisfy himself before starting, and during the journey, that the train is prop-

* "They will always bring their train to a dead stop to take up or leave passengers."—1853.

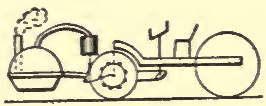
† "The signal for starting the train must be given by the guard blowing his whistle and showing a hand signal."—*English Standard.* "The guards and other servants of the company must take their seats in the trains before they are in motion, so as to avoid the dangerous practice of jumping on the steps, or getting into the carriages after the trains leave the platform."—*Great Northern Railway, England.*

‡ "They will also report all the interior defects of their cars, like the rattling of doors, windows, etc."—1864.

§ "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 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."—1853.

erly 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



Locomotive, A. D. 1769. (Cugnot's.)

sufficient for the guard, on commencing his journey, to see that all the wagons and their loads in his train are in 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."*

Freight conductors should make themselves generally acquainted with the duties of enginemen and brakemen, and enforce the rules and regulations applicable to them upon their trains, and report to the proper officer any insubordination, neglect of duty, or misconduct.

They should see that the couplings, wheels, journals and brakes of the cars in their train are in good order before starting, and inspect them, when their duties permit, or as often as

* English Standard.

the train stops to take fuel or water or arrives at a meeting or passing point.*

They should station the brakemen at their posts† on the train and see that they keep their positions and use the brakes with discretion and good judgment—particulary when descending heavy grades.‡

Conductors and brakemen of freight trains approaching stations should be out on their trains at least one mile from every station, and remain out until all switches are passed, looking for signals, and be prepared to do anything required for safety or expedition.

At all times when freight trains are in motion, the conductor, or one brakeman, should be on the engine, or on top of the cars in the forward part of the train.

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* "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."—1853. "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 brakemen from traveling backwards and forwards 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 such mischief" (*i. e.* the cause of a collision).—*Trainmaster's Assistant*, p. 124.

A conductor or brakeman should, in all cases, be stationed on the rear of every train, and the brakes of that car should be ascertained to be in good order before starting.

Freight conductors should know that the cars in their train reported empty are so in fact.

They should see that cars are locked, except when loading or unloading freight.

They should also see that the windows of cars are fastened.

They should take loaded cars from all stations when they can haul them, although their train may be behind time.*

They should treat those in charge of live stock politely, and render them every assistance possible in taking proper care of their property.

In leaving loaded cars at a station, they should leave them at the most convenient place for unloading, and in cases of this kind they should act in harmony with the agent.

They should deliver way freight on the platform at the freight house, or at such other place as the agent may designate.

In delivering way freight the train should not be delayed unnecessarily.†

Freight trains should stop at the places specified in the schedule, unless on approaching a station or siding, a signal is given by the agent or signalman that it is unnecessary.

When this is done, the train may run past the station or siding without stopping, unless there are cars or goods to leave, when the engineman will have instructions from the conductor to stop. In the case of a train timed to stop at a station or

* "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 a way bill ready; 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." —1853.

† "They with the brakemen, will render all aid in their power, on the arrival of their train at a station, to enable them to leave in the shortest space of time; that as much time may be used in running and as little in stops as possible."—1853.

siding "when required" the engineman of the train should stop at such station or siding unless he receives a signal to proceed.*

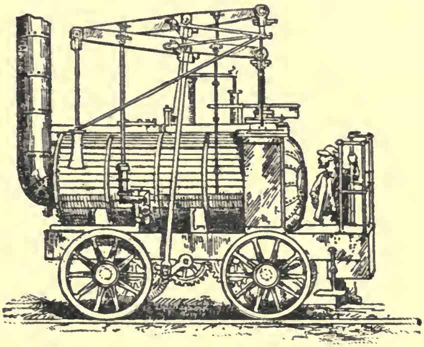
Freight conductors should not permit persons not duly authorized to enter cars or handle freight on their train.

They should report any confusion or want of method upon the part of agents in loading freight.

When waiting upon sidings, and at other times, they should exercise watchfulness to prevent cars from being broken open and the contents thereof stolen or damaged.

Conductors when at stations doing business should attend personally to the switching.

They should not absent themselves from duty without permission from the proper officer.†



Locomotive, "Puffing Billy," A. D. 1813.

While waiting at stations, they should do such switching as may be reasonably required by the agent, and perform

* "In order to prevent the unnecessary stoppage of the train if the engine has a full load and can not 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 can not 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.*

† "Goods guards must not leave their trains until they have been delivered over to the foreman, yardman or shunter."—*English Standard.*

such other duties in connection with their trains as may be necessary to the expedition of business.*

They should be sure that no cars have become detached from their train and left on the main track, and when cars are left on a siding they should see that the brakes are securely applied, and the wheels carefully blocked, if necessary, to prevent such cars from being moved, or interfering with trains or cars upon other tracks.

They should make immediate and complete reports to the proper officer of all unusual detentions to their trains, and in case of accident to cars, resulting in damage or loss of property, should at once telegraph or write all the facts to the proper officer.

They should enter upon their reports the number of cars taken from and left at each station, as described, and make such other regular returns as may be required of them.

GENERAL INSTRUCTIONS TO BRAKEMEN.

While on duty, brakemen are under the direction of the conductor.†

They are charged with the management of the brakes, the display and use of signals, and the lights, stoves, water, gas and other fixtures of trains.

They should be furnished with a full set of train signals, which they should keep in good order, and at hand, ready for immediate use.

The rear car of every train should be a brake car. A man should always be on the rear car of trains; provided, however, that when stopping a train he may set the brakes upon forward cars after having set the brake on rear car.

In the absence of automatic or steam brakes they are required to stop their trains at stations, and control them when descending heavy grades without the whistle signal of the engineman.‡

* "They, with the brakeman, when not otherwise employed, will render what aid they can in wooding and watering, to shorten their stops."—1853.

† "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."—1853.

‡ "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

In damp or frosty weather the brakes should be applied sooner than usual to prevent running past the station.

Brakemen should obey the order to apply brakes instantly, without waiting to ascertain the occasion of the signal.

The post of the rear brakeman is on the last car in the train; he should not leave his post while the train is in motion except to protect it, or to apply the brakes, if necessary, on adjoining cars; he should be provided with the necessary signals, and see that they are displayed at the rear, in accordance with the rules; in case of detention or accident to the train, he should immediately go back, as directed in such rules, for the protection of trains; he should do this promptly and without waiting for a signal from the engineman or instructions from the conductor.

The front brakeman is charged with the duty of protecting the train with signals when, from any cause, the fireman is unable to perform this duty.

In case the train parts on the road, the rear brakeman should immediately apply the brakes and stop the cars, and then send forward the most reliable person he can command to make danger signals, while he protects the detached portion until the engine or front part of the train returns.

When an assisting engine is attached to the rear of a train, it should be considered as a part of the train, and in case of accident or detention, the brakeman should go back as in other cases.

Brakemen should examine the running gear of cars at stopping places, reporting to the conductor any defects noticed.

They should be held responsible for the brakes and the condition of the coupling apparatus. It is their duty to see that these are in good order before trains start.

It is the duty of an employe who opens a switch upon the main track to see personally that it is afterwards closed and locked.

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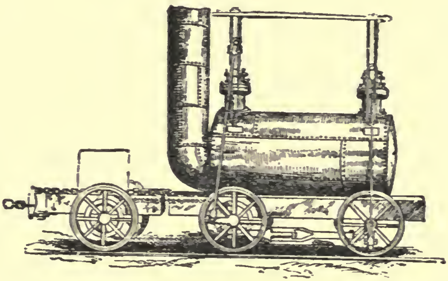
on approaching a station that it is a signal, without waiting for the sound of the whistle to apply the brakes, using judgment in order to stop at the proper place at the station, without allowing the train to press hard upon the tender or engine, allowing the engineman to stop the engine and tender without causing them to draw or press upon the train."—1853. "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.*

PASSENGER BRAKEMEN.*

Passenger brakemen should report for duty at the time appointed, open the doors of the cars, and assist conductors in the proper disposition of passengers, and aid them in all things requisite to the prompt and safe movement of the trains, and the comfort and convenience of passengers.

At all stopping places they should twice distinctly announce the name of the station, and the length of the time the train will stop, when such stoppage exceeds two minutes. Immediately after leaving a station, they should announce the name of the next stopping place.



Locomotive (Stephenson's), A. D. 1815.

They should assist the conductor in preserving order, and not permit passengers to stand upon the platforms while the train is in motion, nor in any way to violate the rules of the company.

They should be respectful to passengers, and give polite attention to their wishes, avoiding, however, any unnecessary conversation.

When it is necessary to pass through sleeping cars, they should do so quietly, so as to avoid disturbing passengers.

When not otherwise engaged, they should stand at the door of the car, ready to respond to the signal of the engineman, and they should occupy this position whether the train is equipped with automatic brakes or not.

* "Brakemen on passenger trains will be required to wear coats or overalls when on duty."—1854.

They are required to see that the water closets of cars are kept in a cleanly condition.*

FREIGHT BRAKEMEN.

Freight brakemen should report for duty at the time appointed, and assist the conductor in the switching and making up of trains.

They should not leave their posts while the train is in motion, nor take any other position on the train than that assigned to them by the conductor.

They should assist in loading and unloading freight.

They are required to stop their trains at stations, and control them when descending heavy grades, without the signal of the engineman. The brakes should not be applied so as to slip the wheels, and on heavy grades the brakes should be changed frequently from car to car so as to avoid heating the wheels.

TRAIN AND STATION BAGGAGEMEN.

The duties and responsibilities of these officials are explained in a separate volume in connection with the conduct of the baggage department and the traffic incident to it.†

ENGINEERS.

When passing over the road without a conductor, engineers will be held responsible for the faithful and intelligent use of all

* "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."—*Private letter from 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.*

† "Baggage, Express and Mail Business."

the precautions required by the rules and regulations governing the movement of trains. They should, therefore, familiarize themselves with such rules and regulations, including those for the government of trainmen.

They are intrusted with the lives of passengers and the property of the company and its patrons. It is important, therefore, that they should not only attend promptly to the signals given them, but that they should be vigilant and cautious, not trusting blindly to the signals they receive, nor the rules and regulations provided for their safety.

The engineer, before commencing his day's work, should examine the notices posted for his guidance, in order to ascertain if there is anything requiring his special attention.

"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 necessarily otherwise engaged."*

It is the duty of engineers and firemen at all times to keep a sharp lookout to see that no portion of the train becomes detached without their instantly observing it.†

Engineers are under the direction of conductors when upon the road, in all things not in conflict with established rules.

Engineers should observe the orders of inspectors and master mechanics in regard to the working of their engines and the proper use of fuel and stores.

They should obey the orders of the yard master or person in charge in regard to switching and making up trains.‡

They should not start their trains till directed by the conductor, nor till the bell of the engine has been rung. They should start with care, and see, before they get beyond the limits of the station, that no portion of their train is detached.§

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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."—1853.

‡ "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.*

§ "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

They should start and stop the train slowly, otherwise the couplings and chains are liable to be broken.

In stopping their trains they should pay attention to the state of the weather and the condition of the rails, as well as to the length of the train. These circumstances should have due weight in determining when to shut off the steam. Terminal stations should be entered with special care.

They should be careful not to shut off steam suddenly (except in case of danger), so as to cause a concussion of the cars, by which trainmen and others may be injured. Engineers of stock trains are required to be particularly careful in starting and stopping their trains.

Engineers should know exactly what time is allotted them in the schedule, and they should not start from a station, even though they receive a signal from the conductor, unless they can reach the next station without encroaching upon the rights of other trains.

They should have their engines in good working order, supplied with the necessary signals, stores, tools, fuel and water, and the steam up ready to attach to the train at least thirty minutes before the schedule time for starting, and as much earlier as directed by the proper official.

Each engine should be supplied with twelve torpedoes, four fusees and the necessary signal lamps and flags; also with a pair of screw jacks, extra spring hangers, and such other tools as may be necessary to operate the engine or provide for accidents or delays.

Engineers should see before leaving the engine house that the spark arrester and wire netting over the smoke pipe, and the ash pan of the engine as well, are all in good condition.*

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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 station master or guard that may be necessary."—*English Standard.*

* "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."—1853.

In running passenger trains, engineers should observe great care in the manner of working the automatic brake. It should be applied when the engine is first attached to the train, before starting from the station, to make sure that it is in working order; in making regular stops, it should be applied in such manner as to avoid injury to the brakes or discomfort to the passengers. Especial care should be taken with short trains to apply the brake sufficiently early to obviate this difficulty.*

The brakes should not be relied upon when approaching railroad crossings or other hazardous points, but steam should be shut off, and the train, whether passenger or freight, held under such control as to prevent running past the objective point before stopping.

Engineers are required to see that the bell cord is not obstructed by fuel or otherwise. It should not be unfastened until the end of the trip, and when more than one engine is attached to the train the bell cord should be attached to the leading engine.†

Cars should not be switched into sidings, nor to other cars upon the main lines, without remaining attached to the engine, unless the cars are attended by a brakeman or other person prepared to apply the brakes or blocks, as the case may be, so as to prevent their coming into violent contact with other

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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.*

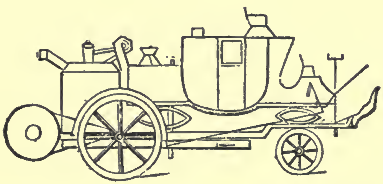
† "When two engines are employed in drawing the same train, the engine driver and fireman of the leading engine are responsible for the observance of signals; the engine driver of the second engine must watch for, and take his signals from, the engine driver of the leading engine, but the engine driver 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.*

cars or vehicles, or obstructing other lines. When cars require to be switched into incline sidings, the cars to be moved at one switching should be limited to such a number as the engine can push without going at a violent or excessive speed.

Engineers should promptly obey all signals given, even though they may think such signals unnecessary. When in doubt as to the meaning of a signal, they should stop and ascertain the cause, and if a wrong signal is shown it is their duty to report the fact to the proper officer.*

They should notice whether watchmen and flagmen are at their posts, and report to the proper officer any neglect of duty they may observe.

They should report the absence of lights at switches, where such lights should be shown.†



Steam Road Carriage, A. D. 1832.

They should approach and pass stations where their trains do not stop, with caution.

When trains are running over the road in heavy storms, or immediately after such storms, engineers should run cautiously without regard to making schedule time. They should run slowly and cautiously in approaching curves and places where the track is likely to be washed away.

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* "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.*

† "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.*

Great care should be taken to prevent the killing of live stock, and engines should come to a full stop, if necessary, to avoid killing or injuring stock.* Conductors and engineers should report to the proper officer in writing, giving full particulars whenever stock is killed or injured by their engines or trains.

"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."†

Engineers should not permit burning cotton, waste or hot cinders to be thrown from the engine or tender while in motion, and should use every precaution when passing bridges, culverts, buildings and fuel piles, to prevent the same from taking fire from their engines. The dampers of ash pans should be closed when passing over wooden bridges or culverts.‡

They should not clean or empty their ash pans on the main track, except at points designated by the proper officer.

They should not leave their engine during the trip, except in cases of necessity, or when required by the regulations, and when absent from it, they should leave the fireman or other competent person in charge.

When a conductor is disabled, the engineer will have full charge of, and be held responsible for the safety of, the train until an authorized person assumes charge of it. Engineers should never leave their engine when steam is up without shutting the regulator, throwing the engine out of gear, and applying the tender brakes.

They should report the condition of their engines to the inspector or master mechanic at the end of each trip.

Engines should never stand unemployed on the main track.

Engineers should at all times keep the headlights of their engines in good order. Headlights should be lighted when running after dark, or when storms, fogs, or other causes render it necessary. When trains are waiting on the side tracks, clear of the main track, or on the end of double track, the headlights of engines should be covered. In case of trains running as sec-

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* "Pass all roads cautiously; be careful not to frighten horses, and at Blank take extra care."—1853.

† English Standard.

‡ "Pass all important bridges carefully and at a reduced speed, with the ash pan closed."—1853.

tions of a regular train, the engineer of each section should comply with this rule regardless of the position of other sections.

Engineers should not refuse to take the assigned number of cars in their trains, but use their best efforts to haul them. Should engineers think the capacity of their engines is overestimated, they should report the matter to the proper official for such action as he may think necessary.

None, except the roadmaster, foremen of bridge and road repairers on their own sections, or the conductor and brakeman of a train, should be allowed to ride on an engine without permission from the proper official.

In taking coal, engineers should not take more than will ride on their tanks without falling off and wasting along the track.

Reports of live stock killed or injured should be forwarded promptly to the proper officer. In all cases of doubt whether animals were injured, a report should be made and the facts fully stated. When animals are injured by running between cars, or in any way connected with the train, the engineer should report the facts in the same manner as if the damage had been done by the engine, and, where the facts are not within his personal knowledge, he should give the name of the person from whom the information was obtained. As all claims for stock killed are held in abeyance until a report has been received from the engineer, it is important that careful attention be given this matter.

Personal injury reports should be made by the engineer in accordance with the instructions printed on the blank form, when a person is injured by or on a locomotive.

Engineers should see that their engines are provided with all tools necessary to meet casualties, and they should examine these tools frequently and know that they are in proper condition for immediate use.

Engineers, when applying air brakes, should not use the full pressure of the air, except in cases of emergency. For ordinary stops the brakes should be applied slowly and at a sufficient distance from the stopping place to enable them to stop the train without discomfort to the passengers, sliding the wheels, or injury to the machinery of the trains.

Engineers should, at all times, assist, when called upon, in making any repairs to their engine that may be necessary. When required to work in the shops, they will be subject to shop rules and regulations.*

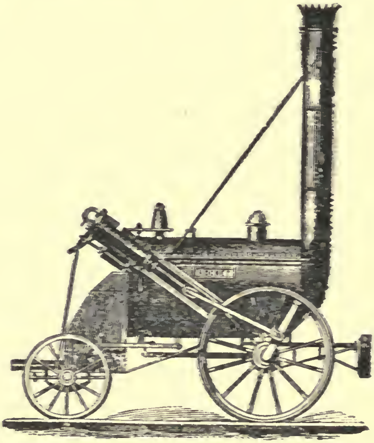
* "When not on running duty, they will assist in the machine shop, and conform to its rules."—1853.

FIREMEN.

Firemen, when on duty upon the road, are under the direction of the engineer.*

They should obey the orders of the master mechanic or inspectors of engines in regard to the use of fuel and the proper manner of firing.

They should be on their engines at least thirty minutes before time of starting, and conform to any directions they may receive from the engineman.†



Locomotive, "The Rocket," A. D. 1829.

They should supply the engine regularly with fuel and water, at the discretion of the enginemen. They should ring the bell

* "They will act under the direction of the engineman, and will aid in the small daily repairs and cleaning of the machine." —1853.

† "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."—1854. "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."—1853.

when required, and assist in oiling, and apply the tender brake, in accordance with the orders and signals of the enginemen.*

They should assist in keeping a constant lookout upon the track, and give the enginemen prompt notice of any obstruction they may perceive.

They should make themselves familiar with train rules, including those that apply to the protection of trains, and should understand the use of signals, and be prepared to use them or respond to them promptly and discreetly.

They should so arrange their fires as to avoid any unnecessary emission of smoke from their engines while standing at or passing stations.

They should take charge of the engine, should the engineman at any time be absent, and not leave it until his return, nor suffer any unauthorized person to be upon it.

They should not attempt to run an engine in the absence of the engineman without permission from the master mechanic, unless they are directed to do so by the conductor or other authorized officer.

They should keep their engines clean,† and assist, when not otherwise engaged, in making such repairs as may be required. When at work in shops, they will be subject to the rules and regulations governing shop-labor.

INSPECTORS OF ENGINES.

Inspectors of engines are required to ride upon the engines and instruct enginemen and firemen in regard to the proper working and firing of engines, so as to obtain the best results in the consumption of fuel and stores. They should study the capacity of the various engines.

It is their duty to see that the regulation pressure of steam is not exceeded, and that the boilers are washed as often as necessary.

They should see that engines are equipped with signals, tools and articles necessary to their efficient working, and that injectors, pumps, brakes and other fixtures are in good working order.

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* 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.

† "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 should advise the proper officer of the number of cars to be allotted to each class of engines, and report to him when engines of through freight trains are not given cars to their full capacity, or when an engine is overloaded.

They should consult with the shop foreman in regard to the daily condition and requirements of the engines running upon their divisions.

They should report to the proper officer the qualifications of enginemen and firemen, and any violation of rules or neglect of duty which may come to their knowledge, and keep them advised of all matters relating to the economical and efficient working of the engines and their crews.

YARDMASTERS.

Yardmasters have charge of the yard and sidings at stations where trains are formed, the movements of trains in connection therewith, and of the yard forces employed thereat.

When the business is not sufficient to require a yardmaster, the duties of the office, generally, are performed by the agent.

Yardmasters are responsible for the dispatch of trains, the prompt movement of cars within the limits of the yard, and the proper position of switches.

They should carry out the orders of their superior officer in regard to the distribution of cars, the making up of trains, and assigning motive power therefore.*

They should give directions for switching and placing cars in proper position in trains, and see that such trains leave on time.

They should see that the train force is ready for duty at the time required, and that both enginemen and conductors are supplied with schedules, signals, lamps, tools and such fixtures as are required for the safety and good management of trains.

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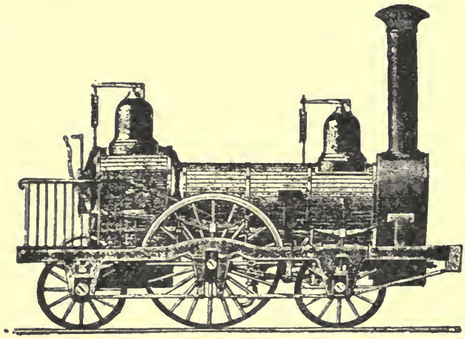
* "At any terminus, or large station where carriages are kept, the station inspectors are to see that they are always in good order, and, before being formed into a train, that every carriage or other vehicle has its proper supply of roof lamps trimmed; that it is cleaned inside and out, and the glasses 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.*

They should not permit a train to start with an engineman, conductor or brakeman who is unfit for duty, nor fail to report such an occurrence to the proper officer.

They should see that the yard is kept in good order, and that cars requiring serious repairs are sent to the shop.

It is their duty to see that car repairmen perform their duties of oiling, cleaning, inspecting and repairing cars in a thorough and efficient manner. Any neglect they may observe should be reported to the proper officer.*

They should see that a record is kept of the number of each car, the date it arrived and departed, and that daily returns of the same are made.



English Locomotive, A. D. 1838.

COUPLING CARS.

Care should be exercised by persons when coupling cars.

The coupling apparatus of cars or engines is not always uniform in style, size or strength, and is liable to be broken.

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* "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.*

It is therefore dangerous to expose the hands, arms or persons of those engaged in this work.

Employes should therefore be directed to examine, so as to know beforehand, the kind and condition of the drawhead, drawbar, link and coupling apparatus, and be prohibited from placing in the trains any car with a defective coupling. Sufficient time should be allowed and may be taken by employes to make the examination required.

Coupling by hand should be prohibited in all cases where a stick can be used to guide the link or shackle; and each switchman, brakeman or other employe who may be expected to couple cars should be required to provide himself with a stick for that purpose.

Uncoupling cars while in motion should be avoided.

DIRECTIONS TO AGENTS IN REFERENCE TO SWITCHES.

Agents have charge of switchmen at stations, and are held responsible for the position of switches; they should keep in mind the fact that a train may arrive at any moment, and be prepared accordingly.*

They should see that switchmen properly signal all approaching trains.

The greatest care should be exercised in the cleaning, trimming and lighting of signal lamps, and agents are held responsible for this work being efficiently performed.

When day and night switchmen are employed, they should not be allowed to leave their posts until relieved, and the one going off duty should inform the one coming on of trains that are due but have not arrived.†

Lamps of switches should be kept trimmed and in order, and never be allowed to go out at night.

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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."—1854.

† "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.*

Agents should see that switches are kept free from snow and other obstructions.*

Switches should be set for the main track, and kept locked, except while being used.

DIRECTIONS TO AGENTS IN REFERENCE TO TRAINS AND CARS.

All vehicles switched off at stations as empties should be carefully searched. The windows of all empty passenger cars should be closed when they are standing on sidings at the stations.†

Agents are responsible for cars remaining at their stations; they should see that the brakes are applied, and the wheels securely blocked so that they can not be moved by unauthorized persons, or blown by the wind, so as in any way to interfere with the safety of trains.‡

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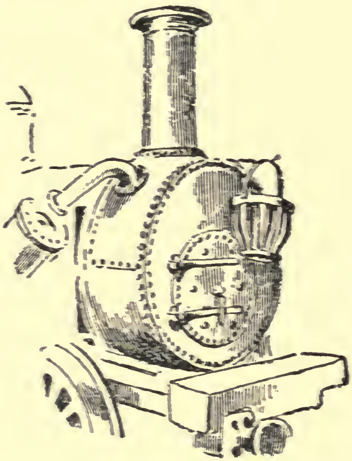
* "He must satisfy himself that the signalmen at or attached to his station perform their duties in a proper manner by night as well as by day, and in order to maintain a proper supervision over the men in this respect, it will be necessary for him frequently to visit the signal boxes."—*English Standard.*

† "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 station master must see that all fixed scotch blocks at his station are kept across the rail; that all safety points are closed against the mai 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 station master, 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 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.*

Agents should see that tracks are kept clear and unobstructed, and not allow any train or engine to approach their station unless they can do so without danger. They should promptly report defective frogs or switches to the proper officer.*

They should report accidents occurring to trains at or near their stations; all damaged cars or goods brought to or left at their stations, destined elsewhere, also the amount of the damage, and how caused.



Headlight, A. D. 1830.

"When a horse is used on the railway, a man must, in all cases, have hold of its head, whether the horse is drawing vehicles or otherwise." †

* "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."—1863.

† English Road.

CHAPTER XIX.

RULES AND REGULATIONS APPERTAINING TO THE MOVEMENT OF TRAINS.—(PART THREE.)

TELEGRAPH OPERATORS.

Telegraph operators at stations should observe the wishes of agents. when such observance does not interfere with their duties.

They should be on duty without intermission during business hours, and should not leave their offices without permission.

They should not leave their post until relieved. The operator going off duty should advise the operator coming on in regard to unfinished business and the position and character of trains upon the line.

Where two or more day or night operators are employed, they should not all be absent at meals at the same time.

Operators at way stations should be in their offices on Sundays twenty minutes before each train is due, and remain in the office until the train is reported as having passed the next telegraph station.

Operators should not leave their offices while a train is at the station unless the business of such train requires it.

They should be courteous in their intercourse with each other and with all persons transacting business at their offices.

Night operators should report to the home office every half hour during prescribed hours.

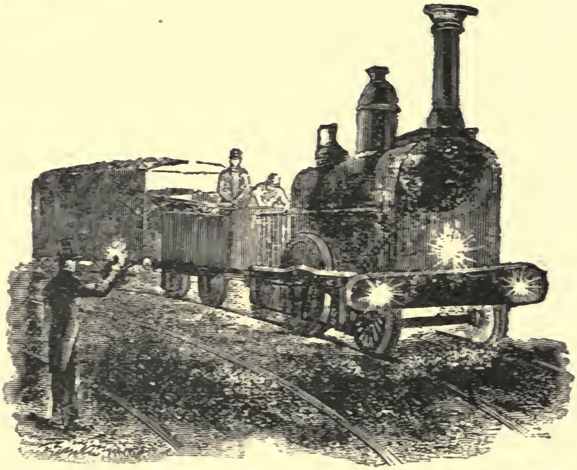
At one minute before eight o'clock a. m. each day, excepting Sundays, all business should be suspended, for the purpose of enabling the home office to report the exact time, and operators and others on the line should forthwith regulate their timepieces to correspond with such report.

At nine o'clock in the morning of each day except Sunday, all business should be suspended, for the purpose of sending car reports to the home office. In sending these reports, care should be taken to punctuate them properly.

All orders and instructions should be carefully preserved and filed for purposes of reference.

When there is a delay of more than fifteen minutes in sending a message, the particulars of the delay should be noted on the back of such message.

When practicable messages received for transmission should be read aloud before being sent, either by or in the presence of the sender.



English Express Train with Mail Signals, A. D. 1844.

Operators should be held responsible for the prompt delivery of messages at their stations.

They should exert themselves to obtain answers to messages promptly when answers are required.

In case persons to whom messages are addressed can not be found, the office at which the message originated should at once be notified.

When answers are required to messages and are not forthcoming, the reason should be explained as soon as practicable.

Operators should retain copies of all messages sent and received, also copies of reports of trains.

Operators should consider telegraphic messages as confidential, and not permit them to be read, except by those to whom they are addressed, nor should they make them the subject of conversation or remark.

Passes received by telegraph should be written with ink, and contain the name of the office where received, the date and time of receipt, and the signature of the operator.

In transmitting messages, the circuit should be firmly connected, the writing should be plain and legible, and care should be exercised to punctuate the communication properly.

In case of interruption or trouble to the line, operators should make diligent inquiry as to its location. The facts should at once be communicated by signal or otherwise to repairers or to trackmen, diligent efforts being made by the operators themselves to remedy the break.

Care should be exercised to protect instruments from being injured by atmospheric electricity.

Instruments should not be taken apart, but carefully preserved in good order, and none should be kept on hand that is not in use. Instruments or fixtures not in use or in a damaged condition should be returned to the home office.

The telegraph should not be used for the transmission of communications which may be sent through other channels.

Operators should promptly report the departure of each train to the proper officer; the arrival of trains should also be reported at terminal stations.

Conductors should report to the proper officer when they are fifteen minutes late, except in cases where the departure of all trains is promptly reported by operators; in the event they neglect to do this, operators should inquire as to the cause of the delay, and forthwith transmit to the proper officer the result of these inquiries, the name of the conductor and the number of his train. If the delay was caused by a hot journal, the number of the car or engine upon which it was located should also be reported.

Operators should keep themselves supplied with proper signals for stopping trains, and have them convenient and in order for immediate use when occasion requires. They should see that their signal lamps are properly filled and trimmed before dark each day.

They should observe the rear of all trains passing their stations, and if red signals are not displayed at once report the omission to the proper officer.

Particular attention should be given to the adjustment of relays when trains are behind time, or when the current is weak.

Operators should not undertake to teach students how to telegraph without permission from the proper officer.

Conversation of a personal nature between operators should not be allowed to interrupt business.

Improper language or profanity should not be indulged in on the line.

Quarreling and contention amongst operators for the use of the circuit is reprehensible. Should the current be interrupted while an operator is using the circuit, he should stop and ascertain the cause; should the interruption be occasioned by another operator having business entitled to preference, he will give way, otherwise he should signal such operator, "Close your key; you are breaking," closing his own key immediately thereafter. If the signal is not at once complied with, the operator should permit his key to remain closed until he can proceed without interruption, when he should report the case to the proper officer.

Operators should disconnect their instruments from the circuit when they leave their offices.

Offices at which there are night operators should be kept open continuously. Other offices should be kept open during the prescribed hours.

TELEGRAPH REPAIRERS.

Telegraph repairers should pass over the road frequently.

They should closely observe the condition of the line, making a careful examination of the connections with the various offices.

They should report to the proper officer each morning the part of the road they propose visiting during the day.

When traveling upon the road, they should ride on the rear end of the last car, so that their view of the line may be unobstructed.

They should keep the telegraph poles in proper position, the wires connected, insulated and clear of all obstructions, and make necessary repairs, calling upon the foremen of sections when assistance is required.

As they proceed, they should ascertain at the various telegraph stations how the line is working.

When upon duty, they should carry with them the tools required in their business, such as pulleys, vises, plyers and files, hooks or cleats, insulators, etc.

They should see that operators and section foremen are supplied with wire, insulators, and other fixtures required in making repairs.

It is their duty to instruct operators and foremen of sections in reference to splicing wire and making other repairs necessary from time to time.

"All Right."

English Signal, A. D. 1844.

In case of a break or obstruction to the line, they should make diligent search for its whereabouts, and, having ascertained its location, proceed at once to make the necessary repairs. Having done this, they should report to the proper officer the location of the difficulty and its cause.

[NOTE.—It is proper to mention here that the intention has been to embody herein only such instructions as relate to the movement of trains. The duties of agents, conductors and other employes in connection with the various branches of the traffic and accounting departments, and the rules and regulations that should be observed, are set forth with particularity in other volumes, to which the reader is referred.]

CHAPTER XX.

ADMINISTRATION OF THE TRAIN SERVICE ON ENGLISH ROADS.

The great English roads are all operated under the block system, or what may be termed a modification of such system. Each line is thickly dotted with signal houses and their attendant appliances. The great bulk of the rules and regulations under which our trains are operated have, therefore, no relevance with them.

While they provide schedules as we do, yet the trains are constantly guarded and protected by the multitude of signalmen scattered along the line.

These men are ubiquitous; trains move or remain stationary as they direct; they approach or remain away from stations at their beck or nod, and when a train has reached a station it departs or not as the signals indicate. So that while trains may be behind time, or may not be recognized by the schedule, they still pursue their way with undiminished speed so long as the signals in their front indicate the track to be clear.*

* A full description of the workings of the block system is embraced elsewhere herein.

The trains manipulated under the eyes of the signalmen of course require double tracks upon which to move.

Upon single track roads in Great Britain the great utility of the telegraph in connection with the movement of trains is practically unknown, and in that respect our system of management is immeasurably superior to theirs.

The duties of the conductor abroad are exceedingly diverse. He may be said to be the creature of innumerable circumstances. Frequently without an assistant on board the train, he is expected to protect it and its occupants; to perform the duties of a brakeman, act as express messenger, baggage master and attendant. Nominally in control of the train when upon the line, his authority vanishes upon its arrival at a station. He assists passengers in entering and leaving the cars, but their fares are collected by another.*

The elaborate force which mans our passenger trains is unknown in England. There the force consists of a guard (conductor), as intimated above. He does not always have an assistant.

The head guard has charge of the train, and its passengers, baggage and express matter.

The assistant guard has a box in one of the cars or vans; he signals the train in case of

* "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.*

danger, attends to the brake, and performs such other duties as he may be able.

In lieu of these men we usually have a conductor, express messenger, baggageman, and two brakemen. Our station service is, however, conducted with a much less force than theirs. Their apparent extravagance in this respect is explained in part by the fact that the rules requiring passengers to purchase tickets before entering the cars are rigidly enforced by them. The outlay

"All Clear." "Slacken Speed." "Caution." "Caution."

English Signals, A. D. 1844.

is, therefore, not an extravagance. In connection with this subject of passenger fares and their payment, the regulation of the Austrian roads, that permits and directs the officials of a company to impose a fine upon passengers who neglect to purchase tickets, or claim that they did not have time to purchase them, is interesting and instructive. The laws of England governing the time and manner of paying passenger fares are also exceedingly strict.

RULES OF ENGLISH ROADS.

Every person employed by the company must devote himself exclusively to their service, 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.

Although 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, yet every such person must make himself thoroughly acquainted with them, and will be held responsible for a knowledge of and a compliance with the whole of them.

Every servant 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 station master's office, so that, if required in cases of emergency, the men may be readily found. Any change of address must be notified to the station master, 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 station master 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 reserve 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 their 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.

"All Right." "Caution." "Stop."
English Signals, A. D. 1844.

The safety of the public must, under all circumstances, be the chief care of the servants of the company.

Wherever 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.

Wherever the words "Goods Train" are used, they must be understood to include "Goods, Mineral, Cattle, and Ballast Trains."

CONDITIONS UNDER WHICH PERSONS ARE ADMITTED TO THE SERVICE—SECURITY—PRIVILEGES—COMPENSATION—ETC.*

A candidate as an experienced clerk must possess railway experience, or experience in other traffic equivalent thereto.

* Great Northern Railway, England.

The salary, not exceeding $400* 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.

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, $1.00 a week is allowed in addition to the salary.

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.

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	"

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 $1.00 a week in addition to their pay, when employed wholly on night duty.

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.

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* I have taken the liberty here, as I have elsewhere herein, when I thought proper, of reducing the foreign currency to the American standard. The rates inserted are not arbitrary, but change from time to time according to places and circumstances.
M. M. K.

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 can not afterwards 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 $500, through the medium of one of the undermentioned guarantee societies, and he can not subsequently, under any pretense whatever, be allowed to change from the society first selected.

(Here follows a list of the guarantee companies.)

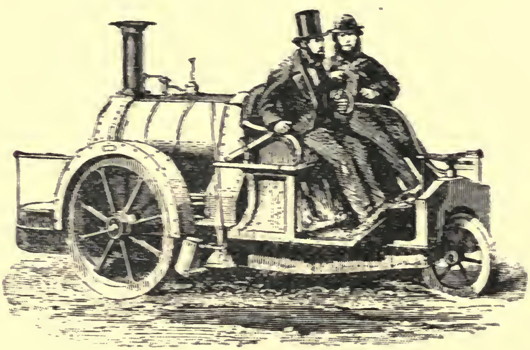
The railway company pays the premium in the case of a clerk whose salary does not exceed $5.25 per week or $6.25 per week without allowances.

A candidate as a porter must be five feet seven inches in height, without his shoes. He must not be less 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 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.

The pay of a porter is, on entering, and

	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 " "



Steam Road Carriage, A. D. 1860.

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.

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 lad porter is, on entering, and

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 the rules and regulations . . . or otherwise given them for their guidance.

The rules of the Sick and Funeral Allowance Fund are furnished to every porter on appointment.

Station inspectors. $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.

Pass. Guards [con.]	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.

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	"

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Gatemen provided with a house by the company are to have coals free, and to 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.

Porters in London, - - - -	$4 25	per week.
" in the Country, - - - -	4 00	"
Foremen Porters in London, - -	5 25	"
" " in the Country, - -	5 00	"
Mineral Foremen Porters in the Country,	5 25	"
Shunters in Londen, - - - -	4 75	"
" in the Country, - - -	4 50	"
Luggage Stowers and Loaders, - -	4 75	"

Police and porters are to 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 are to 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 $6.25, which is a fixed rate of wages, or to the situation of guard or inspector.

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.

Signalmen, at the expiration of every half year of good service, without punishment, will receive a premium of $12.50.

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 UNIFORMS REQUIRED AND THE REGULATIONS INCIDENT THERETO.*

All servants of the company to whom uniform is allowed, are required to wear it while on duty. The uniform of servants clothed by the company is as follows, for twelve months:

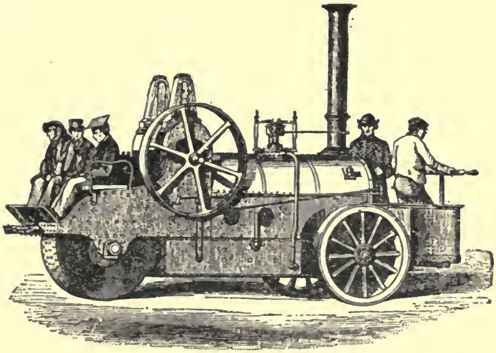
For station inspectors and guards, a great coat, a frock coat, waistcoat, two pairs of trousers, two red neckerchiefs, and hat or

* Great Northern Railway, England.

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 posses-



Truxford's Traction Engine, A. D. 1862.

sion 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; 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. 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 regulations 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 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.

GENERAL REGULATIONS FOR WORKING THE ABSOLUTE BLOCK SYSTEM ON A DOUBLE TRACK ROAD.*

The signaling of trains on the block telegraph system does not in any way 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.

The 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 the company's 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, will be 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 must not 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

* Engine Clearing House Standard.

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 distant 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 vehicle (with tail 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 brakedown 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 fouled, 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.

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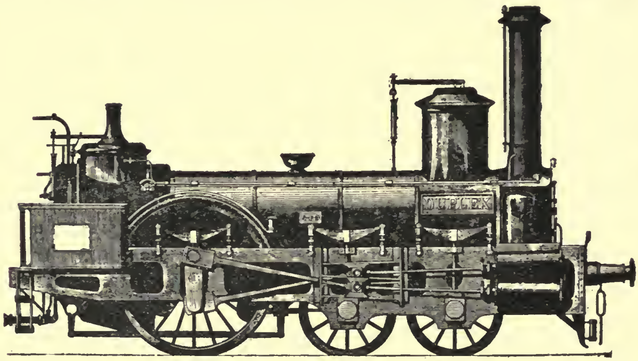
*The "home" signal or semaphore is located in the immediate vicinity of the station; the "distant" signal is, however, located farther away. It is usually worked (by means of a chain running along the ground) by the person who operates the "home" signal. M. M. K.

If a signalman observe 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 vehicle 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



Duplex Locomotive, A. D. 1862.

engine driver 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 engine driver 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 engine driver 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 vehicle 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.

"A." In the event of any failure of the instruments or bells, so that the necessary signals can not 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.†

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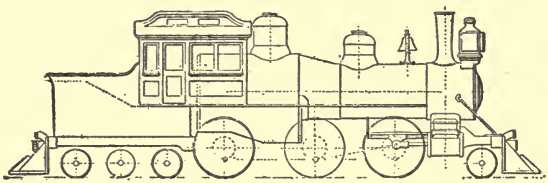
* Not the *right hand* track.—M. M. K.

† "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.*

Steps must immediatety be taken to have the telegraphic apparatus put into working order again.

"B." To prevent delays to breakdown van 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 which the breakdown 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



Locomotive, A. D. 1894.

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, goods, mineral, cattle and ballast trains must be shunted out of the way of passenger trains, and mineral, slow goods and ballast trains must also be shunted out of the way of fast goods and fish trains at stations or sidings where there are fixed signals,‡ in sufficient time

* Wrecking trains.—M. M. K.

† Great Western Railway, England.

‡ *i. e.*, Semaphore signals, etc.—M. M. K.

to prevent the passenger train, fast goods or fish trains, respectively, being delayed by the signals either at the station where the train is being shunted or at the block station in the rear.

Where the block system is in operation, and it is necessary to foul* 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 snow storm, 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.

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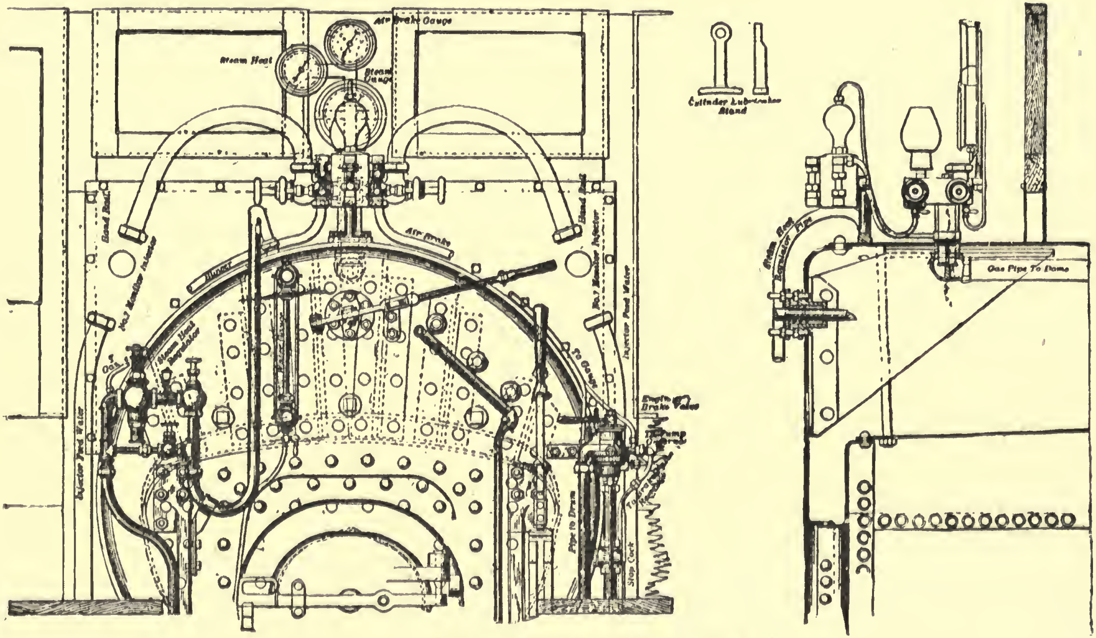
* Obstruct.—M. M. K.



Boiler Attachment of a Locomotive.

APPENDIXES.

APPENDIX A.

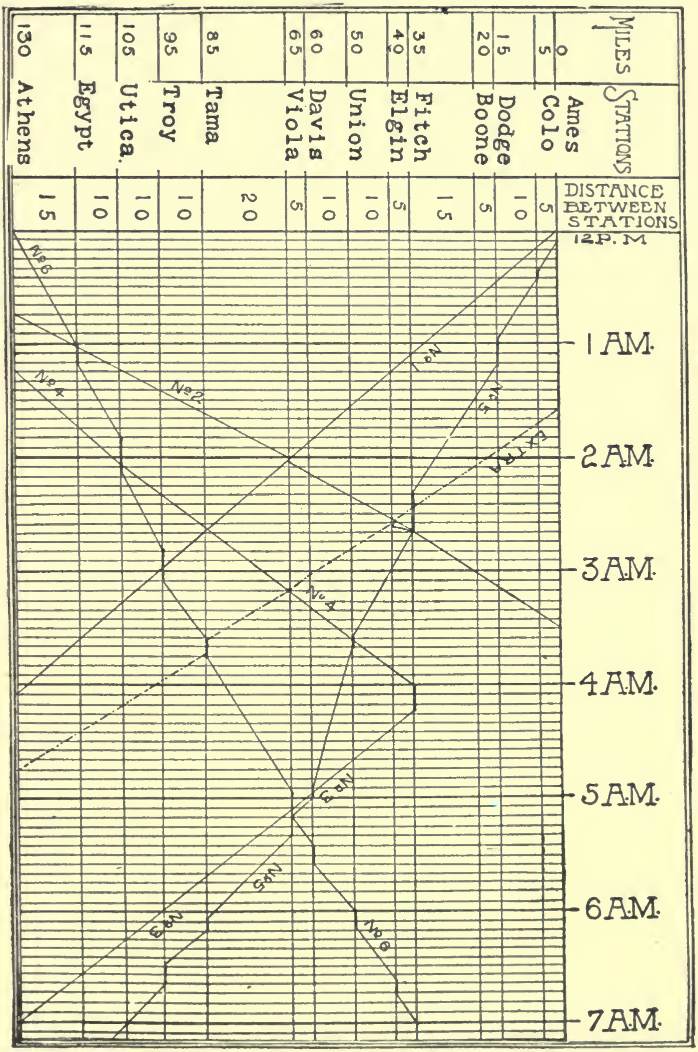


Diagram used in Making Railway Time Tables.

APPENDIX B.

FORMS OF TRAIN ORDERS.

FORM A.—FIXING MEETING POINT FOR OPPOSING TRAINS.

——— and ——— will meet at ———.

EXAMPLES.

No. 1 and No. 2 will meet at Bombay.
No. 3 and 2d No. 4 will meet at Siam:
No. 5 and Extra 95 will meet at Hong Kong.
Extra 652 North and Extra 231 South will meet at Yokohama.

Trains receiving this order will, with respect to each other, run to the designated point, and having arrived there will pass in the manner provided by the rules.

FORM B.—AUTHORIZING A TRAIN TO RUN AHEAD OF OR PASS ANOTHER TRAIN RUNNING IN THE SAME DIRECTION.

(1.) ——— will pass ——— at ———.
(2.) ——— will run ahead of ———, from ——— to ———.

EXAMPLES.

(1.)—*No. 1 will pass No. 3 at Khartoum.*
(2.)—*No. 4 will run ahead of No. 6 from Bengal to Madras.*

When under this order 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.

FORM C.—GIVING A TRAIN OF INFERIOR RIGHT THE RIGHT OF TRACK AGAINST AN OPPOSING TRAIN OF SUPERIOR RIGHT.

[NOTE.—This form of order must not be used when Form A can be used.]

——— has right of track against ——— ——— to ———.

EXAMPLES.

(1.)—*No. 2 has right of track against No. 1 Mecca to Mirbat.*
(2.)—*Extra 37 has right of track against No. 3 Natal to Ratlam.*

[NOTE.—The terms "superior right" and "inferior right," here and elsewhere in these rules, refer to the rights of trains under the time table and train rules, and not to rights under special orders.]

This order gives a train of inferior right the right of track against one of superior right, to a designated point.

If the trains meet at the designated point, the train of inferior right must take the siding, unless the rules or orders otherwise indicate.

Under this order, as illustrated by example (1), 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 example (2) the train of superior right can not 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.

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.

EXAMPLE.

Work Train Extra 275 has right of track over all trains between Stockholm and Edinburgh from 7 P. M. ——.

This gives the work train the exclusive right of the track between the points designated.

FORM D.—GIVING ALL REGULAR TRAINS THE RIGHT OF TRACK OVER A GIVEN TRAIN.

All regular trains have right of track against —— between —— and ——.

EXAMPLE.

All regular trains have right of track against No. 1 between Moscow and Berlin.

This order gives to any regular train of inferior right receiving it the right of track over the train named in the order, and the latter must clear the schedule times of all regular trains, the same as if it were an extra.

FORM E.—TIME ORDERS.

[NOTE.—This form of order must not be used when Form A can be used.]

(1.) —— will run —— late from —— to ——.
(2.) —— will wait at —— until —— for ——.

EXAMPLES.

(1.) No. 1 will run 20 min. late from Joppa to Mainz.

(2.) No. 1 will wait at Muscat until 16 a. m. for No. 2.

Form (1) 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 order is required to run with respect to this later time, the same 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 form (2) the train of superior right 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 before required to run with respect to the regular schedule time of the train of superior right.

FORM F.—FOR SECTIONS OF REGULAR TRAINS.

—— will carry signals —— to —— for ——.

EXAMPLES.

No. 1 will carry signals Astrakhan to Cabul for Eng. 85.

Second No. 1 will carry signals London to Dover for Eng. 90.

This may be modified as follows:

Engines 70, 85 and 90 will run as 1st, 2d and 3d sections of No. 1 London to Dover.

For annulling a section:

Eng. 85 is annulled as second section of No. 1 from Dover.

If there are other sections following add:

Following sections will change numbers accordingly.

The character of train for which signals are carried may be stated. Each section affected by the order must have copies, and must arrange signals accordingly.

FORM G.—FOR ARRANGING A SCHEDULE FOR A SPECIAL TRAIN.

(1.) Eng. —— will run as a special —— train, leaving —— on —— on the following schedule, and will have the right of track over all trains:

Leave ——.
——.
Arrive ——.

EXAMPLE.

(1.) Eng. 77 will run as special passenger train, leaving Turin on Thursday, Feb. 17th, on the following schedule, and will have the right of track 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.

Example (1) may be varied by specifying particular trains over which the special shall or shall not have right of track, and any train over which the special train is thus given the right of track must clear its time as many minutes as such train is required to clear the schedule time of a first class train.

(2.) Eng.——will run as special———train, leaving———on ———with the rights of a———class train,———, on the following schedule, which is a supplement to time table No.——.

Leave ———.

———.

Arrive———.

EXAMPLE.

(2.) Eng. 75 will run as special passenger train, leaving Geneva, Thursday, Feb. 17th, with the rights of a first class train east, on the following schedule, which is a supplement to time table No. 10:

Leave Geneva 10 A. M.
Pekin 10:30 A. M., passing No. 12.
Canton 11 A. M., meeting No. 7.
Arrive Athens 11:30 A. M.

Example (2) creates a regular train and the specified meeting and passing points are to be regarded as if designated in the same manner as on the time table. Such trains will be governed by all rules which affect regular trains.

FORM H.—EXTRA TRAINS.

———will run extra from———to———.

EXAMPLE.

(a.) Eng. 99 will run extra from Berber to Gaza.

A train receiving an order to run extra is not required to guard against opposing extras, unless directed by order to do so, but must keep clear of all regular trains as required by rule.

A "work train" is an extra, for which the above form will be used for a direct run in one direction. The authority to occupy a specified portion of the track, as an extra while working, will be given in the following form:

(b.) Eng. 292 will work as an extra from 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:

(c.) Eng. 292 will run extra from Berne to Turin and work as an extra from 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 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 can not be reached for meeting or passing orders, it may be directed

27

to report for orders at a given time and place, or an order may be given that it shall clear the track for a designated extra, in the following form:

(*d.*) *Work train 292 will keep clear of extra 223, south, between Antwerp and Brussels after 2:10 P. M.*

In this case, extra 223 must not pass either of the points named before 2:10 p.m., at which time the work train must be out of the way between those points.

When the movement of an extra train over the working limits can not 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 76 will protect itself against work train extra 95 between Lyons and Paris.*

This 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. To example (*b*) add the following words:

(*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 these limits by adding to example (*a*) the words:

(*g.*) *Eng. 292 is working as an extra between Berne and Turin.*

A train receiving this order must run expecting to find the work train within the limits named.

[NOTE.—The committee have recommended two forms of orders for work train extras, leaving it discretionary with the roads to adopt one or both of the forms, according to the circumstances of the traffic on the different roads or different divisions of the same road.]

FORM J.—HOLDING ORDERS.

Hold ———.

EXAMPLES.

(*1.*) *Hold No. 2.*

(*2.*) *Hold all trains east.*

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 will only 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, as "for orders."

This order is not to 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. It must be respected by conductors and enginemen of trains thereby directed to be held as if addressed to them. Conductors when informed of the order must sign for it, and their signatures must be sent and "complete" obtained.

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 form:

"——— *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.

FORM K.—ANNULLING A SCHEDULE TRAIN.

———of———is annulled.

EXAMPLES.

(*1.*) *No. 1 of Feb. 29th is annulled.*

(*2.*) *No. 3 due to leave Naples Saturday, Feb. 29th, is annulled.*

Adding "*from Alaska,*" or "*between Alaska and Halifax,*" when appropriate.

This order takes away all rights of the train annulled and authorizes any train or person receiving it to use the track as if the train annulled were not on the time table.

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.—ANNULLING OR SUPERSEDING AN ORDER.

Order No.——is annulled.

This will be numbered, transmitted and signed for as other orders.

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.——.

An order superseding another may be given, adding "*this supersedes order No.——,*" or adding "*instead of———.*"

EXAMPLE.

No. 1 and No. 2 will meet at Sparta, instead of at Thebes.

An order which includes more than one specified movement must not be superseded.

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 superseding 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.

PERFORATED LINE.

LONDON AND PARIS RAILWAY COMPANY.

TELEGRAPHIC TRAIN ORDER No.____

Superintendent's Office, 188 .

FORM 19 *For* *to* *of* FORM 19

SPECIFICATIONS FOR TRAIN ORDER FORM AND BOOKS FOR OPERATORS.

Form as here shown. Blank space for order (4) inches with no lines. The mode of filling the blanks is indicated by small type.

Names of Divisions and office to be varied to suit each Division.

Form (6¾ x 6) inches below perforated line. Book (6¾ x 11) inches.

(300) leaves. Stitched. Bound at top. 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 10) inches, and a stiff tin, same size, corners rounded.

CONDUCTOR AND ENGINEMAN MUST EACH HAVE A COPY OF THIS ORDER.

Rec'd *M.* *Made* *at* *M.* *Rec'd by* *Op'r.*

PERFORATED LINE.

LONDON AND PARIS RAILWAY COMPANY.

TELEGRAPHIC TRAIN ORDER No.____

Superintendent's Office. [illegible] *188* .

FORM 31 *For* [illegible] *to* [illegible] *of* [illegible] FORM 31

SPECIFICATIONS FOR TRAIN ORDER FORM AND BOOKS FOR OPERATORS.

Form as here shown. Blank space for order (4) inches with no lines. The mode of filling the blanks is indicated by small type.

Names of Divisions and office to be varied to suit each Division.

Form (6¾ x 10) inches below perforated line. Book (6¾ x 11) inches.

(300) leaves. Stitched. Bound at top. Paper cover on face and top. Very stiff back on lower side.

Paper opaque, white, 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 10) inches, and a stiff tin, same size, corners rounded.

CONDUCTOR AND ENGINEMAN MUST EACH HAVE A COPY OF THIS ORDER.

Time received [illegible] *M.* [illegible] *given at* [illegible] *M.*

CONDUCTOR	ENGINEMAN	TRAIN	MADE	AT	RECEIVED BY
Jones	Brown	13	Complete	[illegible]	[illegible]
	(Omit this				
	column where				
	Engineman				
	is not				
	required to				
	sign.)				

LONDON AND PARIS RAILWAY COMPANY.

CLEARANCE CARD.

Dover. ______ 9 15 A.M. ______ March 25, ______ 188 .

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.

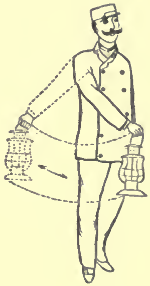
Conductor **MUST SEE** that the number of **HIS TRAIN** is entered in the above form correctly.

Conductor and Engineman must each have a copy.

APPENDIX C.

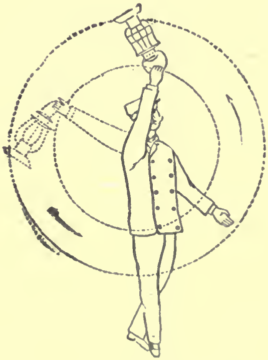
HAND AND LAMP SIGNALS.

"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.)

APPENDIX D.

SOME AMERICAN AND ENGLISH RAILWAY SYNONYMS.

American.	*English.*
Ticket Office.	Booking office.
Station agent.	Station clerk.
Baggage room.	Cloak room.
Car.	Carriage.
Baggage.	Luggage.
Baggage car.	Luggage van.
Mail car.	Post van.
Conductor.	Guard.
Engineer.	Driver.
Fireman.	Stoker.
Freight car.	Goods van.
Section foreman.	Ganger.
Sectionmen.	Plate layers.

INDEX.

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TO

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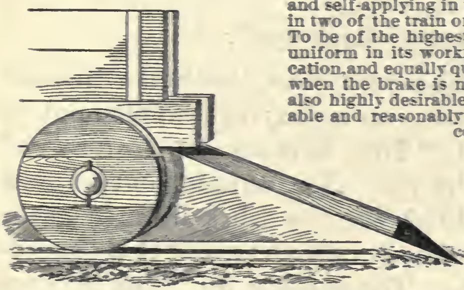
C. G. PHILLIPS, *President,*
The World Railway Publishing Company,
Chicago, Ills.

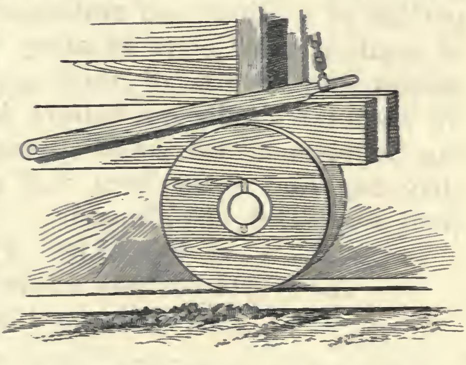
CAR BRAKE—EVOLUTION OF THE BRAKE.

One of the most important devices in connection with the operation of railroads, and one that grows in importance each day with the added weight and speed of trains, is the brake; the device by which their movements may be controlled at will, either by persons on the locomotive or by those who fill the cars. An acceptable brake requires that it should control absolutely the train under every circumstance as regards its weight and speed; also as regards weather and grade, not forgetting, moreover, such mishaps as the separation of the train while in motion. To fulfill these conditions it is apparent that the device must be automatic and self-applying in the case of the breaking in two of the train or other similar accident. To be of the highest utility it must also be uniform in its workings, quick in its application, and equally quick in releasing its hold when the brake is no longer needed. It is also highly desirable that it should be durable and reasonably economical as regards construction and maintenance. These last features, like others that are necessary and desirable in connection with the device, will be more and more fully attained as the needs of the situation are studied and railways have had greater experience in the use of the device.


Early Lever Brake, England, 1630.

In discussing the practical uses of a brake in connection with railways, a brief reference to its origin and evolution is interesting. Like every other object of utility, it was exceedingly simple in the first instance. Its discovery grew out of the need for it. So far as we know, the lever brake, manipulated by the hand or foot, was the first formal device of this nature. Applied originally to road wagons, it was afterwards found equally adaptable to the vehicles of railroads.

Another almost equally simple form of brake was that used at New Castle-on-Tyne in the seventeenth century. However, there have been many forms of primitive brake quite as archaic as either of these. Some of them are illustrated herewith.


Brake or Retarding Bar used at New Castle-on-Tyne, 1630.

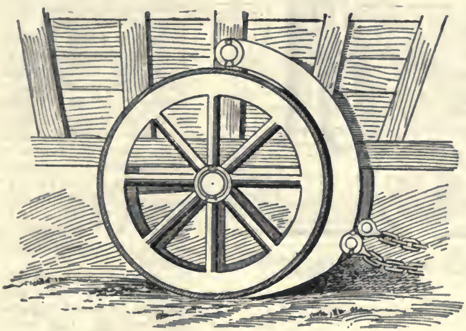
Among these crude devices may be mentioned the "Le Caan" brake, so-called. This was operated by dropping the lever. When this was done the shoe of the brake, falling to the ground, formed a wedge, thus retarding the revolution of the wheel.

Among other primitive makeshifts there were various forms of chain brake, and later the devices in which steam was used; also the hydraulic brake, operated by liquids stored under high pressure.

Reaching a higher grade, comes the so-called plain vacuum brake, operated by an ejector, which withdraws air from the pipes, thereby producing a vacuum more or less perfect.

The automatic vacuum brake, operated by the application of air at atmospheric pressure to a vacuum cylinder.

The compressed air brake. This is worked by an air pump forcing air into the pipes, the air being stored in cylinders under the vehicle.



The "Le Caan" Brake, England, 1796.

Still other forms and modifications might be enumerated, but those given are sufficient to represent, substantially, the progressive steps in the evolution of the brake and direct attention to the practices observed and the principles involved.

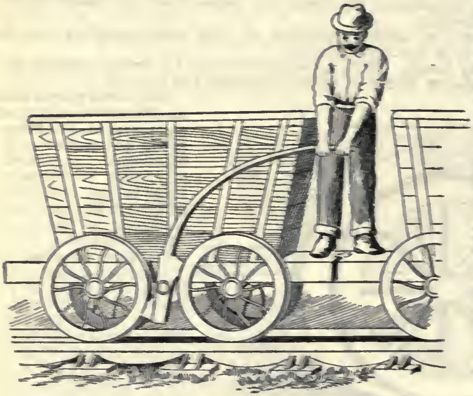
Among the writings of the ancients we find mention of the use of the brake, coupled with vague references to the principles governing it. Nothing, however, definite. Indeed, there was little use for such a device in connection with the chariots and rude carts and wagons used in the primitive ages of the world. For a long period the axle and wheel were one and revolved in unison. Such was the primitive cart. When this was the case there could have been little need of the friction afforded by a brake to stop the vehicle.

Indeed, the difficulty was to make the wheel revolve at all. Later on, as the class of road vehicles improved and the highways became more passable, rude brakes, as we have seen, came into use. They were operated by a lever, applied with the hand or foot in a general way, as shown in the accompanying devices.

A Primitive Device, known as the "Sprag" Brake.

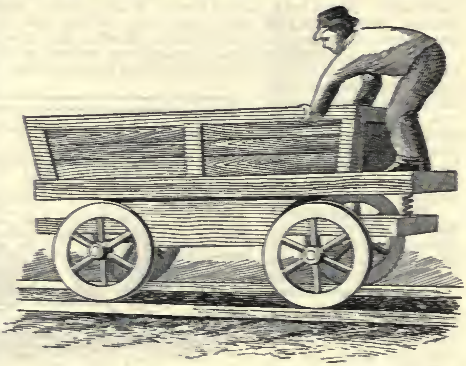
With the advent of the smooth and comparatively level track of railways, some means of controlling the movement of vehicles became a matter of prime importance; hence the universal adoption and use of a brake. It has ever been recognized as one of the most important adjuncts of the rolling stock. Through the introduction of air brakes trains when moving at a high rate of speed can be stopped quickly without undue strain on the machinery or wear and tear on the track. Formerly they were compelled to slow up gradually, thus losing much time and, in many instances, occasioning accidents that railways are now happily free from.

The evolution of the railway brake, as partially illustrated, is interesting and instructive. Its progress in the operation of railroads at least has reached a stage of great complication, as well as of great efficiency. The sum total of railway machinery at the time the first railroad was opened, from Liverpool to Manchester, in 1829, was not greater, probably, than the machinery of the brake and its concomitants at the present day. The scientific features of the first locomotive were exceedingly simple, while the machinery of the air brake has reached a highly complicated stage.



Lever Brake, England, 1825.

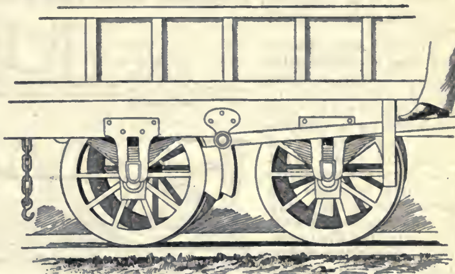
The brake of the present day is so perfect in its working and control of the train that it has come to be considered one of the greatest safety devices of railways. Another feature is the saving it effects in the wear and tear of machinery and track through the smoothness and certainty of its operation. That its development is still incomplete, however, goes without saying. What man exhausts himself upon to-day, what seems to him to be the height of perfection, he discovers upon further experience and reflection to be far from perfect. His growth is shown in his devices—his evolution in his successful striving after something better.



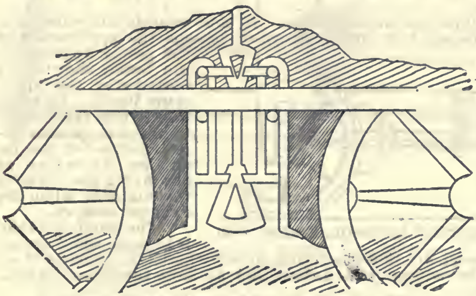
Early Form of English Brake.

The first railway brake of which we have due particulars consisted of a wooden lever, pivoted to the side of the vehicle at one end and supported at the other by a short chain or strap. It is illustrated herewith. This was some time in the seventeenth century. In applying it the chain was slipped off the lever and the latter pressed downward. This primitive device, manipulated wholly by the strength of the person in charge, contained the underlying principle from which all subsequent improvements have been evolved. Those now used, it is only proper to say, are merely elaborations of this form. It represented the principle—the germ.

Robert Stephenson is said to have invented the first steam brake for the driving wheel of the locomotive about 1833.* However, it was applied only to one side of the machine. It is said to have contained primarily the elements of the brake used since on the driving wheels of locomotives, viz: Cylinder, toggle-joint and suspension links. The idea that a similar brake might be used, with extended appliances, on the cars attached to locomotives, also occurred to Stephenson.



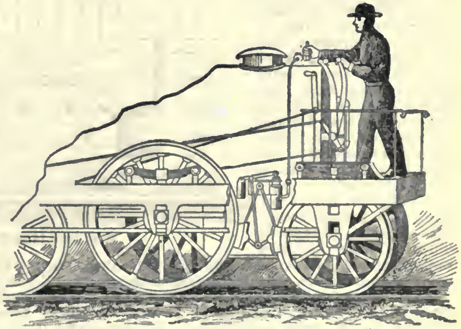
Lever Brake, England, 1832.



Steam Brake for Tender, England, 1832.

Among the devices for checking and moderating vehicles, the hand chain brake so generally used at one time was a most effective invention. Everyone is familiar with its operation. It consisted of a chain or rod running under the car attached to a frame swinging beneath and hanging at right angles to the vehicle. The end of the rod was at ached by a chain to the brake shaft, where the power was applied by a wheel worked by hand.

Another form of chain brake is that applied to the train as a whole. The end of the chain is attached to the brake shaft or lever where the power is applied, and the other end to the rear of the last car. When the brake is applied the tendency of the chain is to draw into a straight line, thus swinging the brake frame under the car, which in turn pulls

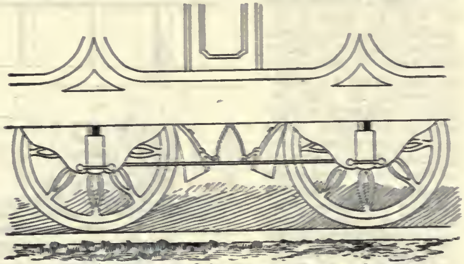


Stephenson's Locomotive Steam Brake for Driving Wheels, 1833.

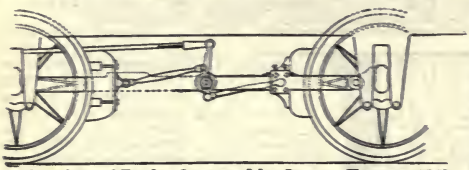
*His steam brake must not be confounded with the air brake, which latter is operated by steam.

rods attached to it and connecting with the brake beams, thus applying the brakes. It is, however, a sectional rather than a continuous brake, and is valuable only on short trains.

Another early invention was the hydraulic brake. Water, or other liquid, was stored under pressure, and operated by a continuous pipe carried along the train, with cylinders for applying the force beneath the cars. The steam pump on the engine generally supplied the pressure. A serious objection to the hydraulic brake is the susceptibility of the liquid to the cold. This is an objection also to steam. In cold weather the water generated by the steam freezes and thus destroys or lessens the application of the power by clogging the brake shoe or by obstructing the apparatus itself. In addition to this fatal objection, steam is also objectionable for use on engines because of obscuring the view of the engineer when the exhaust escapes.



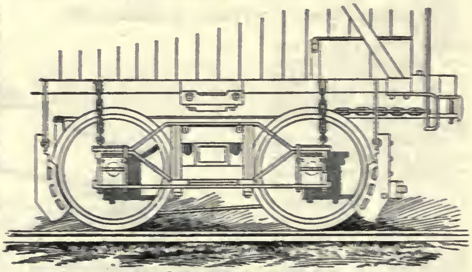
Car Brake Operated by Steam, England, 1839.



Gearing of Brake Operated by Steam, France, 1840.

The vacuum brake is in some sense a competitor of the compressed air brake referred to elsewhere. It consists of an ejector for producing the vacuum (*i. e.*, exhausting air from the pipes); a continuous line of pipe; diaphragms and finally couplings between the cars. The force is applied from the engine. In its operation the ejector takes air from the entire train pipe and the various diaphragms, and in doing this sets the brakes throughout the train. As air is re-admitted to the pipes the brakes are released.*

Various forms of the vacuum brake have been invented. The brake enjoys considerable favor because of its simplicity. Particularly is this true on elevated roads, where the trains are light and short and the stops frequent. The vacuum brake has some features not possessed by the automatic air brake, thus it may be operated so as to only partially release the brake, moreover frequent and rapid application of the brake does not reduce its available braking power. When long and heavy trains are used, however, vacuum brakes do not fully meet the demands of the service. This is principally owing

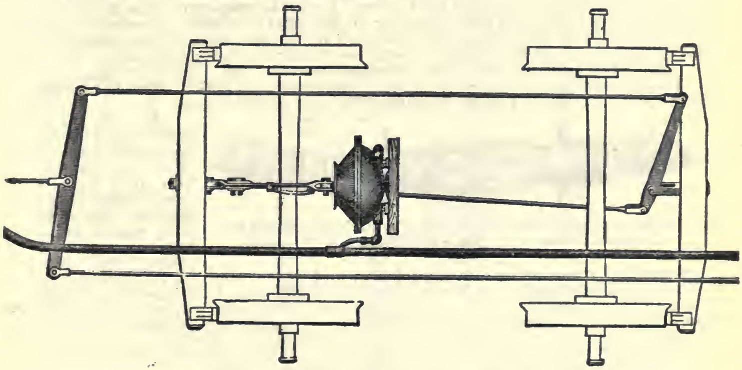


Modern Hand Brake.

* Sufficient air is taken out to produce the result desired.

to the necessity of having abnormally large apparatus (pistons, levers, etc.) in order to get sufficient resisting power upon the wheels, and also because it is in such cases slow to act.

The first form of air brake successfully used was what is technically known as the straight air brake.* The compressed air that was used was stored in a reservoir under the engine. In order to set the brake the engineer's valve was so turned as to allow air to go back through the pipe and fill the cylinders under the car, forcing out the pistons, thus bringing the brake shoes against the wheels. To release the brakes, the supply of air from the drum was cut off and the air in the pipe and cylinders allowed to escape through ingenious devices into the atmosphere.



Diaphragm of Vacuum Brake. The diaphragm (semi-oval device shown above) consists of a kettle shaped iron casting with a loose disc of heavy rubbered duck fastened over its mouth (where the two half sections come together in the center) by means of a ring and cap-screws; the center of the disc, or diaphragm, being provided with washers and an eye-bolt for attachment to the brake lever. When the air is exhausted from the diaphragm, the pressure of the atmosphere from without forces the rubber disc into the iron shell and thus sets the brakes.

The first successful inventor of an air brake is said to have been George Westinghouse, Jr. This was in 1869. Although an improvement over the continuous chain brake and other inventions of early days, it was still too slow in releasing, as all the air in the pipe and cylinders had to escape through the engine valve, and the longer the train the slower its operation. Another fault was if a hose or pipe burst, the brake was rendered useless. Moreover, if a train became parted, the brake had no effect whatever upon the rear section.

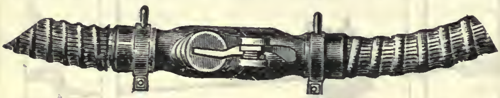
These objections rendered it apparent that a wholly satisfactory brake required that the force (air) for applying it should be stored on each car, and so arranged that it could be used (*i. e.*, the brake set) by those in the car independent of the engineer. Also that it should be automatic in its action (*i. e.*, that any breakage or defect of the apparatus would set the brake). The most primitive conception of this idea was a design in which the operative force was a spring, so arranged as to be held under compression by the air in the pipe, and brought into action when the air escaped. The first necessity this involved was a reservoir auxiliary to the engine for storing the power on the cars; the next was to provide a way by which the stored pressure in the

*The air brake must not be confounded with the old fashioned steam brake. In the latter case steam was forced through the pipes and used as the power, while in the case of air brakes air is used, steam being employed merely to furnish the power for handling the air.

reservoir might be automatically admitted to the brake cylinder whenever the pressure in the train pipe escaped. These improvements were covered by a patent issued by Mr. Westinghouse in 1872.

The device employed is known as the "triple valve." Like nearly all inventions of a mechanical nature, the first design was incomplete and passed through several stages before reaching a point where it was of simple and practical use. The valve in question (which is of a complicated nature) is located in conjunction with the auxiliary reservoir and brake cylinder beneath the car. Upon the reduction of the pressure in the train pipe (through which the compressed air is supplied the auxiliary reservoir from the engine) this valve allows the compressed air in the auxiliary reservoir to pass into the brake cylinder, thus applying the brakes. Upon the pressure in the train pipe being restored the valve allows the air in the brake cylinder to escape to the atmosphere, thus releasing the brake, and opens the ports for the passage of air from the train pipe to the auxiliary reservoir, recharging the latter.

The perfection of the hose coupling between the cars also plays an important part in the development of the stored air brake. Men have tried and are still trying to perfect a satisfactory automatic coupler.



Hose coupling between the cars, through which the air passes in order to operate the brakes on the cars.

An air pump was patented by Westinghouse in 1870. An objection to it was its complicated valve motion. One difficulty was in keeping the square piston rod properly packed in order to prevent friction and wear. Many of the changes in devices had relation to the reversing valve mechanism, but up to the year 1875 no satisfactory result had been accomplished. First a horizontal rotary valve was used, then a double poppet valve, then a vertical rotary valve, and finally a simple slide valve, the latter proving by far the most effective.

Many of the objects sought as necessary in a satisfactory pump were finally covered by Mr. Westinghouse in his device of 1875.

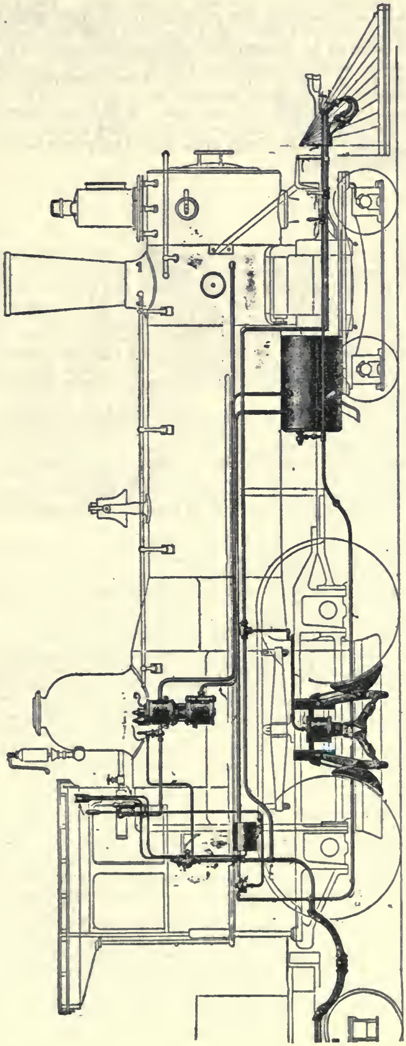
After the introduction of the automatic brake it was discovered that to secure satisfactory results some plan for maintaining a uniform pressure of air without attention from the engineer was needed. The outgrowth of this was the pump governor, which automatically closes the steam pipe leading to the pump when the desired maximum air pressure is attained, opening it again when the pressure has been reduced.

Thus we see, in connection with the brake, every requirement met as it arises by man's subtle ingenuity.

The first form of engineer's brake valve used in connection with an air brake was composed of three openings, controlled by a conical shaped rotary plug. The general principle by which this valve worked was retained in the engineer's valve of later designs. The engineer's valve, manipulated by the engineer, opens communication between the main reservoir and the train pipe, closing the connection and opening the pipe to the atmosphere when the brakes are applied. The equalizing discharge feature of this valve is a device brought out prominently in 1886, being made necessary by the application of automatic brakes to long trains of cars. This device automatically regulates the discharge of the air from the train pipe in setting the brakes, and also gradually closes the exhaust openings, thereby equalizing the pressure remaining in the train pipe, thus overcoming the difficulty experienced with the earliest forms of valves arising from the sudden opening and closing of the exhaust openings, which produced a violent recoil of the air in the train pipe, thus releasing some of the brakes on the forward cars.*

An important feature in connection with the subject of brakes is what is known as the quick action brake. While the so-called plain automatic brake is sufficient on short trains, it does not answer the purpose on freight or other long trains. The head brakes being set some time before those in the rear are

*Mr. Paul Synnestvedt has written a very interesting brochure on the "Evolution of the Air Brake," which I have read with pleasure and instruction.



Theory of the application of the Automatic Brake and Brake Shoe to the driving wheels.

affected, a severe shock occurs to the rear of the train. The first remedy for this was a device with a local vent for quickening the discharge from the long pipe. The "automatic relief valve" and the "cut off and relief valve" are other inventions designed to hasten the application (effective force) of the brake. Many valuable improvements and new forms of quick action brakes have been invented from time to time. One of the most ingenious, carefully constructed and effective of these is referred to in Appendix E of this volume. By reference to this the relation of the brake to the locomotive, tender and cars, both freight and passenger, may be studied more intelligently and effectively from the diagrams that are given than would be possible in a description aside from such illustrations.

An important consideration, it may be said, in connection with the brake is that part of the apparatus commonly called the shoe, or device that is applied directly to the wheel, and against which the friction is produced that retards the latter. It is manifest that the tenacity of the shoe depends not only on the force with which it is applied, but also upon the kind and quality of the material of which it is made. Another thing of great importance in connection with the shoe is the durability of the material used. The power with which this apparatus is applied and the tremendous friction consequent thereon must, it is apparent, quickly destroy the device unless the material is of the most durable character.

One of the devices in the early history of the brake, by which it was made more effective, was to cover that portion of it which touched the wheel—the sole, in fact—with several thicknesses of strong leather. This material may be said to have been used generally before the days of railroads. With the latter highways came heavier loads, moving at a higher speed. This required more effective application of the brakes. The heat resultant from this required not only that the shoe should be of metal but also the parts connected therewith.

Many different kinds of material have been used in connection with the brake shoe, according to the needs of the service and the skill of manufacturers. In the case of railroads the brake shoe is usually made of cast or wrought iron; sometimes of cast steel, or combinations of iron and steel, wood, leather, even paper. It is very desirable, in order to secure proper application, that the material, whatever it is, should be uniform.

An expert on the subject of brake shoes for railroads, a man of high intelligence and a successful manufacturer, writing on this subject, says: "The same air pressure throughout a train of cars on which shoes of different hardness are used, will apply a widely different friction on the wheels of the different cars. It is then impossible to obtain the maximum braking power for hard shoes without sliding those wheels to which soft shoes are applied. It is desirable to fix upon a standard mixture for foundrymen making cast iron brake shoes. Brake shoes are made for three kinds of service: on chilled wheels, on steel tired driver wheels, and on steel tired coach wheels. Those designed for the first mentioned service are made of cast iron, or cast iron with wrought iron pieces in the face, or cast iron with chilled sections. . . . When cast iron is used a strong, tough metal soft enough to grip the wheels is economical, although its first cost is greater than a burnt grate bar scrap mixture. A mixture of number two foundry car wheels and heavy cast scrap has given good results. The combination cast and wrought iron shoe is much more durable than the plain shoe, and more desirable in respect to uniformity, because the same amount of wrought iron, forming one-half the surface of each shoe, will be nearly of the same hardness. . . . When two surfaces rub together the harder will abrade the softer and the latter wear away quicker, but we are limited in the hardness of the shoes by the co-efficient of friction necessary. They must be of a uniform hardness, sufficient to grip the tire without scoring it, and afford friction necessary to make the stops. It is evident that for the different classes of engines different kinds of shoes will be required. The suburban passenger engine, making frequent stops, should be equipped with shoes less hard than applied on a through passenger engine. The combination cast iron and steel shoe has the advantage that the proportion of each metal may be varied to suit the requirements of the service. Brake shoes for steel tired coach wheels are applied under entirely different conditions. They are made either plain or flanged. The plain cast shoe should be soft and tough. Whatever kind of metal is used in the flange coach shoe, care should be taken that the shoe is a good fit to the tire, and so hung that the flange grooves in the shoes are directly opposite to the wheel flange, and above all that the brake beam be free to move laterally as the wheel and axle move. Experiments have proved that a brake beam hung rigidly from the truck, in combination with the flange brake shoes, forms a grinding machine capable of turning a V-shaped flange, and that even with the plain shoe, lateral motion is of decided advantage in protecting the flange."

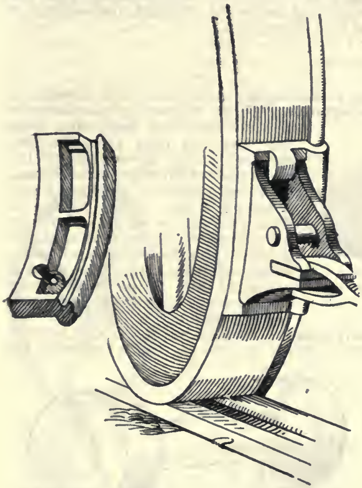


Illustration of the Brake Shoe and its application to the driver.

In connection with the use of the brake shoe, it may be said that its application to the flange of the wheel was not discovered until long after it had been applied to the tread. This application was a new departure and a valuable one in many directions, as it added, it is manifest, greatly to the power of the brake. Its importance will grow with increased use and ability to handle it. The application of the flanged brake shoe to the drivers of locomotives is general. This because the flanged brake shoe tends to keep both tread and flange in the original form and by reason of the additional grip over the flange. One objection that has been made to the use of the flanged brake shoe on cars is that its use in connection with the tread creates a pressure so great that the wheel is inclined to slip. This, it is apparent, is not so much an objection to the brake as a lack of proper adjustment of the power that manipulates it. It is claimed by manufacturers of flanged brake shoes that where the device is not used the tread wears away, while the flange of the wheel remains the same, thus creating a dangerous disparity.*

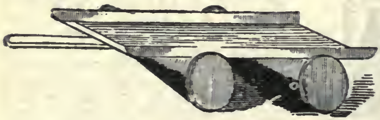
CAR WHEELS—EVOLUTION OF THE WHEEL.

In what I have to say in regard to car wheels, I shall not seek to exhaust the subject. The particulars of their construction and the details of their application are all the time undergoing change; that which represents the highest degree of excellence to-day may be obsolete or greatly modified to-morrow. What I have to say, therefore, is in the order of sequence merely: explaining what has béen done without seeking to point out what yet may be accomplished. And as men are better able to understand what they see by knowing what others have seen, I shall trace briefly the evolution of the wheel. To know the origin and history of a thing is to make us in sympathy with it, and more likely to comprehend its peculiarities than if we know it only in its perfected state. This is the excuse I have to make for the habit I oftentimes

*Further reference to the brake shoe will be found elsewhere, under the head of "Car Wheels—Evolution of the Wheel."

indulge in of sketching a subject from the beginning: getting its prospectus, so to speak. But I do not seek so much to go to the very root of the thing as to excite interest in it. This is the more necessary in the case of subjects that belong to the commonplace. Thus, the wheel of a vehicle, whether of a railway car or a wagon, is a very commonplace thing. But when we trace its history, follow in our minds the ages of evolution it represents and the struggles of men through all their history to perfect it, we find the subject is not so dull nor commonplace as we at first thought.

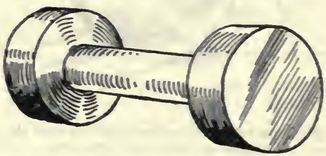
The wheel, above all other things, is the key to the vehicle and, therefore, next to power, the central idea of the art of carriage. In tracing its evolution for the last five thousand years we discover that from its first conception its development has kept pace with the needs of men and the highways 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 what 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.

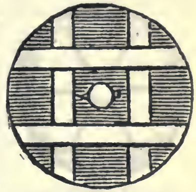
This form of wheel and axle, amplified in detail, is still to be found in use in out of the way places on the frontier of new countries and in the forests and mines of the world where great burdens are to be borne for short distances. It was, however, for many ages the only device known. The Aryans, as we learn from philological sources, had acquired the art of separating the wheel from the axle before they were scattered, many centuries before the historic period. For a long time after the wheel and axle were made a part, 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, as much diversity existed in the construction of wheels as in the present period. Progress in our day seems to be centered in the wheels of cars and locomotives. In other fields, while there are widely different degrees of elegance and strength, new methods of construction are scarcely noticeable. We have the same hub, spoke, felloe and tire as our fathers. But in olden times, when the wheel was in process of incubation, constant evolution was the rule. 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 cross bar, then with two, and so on.



The First Form of Axle and Wheel.

A Primitive Wheel.

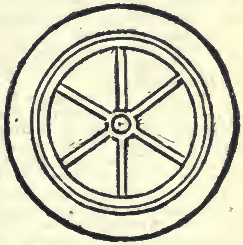
It is a curious fact that with the advent of the railway, the highest form of carriage known, the axle and wheel should again be made to revolve in unison, as in the very dawn of intelligence among men, when the axle and wheel were but a solid piece of wood. The ingenius manner in which the body of the 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 our common road cart does. But so much greater advantages were to be secured by the revolution of the axle and wheels together that the latter plan has, as a matter of fact, superseded the other.


Wheel of an Ancient Roman Cart.

The wheels of the war chariots of the ancients were at first solid; oftentimes made of bronze. The conception of a division of the wheel, substantially on the lines of to-day, for road carriages and wagons, was a tremendous 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 the wheels of chariots and carts.


Ancient Four Spoked Chariot Wheel of the Egyptians.

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.

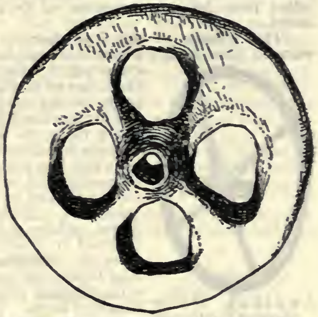

Ancient Wheel.

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, upon the strength and proper working of which the security, oftentimes the life, 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 busily constructing the different parts of the wheel and fitting them together. And, while their work was exceedingly rude, yet the tremendous strain to which the vehicles were put shows that they were strong and durable, and every way adapted to the needs of the times. One of these wheels 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 of the wheel in olden times, instead of connecting sharply as to-day, lapped over, the parts being riveted together.

Ancient Egyptian Wheel.

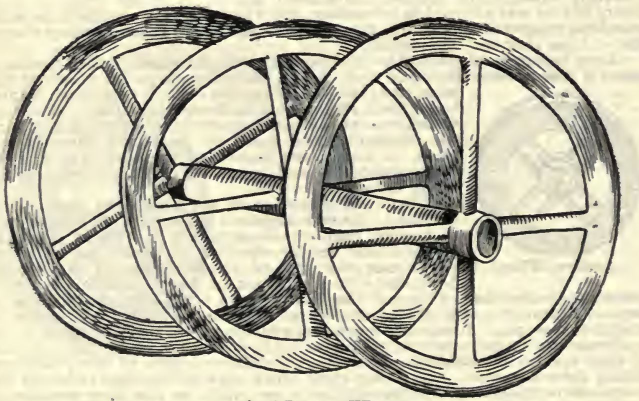
Among the ancients the chariot was the great vantage ground of battle. Victory, as a rule, depended upon the number of such vehicles in action, the skill with which they were handled, and the courage of the occupants. In order to make them more terrible, long, sharp scythes and knives were attached to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

Some very interesting discoveries have been made of wheels used in Germany and central Europe in pre-historic times. The more primitive of these seem to have been made lighter by cutting out the interior of the wheel, without materially weakening the structure. This form is exceedingly primitive, and suggests the inexperience and rude appliances of a far distant age.



Primitive Wheel from Germany.

Another exceedingly interesting discovery of pre-historic times made in the same locality is that of the axle on 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, from which, perhaps, two or even more men may have fought from the bed of the vehicle, on either side of the center wheel.



Ancient Bronze Wheels.

The illustrations we have of the war chariots of the Assyrians, the great warriors 800 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 the war incursions into the mountain districts, which were of yearly occurrence, 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 certain phase of evolution from the solid wheel to the spoke, it is impossible to tell. The lonely island where this wheel was found, lying fifty miles off the coast of the eastern Mediterranean, 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 surrounds it. Thus its fortunes have alternated many times. 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 appliances of earlier ages have been discovered. In the early history of the Assyrian Empire, and before it contemplated the conquests that at once aggrandized and ruined it, we have an account of an Assyrian king who, visiting the Mediterranean (they called it the Sea of the Setting Sun, because it was to the west and supposed to be the end of the world), made an excursion to Cyprus; afterward the island passed under the dominion of his descendants.


Ancient Wheel from the Island of Cyprus.

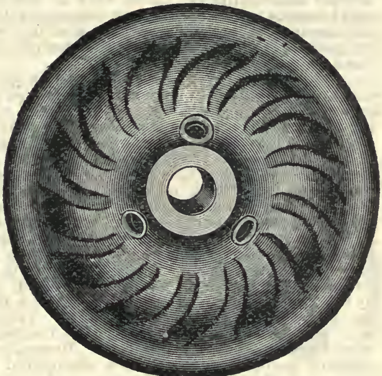
In Bulgaria an exceedingly primitive form of wheel is still to be found in use. The felloe, instead of forming a continuous ring, is disconnected, thus constituting a sort of octagon, as shown in the illustration. As it was in this locality that the wheel was first invented, greater advance might have 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 principles. Its comparatively uneven surfaces and disconnected sections are elements of weakness, and afford anything but an easy means of conveyance.


Bulgarian Wheel.

The spoke, felloe and tire represent the third great stage in the evolution of the wheel. With these perfected, we seem to have come to a standstill, but only, doubtless, to make some further great advance. At present we 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, and 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 is placed under the body of the car instead of at the side is that the width of the vehicle may not be limited by the gauge of the track.

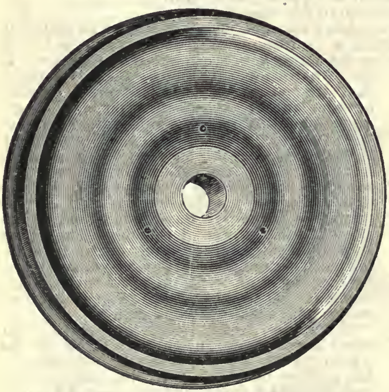
The form of car wheels in use in different countries is not the same, but it has in a measure adapted itself to the weight of the vehicle. But preconceived notions have been a governing force in shaping its form. The wheel in America is heavier than in England; we load our vehicles much heavier.



Cast Iron Freight Car Wheel.

Great business talent and experience are valuable in the making of car wheels; as much so as in the manufacture of any other article. 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), but in the constituent parts of the wheel; in its ability to withstand wear and tear and breakage; in the property of perpetuity it possesses, in fact.

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; this kept 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.



Locomotive Tender Wheel—Cast Iron.

Various kinds of car wheels have been devised; 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 to diminish the jar.

A common form of wheel is that made of chilled iron. It does not have a separate tire. There are different patterns according to the manufacturer's ingenuity. It is described more fully elsewhere.

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 manufacturer's phrase, may be "turned up" when the tread is worn and thus be made to do further service. Steel tired wheels are similarly treated.

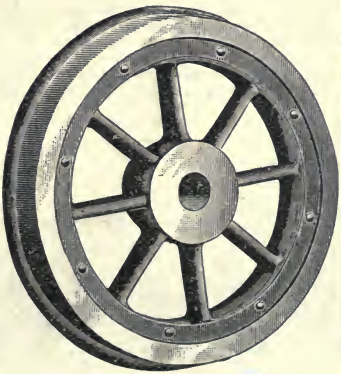
Car wheels were formerly keyed on the axle. A later plan is to make the hole in the center of the wheel a little smaller than the axle, into which the latter is thrust under pressure. The keyed wheel will become loose with use; the other will not.


Bearing.

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 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 wheels are more economical than any 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 passenger car wheels with success. A compressed mass of the substance is placed between the iron hub and steel tire, enclosed 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.


Locomotive Truck Wheel Made of Paper, with Cast Steel Center and Steel Tire.

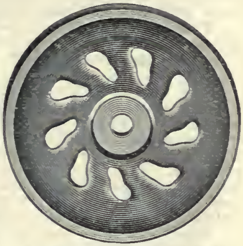

Sectional View of Paper Truck Wheel.

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 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 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

*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.

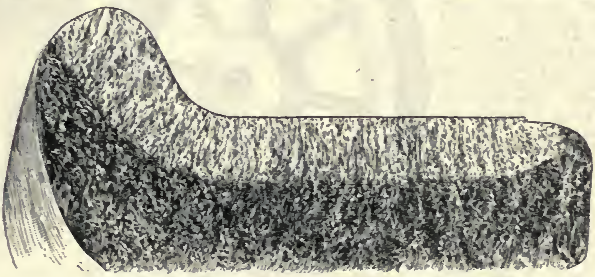
called 'chilling,' and it is upon this principle that the manufacture of chilled car wheels depends. This property of chilling, which certain irons possess, must have been known to iron founders at an early day, for we have evidence of the fact that parts of plows, faces of forge hammers, punches for 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 in a car wheel. 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. 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.



An Ingenious Form of Chilled Iron Wheel for Passenger Cars.

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



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.

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 is constructed 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 gentleman 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 must 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 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 crytalline 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.

While so far as outward appearance is concerned cast iron wheels are all alike, the resemblance is oftentimes 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

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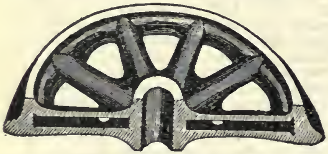
*The "annealing pit" referred to is oftentimes made of boiler plate iron, lined with fire brick and having an air tight lid, into which the wheels are placed while red hot and allowed to remain several days, after which they are taken out and further cooled before being cleaned, inspected and tested.

† 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 fire-brick 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."

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 every event in undue wear and tear.*

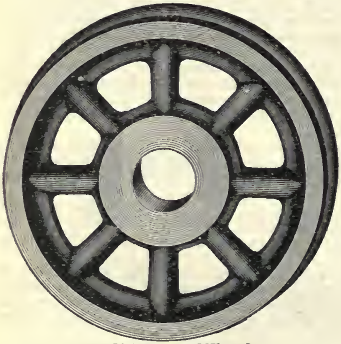
Single Plate Wheel.

Double Plate Wheel.

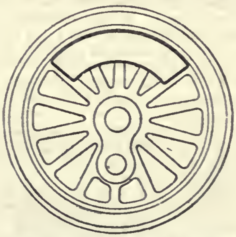


Hollow Spoke Wheel.

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 plate wheel in this, that should one of the plates break or crack the other has sufficient strength to hold the wheel until the defect is discovered.



Solid Spoke Wheel.

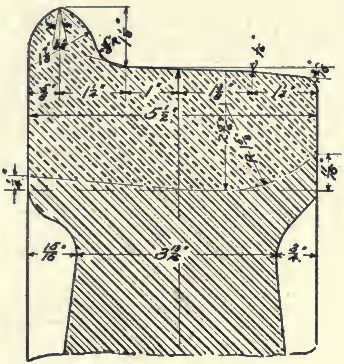


Locomotive Cast Iron Driving Wheel with Steel Tire.

*"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 weight of car wheels varies, but that of the standard thirty-three-inch chilled wheel is from 600 to 650 pounds.

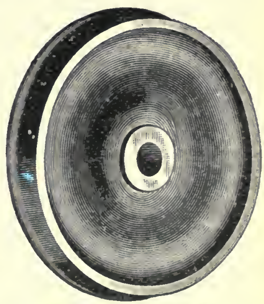
Steel tired wheels were at one time esteemed to be necessary to the passenger service of railroads; safer, in fact, than the chilled wheel. The latter has, however, been steadily coming into favor, with increased weight and improvement in manufacture, till it has reached a point where it is believed 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.



Section of Steel Tired Cast Iron Wheel.

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 journal 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 such as I have referred to. 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 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 first 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."

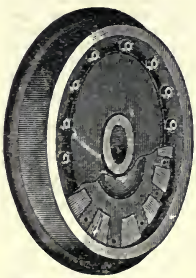
The practice of attaching the car wheels to the opposite ends of the axle

*Mr. E. L. Taylor.

makes the two wheels practically one, so far as movement is concerned, neither being able to move without the other. For this reason the two wheels must be alike in every detail of 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 depends, 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 former 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.

In 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.


English Car Wheel.

Englishmen 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.

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 is an assistant engineer of motive power of the Pennsylvania railroad company. 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 (what is probably the case) 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, 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 can not 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 can not 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 the 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, described elsewhere. 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, as it puts each on his metal. 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, it needs no argument to prove, speaks well for their general excellence. The proof of the pudding is in the eating, as 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 is still much less than tires made of Bessemer steel, which amount to five hundred and ten thousand, the first named shows an increase in the number used of two hundred and thirty-one thousand in the six years, while the Bessemer only shows 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, it may be said that 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 the iron. Steel

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*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.

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.

Taking up again the subject of the movement of trains, in which this volume is particularly concerned, an important problem is the marshalling of cars involved in the making up of trains. This work, as is known, is largely performed at junctions and other centers where the business handled is large. The work requires great systemization, as, in order to secure economical movement of traffic, it is necessary that through trains shall not be interrupted in their progress between important points. This necessitates the handling of traffic at intermediate places by way trains that collect the through business and carry it to the junctions, where it may be classified and marshalled into trains that will take it through to its destination. Many plans for the expeditious making up of trains are in vogue, including unique sidings and turntables of various devices and degrees of utility. I do not know that I can close this chapter more profitably than by describing the system of switching and marshalling of trains by gravitation as practiced on an English road. The arrangement is thus described by the manager of the line:* "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 'grid-irons'), 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." The system of switching thus described grew out of the peculiarities of the ground and the impossibility of selecting any other. The emergency suggested the method of switching described. Its more general use in the future is likely to grow out of the experiment.

*Colonel Findlay.

HEATING CARS—ITS EVOLUTION.

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.

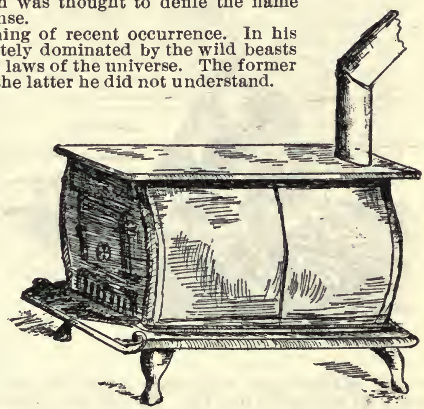
The temple of Vesta, the Roman goddess of fire, stood near a fountain, thus affording the people convenient means for procuring both fire and water. When from any cause the fire in the temple of Vesta became extinguished, all public and private business ceased. The people believed that the connection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

The opinions of primitive peoples regarding the nature of fire as it appeared on the hearth, they also applied 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 purile 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 sentiment. 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; thus 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 home or 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.

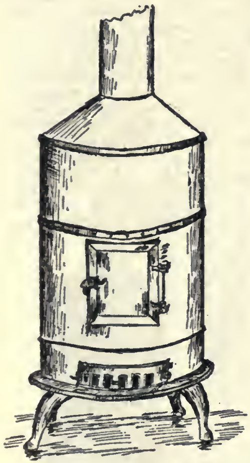
Man's superiority is a thing of recent occurrence. In his earlier stages he was completely dominated by the wild beasts of the forest and the natural laws of the universe. The former he could not overcome and the latter he did not understand.

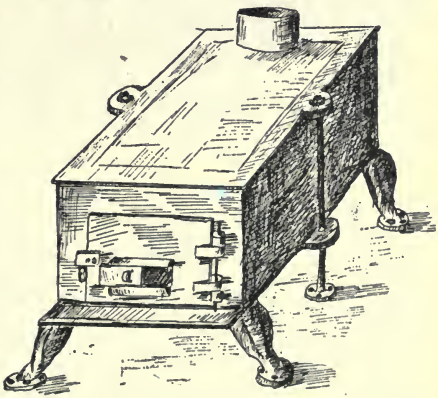


The practical uses to which we put fire were not recognized in the early history of the world. In the first instance men did not cook their food. This effeminacy came long after, when man had emerged from savagery. When men first began to use fire for purposes of warmth and cooking it was lighted on 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 opening and closing doors. The fireplace with its attendant chimney to carry off the smoke came later; it 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.

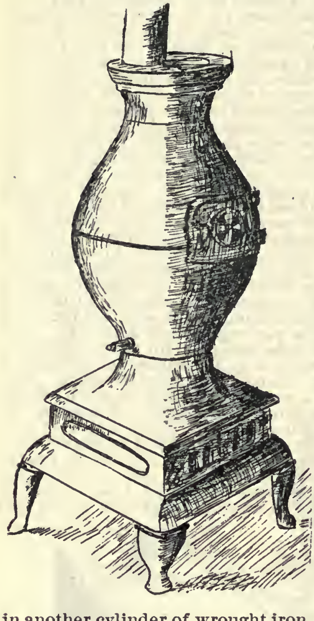
In the evolution of man many different uses have been made of fire. It has been both a religious and a superstitious symbol; an object of worship; religion itself. Then again, the badge of leadership and sovereignty. Its highest use among the ancients was that of a diety or protecting genius of the domestic heaith. It is only in modern times that its greatest good to men has been utilized, 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: 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 passenger 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 of fire in cases of accident and questions of ventilation also intervene.

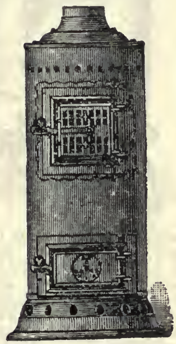
With the introduction of the system of heating by steam from the engine the difficulties of the situation were sensibly lessened. Indeed, so great has been the progress in this direction that it seems as if perfection had been reached. But here, as in every other department of affairs, we shall quickly 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 no provision whatever for heating cars or affording warmth of any kind is necessary. In the northern States of America careful provision is made. 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. Their progressive steps evince this and the perfected methods they employ to-day 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, in a measure, 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.* 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 from 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.† 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 and highly valuable 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. Among the best of these was that known as the Baker system.‡ In the Baker heater a hard coal fire was kept in each car. 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 also run up to and





Modern Coal Stove for Heating Passenger Cars.

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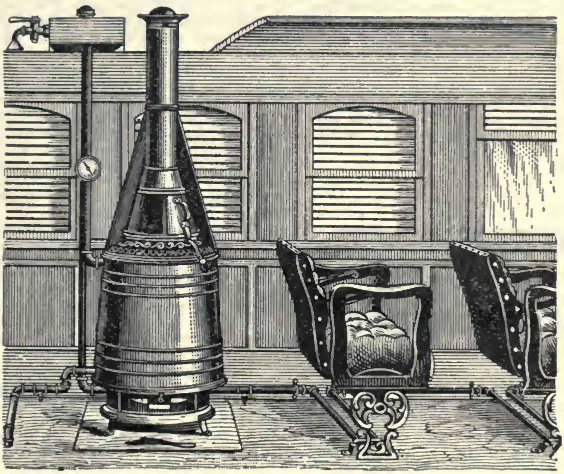
*In localities where crude oil is abundant and cheaper than wood or coal, and facilities have not been provided for heating cars from the locomotive by steam, it may be, and indeed is, used more or less for heating purposes in stoves especially adapted therefor.

†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 up 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 can not 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.

‡I speak of it in the past tense on the presumption that, in the main, all cars will finally be heated from the engine or other extraneous source; that fire will not, in fact, be allowed in or about a car in which passengers travel. This will be a long time, doubtless, as many carriers can not afford the expense at once.

down from a drum on top of the car and then extended the entire length of both sides of the car about six inches from the floor. The iron drum on the roof was an air and water reservoir; the lower half contained five or six gallons of water, the upper half affording 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



The So-Called Baker Heating System.

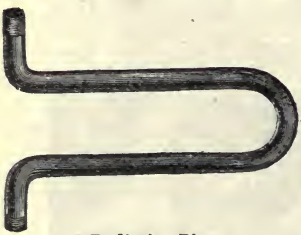
escape in case the pressure exceeded a certain limit. The condition of the fire was ascertained by an indicator attached to one of the perpendicular pipes in the car. The danger arising from freezing was prevented by the use of salt in the water. For this purpose a fine dry salt was used and as much 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 in the Baker heater may 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 Baker heater proper. An increase of the average temperature of the pipes throughout the car is also obtained and in a much shorter time.

Steam generated in and applied from the locomotive is recognized as among the best forms 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 boiler 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 certain portions 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. Thus, when the passenger enters the car he finds it as cozy as a drawing room.

Another method of heating was known as the hot water circulating system, by which the cars received their heat from steam carried through a train pipe. Dry steam was 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 was injected directly into the body of water to be circulated. The circulation was aided by the action of the steam causing a motion of the water. Rapid circulation caused 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 one 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 it 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 is 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 reuniting again in one blow-off cock. 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, a safety valve and a 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 open 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 were 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 adequate provision of this nature can not be overestimated, as its effect is to escape the unavoidable negligence of individuals when their duties require them to look after matters of this kind. Provisions of this nature, like safety appliances, to be effective under all circumstances must be mechanical and self-acting.

How far it will be practicable to use electricity for heating purposes is unknown. It is, however, applied 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 the electric lamps. The practicability of electrical heating has not, up to this time, recommended itself generally in the case of railroads operated by steam.

Such are some of the methods, primitive and otherwise, employed in heating passenger 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 merely to familiarize the reader generally with the matter. Only a very few railway people know anything about the subject, while it is important that it should be understood in its wider aspect by every one connected with railroads. As safe and scientific methods of heating cars come to be better understood and the financial means of railway companies permit such forms to be introduced they will be everywhere adopted. It is a question of means. Such forms of heating are luxuries and, like other luxuries, only those who are well-to-do can afford them. The poorer companies will continue to employ primitive methods.

LIGHTING CARS—ITS EVOLUTION.

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. Men are ever loth to make changes. It involves 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.

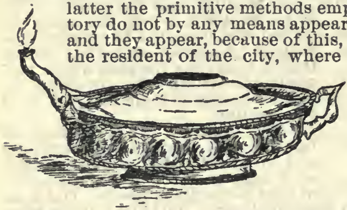
The demand for a method of lighting that shall be safe, brilliant and unobjectionable, is the outgrowth of a high and exacting civilization; of ever multiplying needs. Our forefathers were content with candles and rude oil lamps. But the esthetic taste of our time demands something inoffensive and that shall, moreover, correspond as nearly as possible to 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 towards 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.

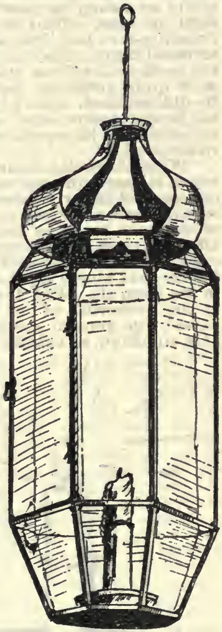
The torch of Agamemnon's time was succeeded in Greece by the oil lamp, which was used at an early day where permanent lights were kept. It came into domestic use in Greece about four hundred years before the Christian era. The lamp was made of terra cotta with a spout or nozzle for the wick and an orifice 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 denizen 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 every-day life. It is because of this, as well as partly to portray the evolution of means of lighting, that I embody pictures of primitive methods here. However, these methods are still more or less in use in lighting cars in remote districts.

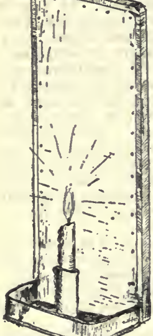


In the early history of railroads and, indeed, to a certain extent, at the present time, all sorts of quaint methods were employed for lighting cars. Upon one road an old-fashioned lantern hung from the ceiling; on another, candles in primitive holders cast a faint glimmer from the sides of the car. 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 supposed 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 a good oil. But proprietors were not then aware of deficiencies in material 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.*

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 train men 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 a high grade of railway service.

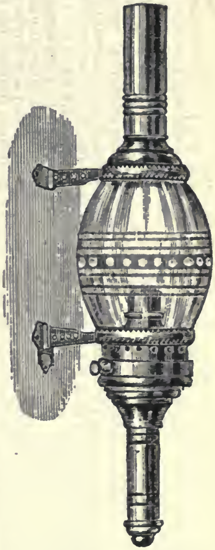


Vegetable oils are used in cases where refined petroleum is difficult to obtain. Rape seed oil, it is probable, has been put to this use more often than any other. Colza,

*By candles, vegetable oils, mineral or petroleum oils, ordinary coal gas, carbureted coal gas, "rich" or oil gas, carbureted air, electricity, and so on.

oil derived from a variety of cabbage, has also been used for lighting cars in some instances.

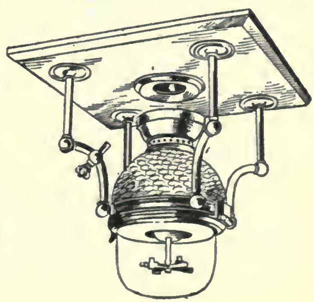
The common form of mineral oil lamp in general use consists of a reservoir of oil from which a wick passes out through a tube. The oil is drawn by capillary attraction through the wick to the top, where it is lighted. The flame is brightened and kept from smoking by a current of air against its surface. 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.



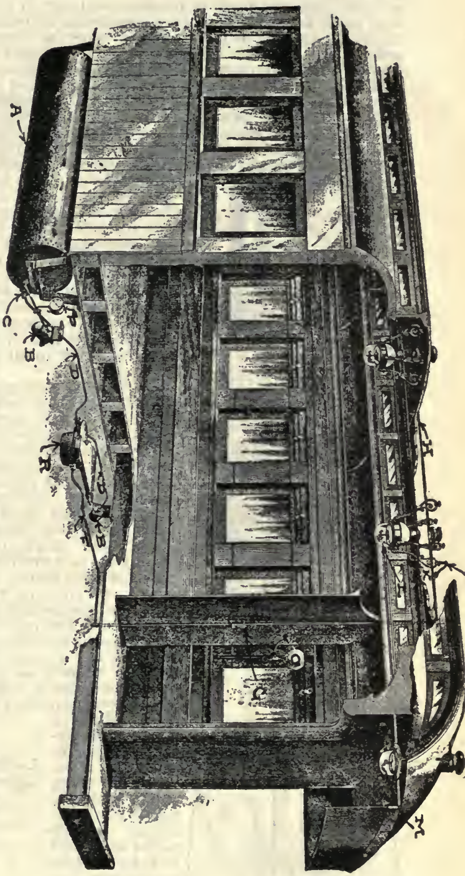
Lamp for Candle.

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 easily studied in the accompanying illustration.



Pintsch Gas Lamp.



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

*A carbureter is made of cold rolled copper about one-sixteenth of an 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 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 entrusted 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 operated by steam from the locomotive. If, however, for any cause, the latter can not 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 believed to be only a question of time. We know that it is possible to thus light cars because there are many trains made

Carbureter.

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.

*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.

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 can not 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.*

Mr. Gibbs, the gentleman quoted, has not found the use of electricity practicable on trains having short distances to run or when cars are to be taken on or detached along a route. He 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 are 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 prac-

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*Mr. George Gibbs, M. E., who has given the subject careful study, and from whom I have derived much information in regard to the practical use of electricity on railway trains, gives the cost of Equipment for different classes of cars as follows:

"Baggage car, including engine, dynamo, switchboard and wiring	$1,250.00
Sleeping car	245.00
Coach	127.00
Drawing-room car	311.00"

The Running cost per trip of four hundred and thirty miles he estimates as follows:

"Attendance on train	$2.62
Supervision	.62
Lamp renewals (two at 40 cents)	.80
Oil and waste	.22
Miscellaneous supplies and labor	.20
Coal to produce steam for light	87
Interest and depreciation at ten per cent. per year on cost of train equipment	.87
Total	$6.20
Or, per car, per day	88 cents
Per car, per hour	6.3 cents"

The above estimate is figured on a seven car train; if a longer train were taken, the cost per car-hour would not be correspondingly greater. The allowance for attendance covers one-half the wages of two men, the other half being charged to care of baggage. This division for labor he holds to be fair, as previously the same number of baggagemen were run on these trains at the same wages. Two men are allowed per train on account of the length of the run, which requires a double staff.

The above figures do not presuppose the use of a special car or boiler to furnish power for the engine. They are based on the supposition that the power is furnished from the locomotive.

tice 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 too expensive for lighting purposes. Other companies confined 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 unsuccessful, and have resulted 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, it is apparent, 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 eletricity 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 300° F. fire test; a Fixed Gas; and Gasoline of 80° 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 of 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 300° F. 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 our experience is so slight, when compared with oil lamps and compressed gas, that definite conclusions can hardly be drawn. We lack knowledge. Several years ago, 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 300° F. fire test oil or from compressed oil gas. As regards safety, it is acccepted 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 here is dependent, as in other cases, somewhat upon the nature of the lamps. They may be very elaborate or simply commonplace. The figures given are for the latter. 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 can not 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.

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*Allowing for six double chandeliers or their equivalent in single burners, the first cost is said to vary from $115.00 to $225.00 per car.

†The cost of the oil gas fixtures and appurtenances complete for a car, with one receiver, is in the neighborhood of $300.00, affording five four-flame lamps, each flame being equal to seven and one-half candles.

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 also be made for damage resulting 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. Mr. Gibbs, to whom I have already referred, has been at considerable labor to ascertain the approximate cost of the different systems of lighting. That for electricity I have already given. The company employing him uses electricity and it is this light, consequently, he favors. However, I have no reason to suppose his investigations have not been impartial and that his figures are not accurate so far as he can determine.* Any account representing the cost of systems of lighting, either as regards preparatory work or expense of operating, it is apparent, is not to be accepted absolutely because of the fact, as already stated, that cost is dependent upon facilities and other circumstances. For this reason figures must be considered as approximate merely. Moreover, in describing particular systems it must be remembered that so many changes are constantly going on that conditions are liable to change at any moment. A treatise, it is apparent, therefore, whether it professes to particularize or not, must be accepted rather with reference to the general information it affords than as final or conclusive in particular instances.

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*His estimate of cost for a year is as follows:

SYSTEM.	First cost of plant per car.	Depreciation.	Fuel supply.	Cleaning and other supplies.	Total yearly cost.
Oil lamps..................	$167.00	$16.70	$18.25	$11.61	$ 46.56
Pintsch gas: For car..... Fixed.......	370.00 182.00	64.30	22.45	6.02	92.77
Frost carbureters.........	536.00	80.40	38.11	12.26	130.77

APPENDIX E.

(For particulars in regard to brakes and their application and evolution, see page 148.)

THE WESTINGHOUSE FORM OF AUTOMATIC AIR BRAKE.

The Air Pump consists of an air compressing piston in the lower cylinder driven by direct connection with the piston of a steam engine in the upper cylinder. The air is delivered to the Main Reservoir.

The Pump Governor closes the steam pipe leading to the pump when the desired maximum air pressure is attained, and opens the steam pipe again when the air pressure has been slightly reduced, so that no attention is needed from the engineer.

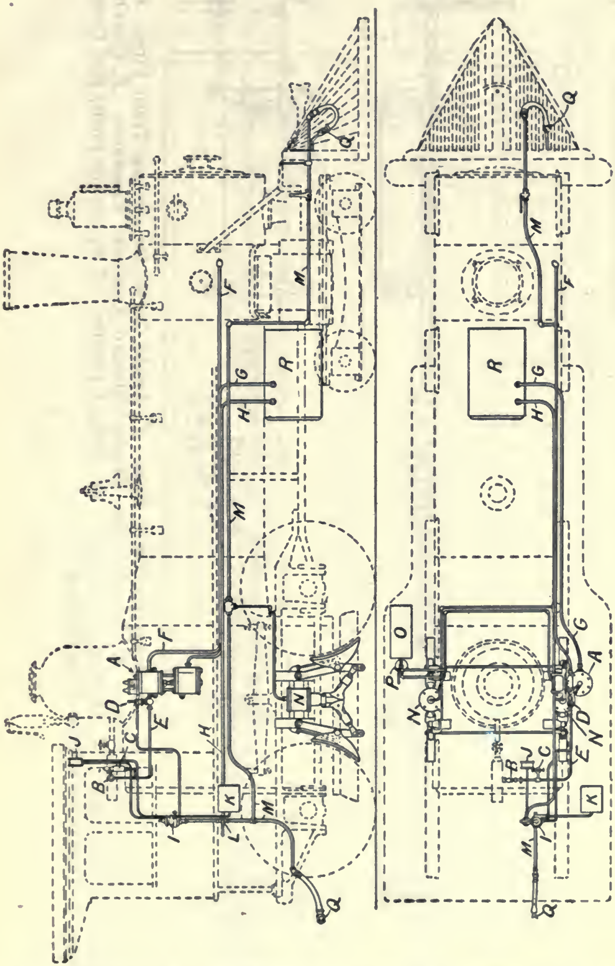
The Engineer's Brake Valve is manipulated by the engineer as desired to open communication between the main reservoir and the train pipe, or to close this opening and open the train pipe to the atmosphere when the brakes are to be applied.

The Triple Valve contains a piston engaging by a stem with a slide valve for opening and closing ports. The outer side of this piston is exposed to the train pipe pressure and the side towards the slide valve is exposed to auxiliary reservoir pressure; it is moved one way or the other by a slight preponderance of pressure on either side. When train pipe pressure is greater the piston and slide valve are moved so as to open a small port from the train pipe to the auxiliary reservoir for charging the latter, and a larger port from brake cylinder to atmosphere to release the brakes. When auxiliary reservoir pressure is greater, the piston and slide valve are moved in the opposite direction so as to close both the openings above mentioned, and then to open a passage from the auxiliary reservoir to the brake cylinder to apply the brakes.

The normal condition when running, is with the main reservoir, train pipe and auxiliary reservoirs charged with compressed air and the brakes off. A reduction of pressure in the train pipe by escape to the atmosphere at engineer's valve, or at the conductor's valve, or by the bursting of a hose or other breaking of train pipe, applies the brakes. A restoration of pressure in the train pipe from the main reservoir by proper moving of the engineer's valve, releases the brakes and recharges the auxiliary reservoirs for further use.

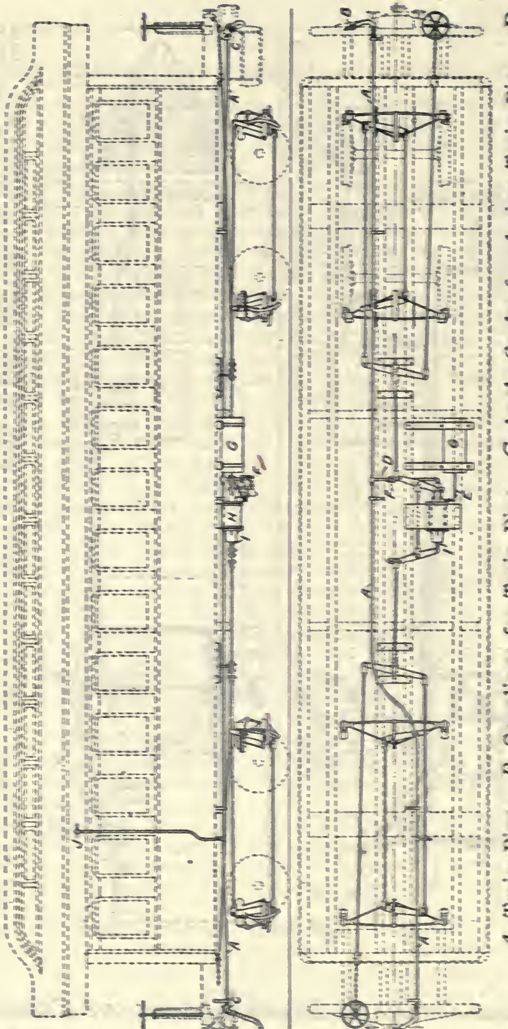
The Cut-Out Cock in the branch pipe and the Release Valve on auxiliary reservoir are for use only when the brake on any car is out of order and must be cut out of service. The Release Valve is for releasing the brake on that car in such case by bleeding the auxiliary reservoir.

The Pressure Retaining Valve is connected by a pipe to the exhaust port from the brake cylinder. It is left wide open for free escape of air ordinarily, but is set by hand before descending long, heavy grades, so as to retain ten pounds pressure in the brake cylinder, and thus keep the brake slightly applied while recharging the train.



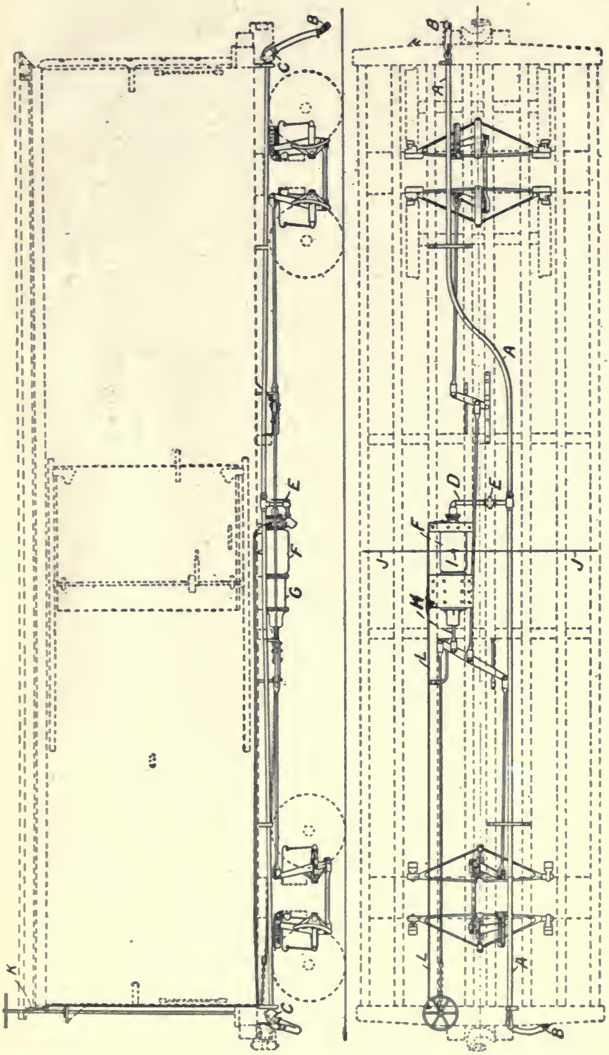
A, Air Pump. *B*, Steam Valve. *C*, Oil Cup for Pump. *D*, Pump Governor. *E*, Steam Pipe to Pump. *F*, Exhaust Steam Pipe. *G*, Air Delivery Pipe from Pump to Main Reservoir. *H*, Air Pipe from Main Reservoir to Engineer's Valve. *I*, Engineer's Equalizing Brake Valve. *J*, Air Pressure Gauge. *K*, Equalizing Reservoir for Engineer's Valve. *L*, Cut-Out Cock in Air Pipe under Engineer's Valve. *M*, Train Pipe. *N*, Driver Brake Cylinders. *O*, Auxiliary Reservoir for Driver Brakes. *P*, Triple Valve for Driver Brakes. *Q*, Couplings for Train Pipe. *R*, Main Reservoir.

WESTINGHOUSE AUTOMATIC BRAKE, LOCOMOTIVE EQUIPMENT.



A, Train Pipe. *B*, Couplings for Train Pipe. *C*, Angle Cocks for closing Train Pipe. *D*, Branch Pipe to Triple Valve. *E*, Branch Pipe, Triple Valve to Auxiliary Reservoir. *F*, Cut-Out Cock in Branch Pipe. *G*, Auxiliary Reservoir. *H*, Brake Cylinder. *I*, Piston (or Push) Rod Cross-Head. *J*, Conductor's Valve for applying brakes.

WESTINGHOUSE AUTOMATIC BRAKE, PASSENGER CAR EQUIPMENT.



A, Train Pipe. *B*, Couplings for Train Pipe. *C*, Angle Cocks for closing Train Pipe. *D*, Branch Pipe. *E*, Cut-Out Cock in Branch Pipe. *F*, Auxiliary Reservoir. *G*, Brake Cylinder. *H*, Push Rod. *I*, Release Valve. *J*, Operating Rod for Release Valve. *K*, Pressure Retaining Valve. *L*, Pipe to Pressure Retaining Valve.

WESTINGHOUSE AUTOMATIC BRAKE, FREIGHT CAR EQUIPMENT.