ontispiece.

THE SCIENCE OF RAILWAYS.

FINANCING, BUILDING

AND

MAINTAINING.

Capitalization, Location, Building and Keeping Up of the Organization and Property of Railroads and the Economic Questions Surrounding these Subjects —Magnitude of the Interests Involved and their Intricacy and Vast Importance—Influences, Purposes, Principles and Methods that Govern.

WITH ILLUSTRATIONS

OF THE

Inception, Growth and Evolution of

PRIMITIVE TRANSPORTATION.

BY

MARSHALL M. KIRKMAN.

IN TWELVE VOLUMES — VOL. II.

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PRIMITIVE CARRIAGE.

The illustrations of primitive carriage contained in this and the accompanying books will excite various degrees of interest. But in regard to one phase of the subject I think there will, in the end, be no difference of opinion, namely, that in picturesqueness and variety of method the carriers of India surpass all others of the world; the architecture of the country; the peculiar character of the people, their dress, habits and picturesque means of transportation, make India a never ending panorama of beauty and variedness. The magnificence of the elephant as a carrier adds to the beauty and impressiveness of the scene. The camel, while less impressive, in his trappings and leonine aspect divides with the elephant our admiration and never ending interest. Even the cattle used in India as carriers are different from others in conformation and stature; they vie with the horse not only in size but as travelers, being able to draw the same load as he and keep pace with him on the public highway. From whatever standpoint we view the native of India, he is interesting, picturesque and unique.

Directly the reverse of India, Africa is the least varied in its methods of carriage; there primitive forms peculiar to savage peoples still generally predominate, and it is to Africa, consequently, that we must go to find in its most perfect state the germ of transportation. Here the labors of carriage that are elsewhere performed by animals or the mechanical contrivances of man, are still borne by men and women. In every country, however, it will be observed, primitive methods of transportation are still more or less practiced; but the burdens are light and the service local. In the interior of Africa, however, all the drudgery connected with the carriage of passengers and goods, far and near, is borne by men and women.

In the ten volumes that succeed this, the reader will find the Illustrations of Primitive Carriage to grow in number and interest. Nearly a third of a century has been occupied in making the collection of these beautiful pictures.

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SCIENCE OF RAILWAYS.

CHAPTER I.

CAPITALIZATION—BASIS AND METHOD OF CAPITALIZATION.

The risks that attend the investment of capital in new railroads or the improvement of old ones where the return is doubtful, enforce abnormal rates of interest. The discount suffered in disposing of securities under such circumstances will depend, as in other cases, on the plentifulness of money and the probable productiveness of the property, the latter being under rather than over estimated. When money is scarce or the security doubtful, or the temper of the people unfriendly, the rate of interest on railway securities will be high and the price that they will bring will be low.

The influences that affect the capitalization of railways are very imperfectly understood, and the methods that it has been necessary to follow in order to secure the money needed in the construction of these enterprises have been, and are still, severely and unjustly criticised. Criticism is not confined to any particular country. It is

Carriage in Africa.

the common property of idealists everywhere. The practical realities of life never conform to the illusions of these people. They approach business propositions in the spirit that a child does the construction of a block house, or the mathematician the solution of a problem wherein the processes are preconceived and the result always the same. The necessities of business and the compromises of conflicting interests they know nothing about and do not regard; different circumstances and surroundings are as if they were not; the peculiarities of men and the requirements of capital cut no figure in their child world. It is their happy fortune to be always superior to facts. They live in a Utopia, a world quite apart, where men are not led to achieve results because of a love of money, but are animated by a lofty public spirit; a world where mankind labor for the public good while their children starve. This class comprises a large number, but not all who criticise railroad corporations. It looks upon itself as a public guardian. To it the acquisition of wealth in railroads is treated as a misfortune and not a thing in which the people equally share. It speaks of railway corporations indifferently as extortionists and railway managers as robbers. It does not recognize that owners have either wisdom or honesty. Naturally, it is a warm advocate of public interference, public supervision, public regulation.

Generally speaking, the capitalization of railways represents their cost, neither more nor less. It includes commissions paid, interest during the period of construction, and discount suffered on the securities sold. If the credit of a company is such as to enable it to sell its securities at a premium, the amount realized goes to reduce capital.

Cost per mile varies greatly upon different roads; the extent of a property, it is apparent, depends on the industrial character of the country and the traffic to be handled. Cost is especially affected by alignment, grades, price of material, labor, sidings, amount of equipment, and right of way. Many items of cost are affected favorably or otherwise by the nearness or remoteness of markets. How far, if at all, a company may issue shares to its owners at par to cover construction work, when such shares command a premium, is a subject about which men differ. In some cases the practice is followed; in others it is forbidden by law.

The relative increase of capital account per mile since the inauguration of railways has been much greater in England than elsewhere. This is attributable partly to extraordinary outlays for new facilities at terminal points and partly to large investments in collateral enterprises. The comparatively small increase in the United States is owing, in a measure, to the fact that much of the construction work has been paid for out of earnings and has not yet been capitalized. In other words, profits instead of being divided in full among owners, in the shape of dividends, have been used to make improvements.

The basis of capitalization of railways is cost. If America has departed from this rule, it has been on the safe side, on the side of reduced capitalization. Of this there can be no doubt, theories and general impressions to the contrary notwithstanding.

In reference to the methods of raising money for the construction and improvement of railway properties, they vary so greatly that it is hardly worth while to attempt a description of them. Railways are, however, coming more and more to be built under the subvention of companies already well established. These latter are guarantors. In many instances they issue their own securities, hypothecating those of the new enterprises. Thus the latter receive the benefit of the credit of the established company.

The importance to be attached to statements and estimates of the cost of railroads to be built and their probable productiveness afterward, depend upon the Character and Experience of the men making them, the location of the property, and the care with which surveys are made. It is not an unusual thing for cost to be double or treble the estimates, thus compelling those who have provided money to put up the added amount in the hope of saving that already furnished. Investors should, therefore, always scrutinize the character and practical knowledge of men back of railway enterprises.

To be of value, estimates of cost must be made by capable and responsible engineers. Abundance of time must be taken. Men of entirely different experience and talent are required to forecast the future of properties. It may be done with reasonable accuracy. The many instances in which estimates of cost and forecasts of business have proven delusive should teach those having money to invest in enterprises of this character to exercise circumspection.

The value of the securities of prospective railways, unless guaranteed by a stable concern, is always more or less a question of doubt. Such properties are largely speculative, and like all speculative enterprises must be liberally discounted. They should never come within the domain of those who can not risk the loss of a part or the whole of their capital. They afford a field only for capitalists and others who are able to assume such risks. The extent of the risk run in the past, in the United States, may be seen in the number and character of bankrupt and unproductive railroads. The number of promoters and speculators who by specious arguments and false representations, have induced the people of Europe to invest in worthless railway securities in the United States, can hardly be counted. The result has been highly disastrous to the credit of the country and an enormous injury to the people who have placed confidence in their statements.

Up to this time little has been written about railroads by those familiar with their practical working. Men engaged in railroad work have but slight taste for such matters. Theorists have occupied the field. A few phases of railway administration, such as pools, accidents and rates, they have been able to grasp. They do not, however, confine themselves to such subjects. They are cosmopolitan. Each has his theme, each his particular subject. He sees in it, however, the all in all of railway life. One finds it in heightened facilities; another in abolition of class privileges; another in better protection of life; another in lower charges; another in more stable tariffs; another in the abolition of traffic distinctions; another in the abolishment of passes; another in government supervision; another in government ownership; another in the the enforcement of agreements between railroad companies; another in restricted railway construction; another in prevention of fictitious capital; another in securing more adequate returns and accounts; another in better management; another in prevention of speculative tendencies on the part of owners; another in greater interest in the welfare of railway employes; another in curbing the prejudices and passions of the people; another in preventing hasty and inconsiderate legislation. The subject is an endless one. Each writer pursues his theme with fervor amidst the acclaim of friends and ignorant lookers on. All these writers are, in the main, honest; all are fully assured of the efficacy of their panacea; each believes it to be the thing necessary to enforce efficient service, shield the innocent and punish the wrong doer. The most of the views thus put forth are empirical. They take no account of the restorative qualities of nature, of natural adjustment. A doctor is necessary! Wherever their advice is followed bad matters are made worse.

Zulu Carrier.

Every fault in railway administration contains within itself the germ of its own cure by natural means. When thus the cure is effected, it is equitable and lasting. Railway critics will not, however, await so slow a process.

The capitalization of railway property has always been a favorite theme with writers and speakers. It has not been necessary for them to know anything about the subject; they have had simply to cry injustice, fraud, wrong! However, the capitalization of holdings in railway property has been based on equitable and business grounds. The exceptions are unworthy of notice. But they have differed as widely as the practices of men in other matters. Thus, owners of railroads have differed very much in regard to the disposition they have made of their surplus revenue. In Europe it has been very generally the rule to divide it among the proprietors to the last farthing, every cent spent for construction being capitalized so that it may return something to the owner from the start. In the United States it has been very generally the custom of railway companies to invest a portion of net earnings in needed additions and improvements. In some cases this is capitalized, but more often not. Such use of a company's surplus is, however, always in the nature of a loan. In making it, the owners clearly do not relinquish the right to recall it at pleasure; do not relinquish the right to capitalize it whenever their interests will be benefitted thereby. Loose and ignorant writers sweepingly designate increased capital of this kind as watered stock. This is wrong from every point of view. Its immediate effect is to greatly injure the owners of railways in the minds of the public. They are blamed for the actual benefits they confer on the community. These and kindred facts suggest the need in the United States of a self respecting class which will frown down unwarranted criticism of railroad corporations with the same spirit that they would condemn efforts to destroy the credit of merchants, manufacturers and banks. The result is equally bad.

The era of railway construction has been one of perpetual change, of financial evolution; periods of great prosperity, succeeded by expanded values, followed by distressing reverses. It is the same with these properties as with other great interests. Whenever more money is put into them than the community can spare, or it is unwisely placed, reaction follows, as in the case of over investment or unproductive outlay elsewhere.

The cost of railway construction in the United States for the last twenty-five years, it is said, about equals the savings of the people from reduced rates. The added facilities that have been needed have been constructed out of profits saved to the community. "Had the actual quantity of merchandise moved by the railroads in the year 1880 been subjected to the average rate per ton per mile which was charged from 1866 to 1869 inclusive, the difference would have amounted to at least five hundred millions of dollars and perhaps eight hundred millions of dollars more than the actual charge of 1880."*

Political economists are not agreed as to the ratio they think the capital of a railway should bear to gross earnings. It has been estimated that it should not exceed ten times the yearly receipts.†

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* Edward Atkinson, "The Distribution of Products," page 236. To cite special cases, it appears from statistical returns that the reduction in rates in New York for 1883 as compared with the rates of 1870 amounted to $74,549,000, and in Ohio to $89,400,000. It is estimated that the reduction of rates (*i. e.*, the amount saved to the people) in the year 1883 for the country at large amounted to $400,000,000. M. M. K.

† "It has been held by high financial authorities that, in order to be a commercial success, a railway should not cost more than ten times the amount of its yearly traffic; or in other words, the annual traffic should be 10 per cent. of its capital cost."—*J. S. Jeans, "Railway Problems," page 25.*

Estimates of this kind are, in the main, unprofitable and harmful. The cost of operating, quite as much as the earnings of a railroad, determines the percentage of profit. So long as it costs in one case fifty per cent. of gross earnings, and in another seventy per cent., to operate a property, it is apparent that no uniform standard of capitalization based on gross earnings is possible. On the other hand, it is a safe statement to make to say that a property should not be capitalized beyond a moderate return on its business. Cost should be restricted as much as possible consistently with the object the property is intended to serve.

The excessive cost of operating the English roads consequent upon their prodigal outlay for safety appliances is said to seriously cripple England's internal industries, rates being necessarily so high as to prevent competition with more favored localities. It is claimed that the low rates of American railways will ultimately drive the interior manufacturers of England out of the market if their carriers do not find a way to reduce rates. America is indebted for her low rates to free railway construction and active competition. England has not been subjected to the stimulating effect of the former. The extra safety devices of English roads have added much both to cost of construction and working. The hypothetical safeguards there thrown around life have grievously burdened the country at large; they have made the cost of food and clothing dear in order that the reckless and careless in the community may not be run over; they have denied the poor many necessities and comforts of life in order that the absent minded, the tramp and the drunkard may be safe. This is an extreme way to state the case, but its essence is true.

It is fashionable to claim that every safety device introduced is a gain—a step forward. This is a superficial way of viewing it. Practically every safety device that adds to the cost of doing business (over and above its savings) is a Perpetual Tax on the community. It is like money sunk in any other enterprise that does not yield a return. It is in matters of this kind that the practical common sense of business men is a safer guide than the theories of the engineer or publicist. The business man provides only when the urgency is great; when the time ripe. The others provide as a matter of course wherever necessary to perfection. In the case of the engineer, perfection is necessary to substantiate his skill and reputation. He is an idealist. Cost is a secondary matter. Nor do governments or communities stop to think of the outlay; they simply know that an additional safeguard may be made available; the hardships that unwise expenditure of capital engenders, the industries it prevents, the heightened cost of food and clothes it entails, they do not for a moment consider.*

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* The matter of the safety appliances of railways finds more proper reference in the volume on "Operation of Trains." I can not forbear, however, referring to it here. The disposition

The safety appliances of railroads resolve themselves finally, like everything else, into a purely practical question, a question of finance. Governments will not, however, view the subject as a practical one. To them a thousand people starving in silence is not so distressing as the dramatic death of a single man at some railway crossing. The subject should be stripped of sentiment. The limit of expenditure for safety appliances can not be fixed. It must be determined for each property apart. It should go as far as circumstances warrant, no further. And in making such expenditures it should be remembered that every dollar saved to the owners of railroads in this direction is a dollar laid away for business purposes, for future improvements, to build and operate railroads, factories, mercantile houses, and to endow hospitals, schools and kindred institutions.

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to sink money in romantic efforts to surround life on railroads with safeguards not esteemed necessary on our common highways, strikes me as being the acme of extravagance and folly. Thus, the block system has been made compulsory, practically, on all English railroads. Its effect, while satisfying the romantic element of society, strikes those less emotional with a chill. It greatly increases the cost of operating and thus renders the profitable working of many properties very difficult. It also absorbs money needed for other and more necessary things. The action of the British government in making every road conform to a particular system is in accordance with governmental methods; in accordance with their craze for uniformity. If, instead of making the poor roads conform to the block system, it had prescribed a reduction in the speed of trains and adopted other simple devices, it would have shown greater practical sense and interest in the people. But its action would not have been so dramatic.

Many countries seek systematically to prevent extravagant railroad construction by methods of capitalization. Thus, England sought through the law to compel two-thirds of the money to be raised by the sale of stock; only one-third could be raised by bonds or debentures. In the United States, on the other hand, ninety-nine per cent. of the cost has more generally than otherwise been raised by bonds; indeed, as a rule, its railways are constructed entirely from the proceeds of bonds. The difference in practice does not imply wrong. It is necessitated by different conditions. In one case the investment has been practically secure, in the other speculative; in one country money has been plentiful, in the other it has been scarce.


Primitive Carrier.

Differences in method of capitalization in England and America are not more noticeable than differences in cost. Greater cost in the former country is occasioned largely by the high price paid for right of way and the ideal thoroughness with which the work is done before the roads are thrown open for business. Government aid has been a factor in railway construction on the continent; in Great Britain, however, the government has never in a single instance guaranteed the debt of a railroad. The wealth, courage and commercial enterprise of the people have rendered such a course unnecessary. Guarantees have, however, been freely made in the British colonies. In all new countries the aid extended to railroad companies commonly takes the form of concessions of land and local assistance. This is the form it has taken in the United States, except in the case of the Pacific roads, which the government, for political reasons, aided by guarantees.

The growth of railway enterprise is not uniform. Thus, the rate of increase has been in recent years much greater in the United States than in England. For the fifteen years ending 1884 the increase was one hundred and ninety per cent. in the former and only forty-five per cent. in the latter.* In considering these great advances, so important to the development of the country, it should not be forgotten that they are the outgrowth of individual enterprise; are wholly due to the foresight, courage and savings of private citizens unaided by the government.

* J. S. Jeans, "Railway Problems," page 28.

Carriage in Ancient Assyria.

CHAPTER II.

CAPITALIZATION—METHOD OF CAPITALIZATION AND MANAGEMENT IN DIFFERENT COUNTRIES.

Wide fluctuations in the dividends of railroads suggest many widely different causes. In the case of corporations paying small dividends, or paying no dividends at all, we are led to enquire: Were the roads needed; were they built in advance of their time; will they ultimately be productive; were they wisely located and properly constructed; are they efficiently managed; are they oppressed by the government; are they permitted to base their rates on Economic Laws, on what the traffic will bear, or are they treated as things apart?

The productiveness of railway property varies greatly in different sections of the same country. Thus the average for the northwestern portion of the United States has been scarcely one-third what it has been in the eastern states. The agrarian spirit that characterized that section at one time seemed likely to increase the disparity rather than diminish it. Happily conditions have changed, so that it is probable in the course of time that the railroads of this section will be as productive as any in the world.

Under normal conditions railway investments should grow steadily stronger, steadily better, because the property should grow stronger with the development of the country it does so much to occasion. Wherever improvement is lacking, it indicates want of commercial enterprise, or other unfavorable influences.

The English companies have very generally paid dividends from the start. No American company has done this, and only the higher classes have made any return on their stock up to this time. Only the securities of these last are consequently generally dealt in by the public—and these only to a limited extent. Wide fluctuations in the price of railway securities have caused the American public to generally distrust them. Mortgage bonds have been the favorite form of investment. In England, on the other hand, capital stock has been the popular form. With the growing cost of railroads and increased capitalization, however, debenture stock (which partakes of the nature of a mortgage) is taking its place.

The growth of railways, both in mileage and productiveness, has been greater in the United States than in any other country. This result has been achieved without injury to any and with advantage to all. Improved methods of business have kept pace with increased growth, while decrease in rates has been steady and marked. This decrease amounts at this time to about eighty per cent. of the original sum. Reductions in rates have been scarcely perceptible in other countries. How much further progress will be possible in America, it is impossible now to tell. Much will depend upon the law making power and the spirit in which the laws are enforced. Both must conform to the laws of trade and the commercial needs of the country.

The ability of a railroad company to capitalize its property on favorable terms depends upon the plentifulness of money, upon the security offered and the confidence felt in the ability of the property to earn a return on the investment. The last, it is manifest, depends upon the productiveness of the country, its friendliness, the economy and skill used in construction and, finally, the experience and fidelity of managers. This last, generally speaking, may be said to be assured.

There is no difference, so far as injury to the public is concerned, between improvident management of private owners and that of the government. Productiveness is the *sine qua non* of property, of railroads as well as of everything else. Railroads that will not pay a return on the capital invested should not be built. The injury that a community suffers from the construction of unproductive roads, extravagant, wasteful, inexperienced, unfaithful or reckless management, can not be measured in dollars and cents; it finds reflection, however, in the market value of the securities of such properties.

Every dollar lost or wasted in railway construction or administration impoverishes the owner and the community to that extent. If roads do not earn what they might be made to earn, if they cost more to maintain and operate than they should, the loss falls on the owners and through them on the community. Railways that do not earn a return on their capital are like unprofitable manufactories, a curse to the country.

Kaffir Carriers.

In the United States and England, where commercial needs have been left free to govern the construction of railroads, only such properties as are needed should have been built and, consequently, only productive properties (present or prospective) should exist. That the contrary is true is due to excessive enterprise, the result partly of overzeal, partly of speculation.

Wherever a line is located on other than business grounds, whether to conserve military or other ends, it becomes a perpetual tax on the community, just as much as the army or navy of a country.

So far as comparison can be made between governmental methods and those of private owners, Germany makes the most favorable showing for the former. This is due in part to the fact that its civil service is the best in the world and in part to the fact that the most productive railways of the country were early taken possession of by the government. The intervention of the German government has been greatly influenced in many cases by inability of government lines to compete successfully with those owned by private parties. The government was compelled to absorb the latter in order to save what it already had. In view of this fact, whether Germany has been benefitted or not by the transfer, the reader may judge. Military objects are also believed to have influenced the German government in assuming the ownership and management of railways. The experiments of German officials with classifications, methods of rating and other forms of railway business, have been such as might be expected from philosophers and professors governing under bureaucratic methods rather than commercial instincts and needs. The experiments have not been such as to encourage further departures from established usages. The Germans are learning that commercial laws, rather than a desire to be isolated or peculiar, animate railroads quite as much as they do manufacturers.

Nowhere do railroads cost so much per mile as in England. Correspondingly, however, their traffic is larger. The English roads are honestly constructed and are ably and efficiently managed. The return on the capital invested is generally satisfactory.* The expense of operating English roads is more per train mile than on the continent, and is less than in the United States. The average train load is, however, much less than in the United States. On the basis of cost per ton or per passenger per mile—the only true basis—the expense of maintenance and working is much greater in England than in America. The relative cost, progressively, per unit of increase of net revenue is also much greater in England than in the United States. In the United States four millions has been found sufficient to increase the net earnings seventy-two millions; in England ten millions has been needed to increase the net earnings six millions.†

The difference in cost of railways per mile in the United States as compared with those of Europe, although very large, is not so great as appears from the accounts. The disparity is due in part, as I have explained elsewhere, to the fact

* "Railway Problems," page 56.

† For particulars in regard to details of capitalization of English railroads, see Appendix A.

that much of the construction work in the United States has been paid for out of net earnings and is not yet capitalized. But after allowing for this, the cost of right of way and station and yard facilities in the United States has been very much less per mile of road or unit of service than in any other country with which its railway system may properly be compared. The cheapened cost of American roads is, however, in the main due to the fact that the owners of railroads were not held to any hard and fast rule by government officials as regards bridges, crossings, and other details, but were left free to build according to their judgment of what was best. The country thus got the benefit of their prudent and economical methods. Government interference in the United States has come too late to make her railroads dear, but not too late, if ill advised, to make their operations wasteful and injurious to the country.

The policy that different governments first adopted in regard to railways, they have generally followed to the end. In some countries final ownership by the government was contemplated at the start and the thought that suggested the idea has borne fruit in its consummation. New authorizations of railroads have not, however, been the same from year to year, but have changed as experience or interest suggested. Thus, rights freely accorded early railroads have been grudgingly granted or wholly denied later applicants. But no great hardship has followed.

In the United States railroads are chartered by the various states, some under general laws, some under special acts. The railroads, while more or less amenable to the police regulations of every township through which they pass, are governed generally by the regulations of the state. Each state has the right to determine the methods of capitalization of railroads within its boundaries and fix the amount of taxes. The general government has jurisdiction only over interstate traffic. Both the general government and the various state governments have commissioners to look after their interests, respectively. Their action is generally subject to revision by the courts.

In France the railway system is of a mixed character—it is owned partly by the state and partly by private companies. Government interference, however, has been very active. It was the original contemplation that all railways accorded guarantees and immunities by the government should become the property of the state at the expiration of a certain period. In 1883, however, because of the financial troubles of the government and the strong competitive position of private companies, the government found it necessary to surrender the right of purchase except upon practically prohibitive terms. In regard to railroads constructed after that date, the arrangement in the main is that the companies shall contribute a certain amount of money per mile for construction and equipment, the balance is borne by the state, the companies, however, providing all the money in the first instance, the state to make annual payments to the companies on account of interest on the amount advanced and to create a sinking fund to extinguish the principal by the time the concessions terminate, when such lines will become the property of the state. The French government designates the territory each railroad shall own and protects it therein. The larger portion of the French lines is owned and operated by private companies, occupying distinct territories. The price the public pays for the intervention of the French government is absurd, and greater than would be allowed if the value of independent management of railways was properly understood. Thus, the French government requires the free transportation of its mails and a very low rate for its military and civil servants, and in addition to other enactments, levies a duty or income tax amounting to ten per cent. on certain classes of earnings. Governmental interference in France, like that in Germany, is not such as to suggest imitation elsewhere. It has greatly lessened individual interest and, through its cumbersome exactions, has materially modified railway enterprise. The French system is said to be extravagant and top heavy; the government in its zeal to protect everybody has carried its interference in many directions so far that its *savants* only understand the technicalities of the service or the rights of carrier and patron. Thus, business is retarded The supervisory power of the French government is said to be both costly and annoying. Intended to protect the people, it has ended by becoming a burden. But this is the effect of government management everywhere and under all circumstances. It is not

Madagascar Carrier.

special to France. Its effect is more noticeable in the case of railroads than in other things because of the vast importance and complex character of these properties. No matter how admirable government management may be, it can not be so wise, so attentive, so alert to the needs of trade as private ownership. It is always expensive, slow, cumbersome and officious.

The debenture or bond system of capitalization is more favorably viewed by the French people than any other. Stocks, unless guaranteed, are too uncertain for these thrifty and cautious people. They require definite guarantees; specific agreements as to the extent of the return and dates of payment. The French are greatly to be admired. No people are so apprehensive of commercial results as they, so quick to take advantage of them, or so careful in preserving the fruits of their industry, frugality and foresight.

Germany exercises a supervision over its railroads such as we might expect from a strictly military government. It requires to be consulted in advance in regard to the route roads propose to traverse, the nature of their construction and equipment, capitalization, sinking funds and working arrangements. The state has from the start extended more or less aid to its railroads, and it has the right to purchase at pleasure, subject to certain conditions as regards time and compensation. The German government enters with military precision and autocratic power into every detail of operation. It undertakes to scrutinize with particularity construction work, fitness, adequacy and handling of equipment, administration of property, expense of operating, details of receipts, and finally, the inspection of trains stations, and other property.

Its admirable bureaucratic system, the result of a century of patient and systematic growth under a stable and honest government, in a measure redeems its operations from the cruel hardships and gross inefficiency that generally characterize government management. But its railroads would be operated with greater economy and efficiency if left in the hands of private citizens.

In Austria the bulk of the railway securities are guaranteed by the government and the properties, save their equipment, revert to it at the expiration of ninety years. The Austrian-Hungarian government, like that of Germany, has a creditable civil service and performs what it undertakes with more than average efficiency. It is not able, however, to supply the place of private endeavor and interest. It has striven to throw around railway construction and management every needed safeguard. But, as a rule, its regulations are more specious than valuable. Thus, one of them provides that in the event profits exceed fifteen per cent. the government shall have the right to reduce them to that figure!*

In Belgium the government has interested itself directly and actively in the operation of railroads from the start. It first took upon itself to provide the land they needed. Afterward its intervention extended to the work of construc-

*This is one of the reservations governments make that seem so sagacious, but that are really unnecessary, unbusinesslike and absurd.

tion and management. It practically owns all the railroads. In some cases they are leased to private parties, but in many instances are managed directly by the state.

The Italian railroads were built partly by the state and partly by private parties. Its guarantees were, however, important. The government exercises a general and strict supervision over affairs. At the present time the railroads are vested in two great companies having leases for sixty years, with the right to relinquish at the end of twenty or forty years. The rental paid is based on a reciprocal division of receipts.

In Holland the state railways were constructed by the government with public moneys. The working of the roads is, however, entrusted to private parties, the state participating in the revenues on an agreed scale.

The number of railways built and managed by private corporations in Russia is greater, relatively, it is said, than in any other country on the continent of Europe. Private management it is thought will not continue permanently, the nature of the country and the military exigencies of the government rendering possession of the railroads by the government necessary. However, the autocratic powers of the Czar are such as to give him control tantamount to that of individual ownership. The growth of railroads in Russia has been fostered by governmental aid, conditioned upon the lines reverting to it under certain conditions.

Such is a brief retrospect of the railroads of some of the great countries of the world In comparing the methods that have attended the inception, growth and administration of railroads, the superior wisdom and sagacity of the English government is apparent. It has believed from the start that the greatest good was to be attained by encouraging individuals to take the initiative, and by granting them sole power and responsibility of management. It has not reserved to itself powers that could by any possibility embarrass owners or cripple the earnings or capacity of properties. Its intervention has never extended further than to prevent two roads being built where one only was needed. Wisdom such as it has displayed is rare in the history of mankind, but such as we might expect from a nation of business men, who by their conservatism, energy and wise administration of affairs, have made their country the greatest the world has ever known. The business men of America are not less wise, not less conservative, not less energetic than their English cousins. The action of England and the United States has from the start been based on purely commercial principles. It has been such as the greatness of the occasion and the exigencies of railway property required. It may well find favor and imitation in other less progressive and worldly wise countries.

CHAPTER III.

CAPITALIZATION—RELATION OF CAPITAL TO EARNINGS AND EXPENSES.

In capitalizing railways care should be exercised not to issue a form of security that may at some future time make those holding it antagonistic to the best interests of the property; that may prevent a conservative course being followed; that may have the effect to trench on necessary revenues or suggest reckless financiering in other directions. Circumstances will sometimes compel such a course. The financial situation of a property may be such as to prevent full consideration of future contingencies. The vicissitudes of business afford continual illustrations of this kind, in private life as well as in corporate experience. While they are to be deplored, they can not be remedied or their consequences avoided. Business men live in a practical world and provide as best they may for its wants as they occur, leaving it to their successors to do the same. However, an emergency that compels a disregard of the future in corporate existence must be real and pressing. Nothing else can excuse it. Such an occasion may, for instance, justify the issue of an income bond or a stock upon which no dividend can be paid until a certain return has been rendered on a prior security. But such conditions will be sure, sooner or later, to create antagonisms between holders whose interests should lie together. When this occurs the scales of justice can not be so evenly balanced or properties affected so impartially administered as to satisfy the requirements of all. Whenever it is in the power of a particular class of holders to take advantage of another class of holders, we may be certain that sooner or later they will do so. Such struggles teach men wisdom, self reliance, foresight, prudence. They are therefore not an unmixed evil.

The holders of different kinds of railway securities represent different classes of people. Those whose fortunes require a definite and sure income are exceedingly conservative and invest only in securities of a higher class. Many business men and capitalists also are attracted only by securities of this kind. Those not so conservative or to whom present income is not a matter of especial concern, take into account future possibilities. The speculative classes invest in anything they think they may extract money from; they are like the fireflies that glimmer in the dusk of a summer's evening, now here, now there, affording neither light to guide nor fire to warm.

Under normal conditions railway securities command a price based on present returns conditioned on future probabilities. Capital here as elsewhere is sensitive to extraneous influences such as unfriendly legislation, possible reverses, and so on. Many securities do not command a price proportionate to their value because of not being known to those who have money to invest in enterprises of this character. On the other hand, many securities command a much greater

Armenian Carriage.

price than their intrinsic worth warrants because of being known and generally traded in.

The holders of railway securities are both appreciative and apprehensive. In nothing is their businesslike character so quickly and unmistakably evinced as in condemnation of attempts to bolster up properties by such fictitious aids as the payment of unearned dividends or a division of profits required to be kept in the property. Such action always results in weakening the security affected. Thus it frequently happens that the payment of a dividend will depreciate a stock to a much greater extent than the amount divided. So well is this understood in the United States that men of conservative judgment who manage railways and are allowed discretion will not declare a dividend for a sum greater than the actual financial affairs of the company warrant, erring, if they err at all, on the side of a reduced rather than an expanded sum.

In the inception of railways they were constructed wholly from the proceeds of capital stock. But the discretion such form of security accorded those charged with the management (as to time and amount of return to be rendered holders) did not long satisfy investors. Not that managers were generally unfaithful, but that results did not realize the expectations of owners. They did not have the control over their property that they desired. Hence, while the use of stock was not wholly abandoned, mortgage bonds and other definite forms of security as regards returns took its place. The wisdom of this course can not be doubted.

The construction of railways is attended by an infinite variety of influences; an infinite variety of conditions. Upon these the amount and nature of capitalization depend. This capital, whatever its amount or form, represents the property. It is the axis about which everything revolves, the center of expectation and desire. It is the tangible evidence of ownership, of accumulated wealth, of hope of income or gain in the future. Its fluctuations in the market are consequently marked by gladness or sorrow, comfort or deprivation, abundance or want.

The general uniformity of relation that earnings, expenses and net income bear to capitalization over the world is an evidence of the wisdom and good management of the capitalistic class. It proves that notwithstanding the vagaries of governments and peoples, the expectations of capital in all financially strong countries have not generally been disappointed.

Because of necessary and unavoidable limitations, investments in railways can never exceed, if they equal, average rates of interest in other directions. But they should not fall far below, and when they do, it indicates abnormal conditions requiring to be remedied.

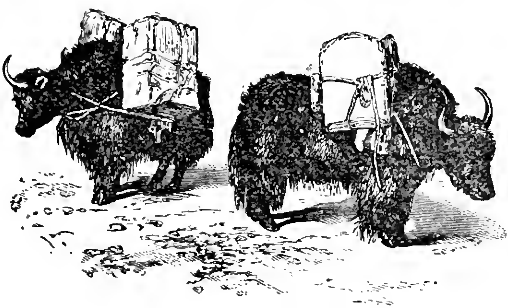
The greatest possible differences exist as to the relation earnings and expenses of railroads bear to each other. It is said that the latter, including taxes, for railroads as a whole, is about sixty-two per cent. The relation that expenses bear to earnings is generally construed as indicating the relative value of properties or the economy exercised in working them. It will be found to vary, however, very much from year to year, also in the case of particular properties.

Special statistics, such as those based on train mileage, while of great value are oftentimes misleading. Results are never to be taken as a whole. It is said that the average receipts per train mile decrease with the multiplication of trains; in other words rates naturally fall with increased business. This is probably true of railroads as a whole, but is frequently not the case in particular instances. Natural laws govern. In the United States where trains are heavily loaded and are run at a moderate rate of speed the greatest results in the shape of net receipts from the train mile standpoint are attained. But in order to determine the value of a property, cost, expense of operating, and earnings in gross must be ascertained. Earnings are not an indication alone; they must be considered with expenditures. The latter depend, as I show elsewhere, on climate, character of the country, condition of property, price of labor and material, and the skill and fidelity of those in charge.

Railways generally may be depended upon to show the best results whose organization is the best. Wisdom and skill in organizing precede and attend wisdom, skill and fidelity in managing. Only the securities of such companies afford safe investments; only such should be traded in. Others may be stable for a time, but are speculative and unsafe.

Men differ greatly in regard to the relative efficiency of management. From results achieved and investigations made, I am led to believe the administration of railroads in the United States to be the best in the world. That no others equal it in ability to achieve great ends with so little friction or at so small a cost. Moreover, it grows each day more and more effective; each day the management becomes better balanced, more accountable.

Corporations managed by private owners are the most effective, the most useful to the com-



Thibet Carriers (Yaks).

munity. In France the percentage of expenses to earnings in the case of private ownership is very much less than it is in the case of public management. This is in part explained by the fact that private properties are the more productive; but aside from this, government management, it has been demonstrated, is more expensive than that of individuals. In Austria-Hungary the expense of private management is forty-five per cent. as against ninety-two for the government; in Belgium it is fifty-two per cent. as against sixty-two; in Germany the result is also against the government, but, because of the fact that the most productive lines are operated by it, the result seems to be more favorable to such form of management; but it is only seeming; the government here as elsewhere is not as efficient as private management. In considering the difference in cost it should be remembered that the loss to the community is only represented in part by the difference in expense of working under government management and under that of private persons. Extravagant expenses represent high rates; economical management, low rates. Under one many industries that are impossible may be carried on profitably under the other. Extravagance in the management of railways, therefore, means a great deal more to the public than the difference in the amount of the expense account.

Of the factors that affect the productiveness of capital invested in railways, the cost of maintaining and operating is of the greatest consequence. From past experiences it is reasonable to expect for a considerable period continued decrease in cost of both of these items. But on the other hand they may be offset by possible exactions of labor and enforced requisitions of governments under one specious pretext or another.

CHAPTER IV.

CAPITALIZATION—RELATION OF DIFFERENT SECURITIES TO EACH OTHER.

The capitalization of railways takes on that form which best conserves the interests of the property, taking its whole life into consideration. Instances where this is not so are exceptions—exceptions that may properly be guarded against but are not to be made the basis of laws or systems of administration.

The forms of capitalizing railways are few and simple, and such as investors understand. Men will not place funds in ventures difficult to comprehend or that they are unused to.

If the law takes cognizance at all of methods of capitalizing railways, it should prevent stocks or bonds being issued except for *bona fide* consideration, for new property or improvements. However, the intervention of the law-making power is not necessary, except to legalize what is done. Buyer and seller may be safely left to adjust details and arrange prices and methods. Private citizens are quite able here as elsewhere to guard their own interests.

Forms of capitalization arranged by individuals familiar with such matters and personally concerned in their success will always be wiser than those suggested by persons unfamiliar with the requirements of business or the necessities of particular cases. It is a purely practical question, to be settled between practical and self adaptive people.

While evils have, no doubt, attended the incorporation of particular railroads, personal surveillance and self interest are more powerful to control and keep such matters in check than any other influences. The state on the whole has not suffered because of laxity in this respect. On the contrary, enormous advantages have accrued to it from the successful launching of railways, through individual enterprise, that would have been impossible under a more complex form of government.

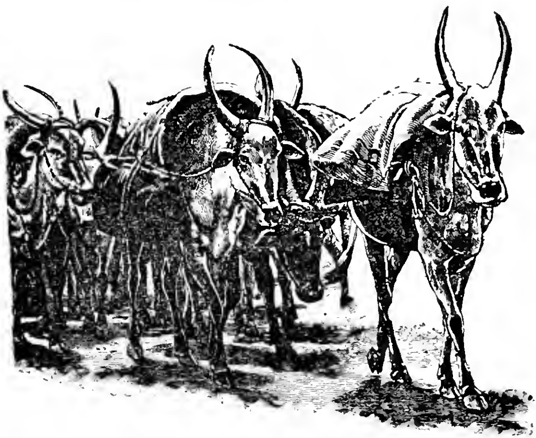
Men who invest money, as a rule, look carefully to the security they get, and may be depended upon to hold in restraint those with whom they trade. If they fail to do so, the experience gained through their losses is money well invested. Men are thus taught self reliance. On the other hand, governmental interference perpetuates indefinitely the evils it seeks to prevent. It fosters ignorance and builds up a dependent instead of a self reliant people.

In all matters of a commercial character man's covetousness will crop out—will lead him to do things he ought not to do and omit to do things he ought to do. It has been so from the beginning and will be to the end. Acquisitiveness is the instinct of trade,—its aroma. We make a mistake in attaching undue importance to many of the practices it occasions. Railway owners have been singled out for especial animadversion in this respect; kindred practices on the part of merchants, manufacturers, bankers and others have passed unnoticed. Those who own and operate railroads compare favorably with others engaged in commercial pursuits. Their failures are not on the whole prejudicial to public good. Their lapses from virtue are not more frequent than those of editors and farmers. When lapses occur, it is wrong to attribute to them the importance of conditions. They should be treated, if criminal, as we treat criminal acts in other walks of life. But the whole community should not be bound over to keep the peace because of them.

An extreme instance of deliberate wrong doing is the case of those who build railroads without reference to their need or earnings power, with a view to making money out of their construction, capitalization or sale. Such transactions may properly be prevented by law, if it can be done without creating in the mind of the people a further desire to interfere through the legislature in commercial matters. A law requiring the projectors of railroads to secure the approval of an Impartial governmental board of Experts would be an advantage.

The necessity of concentrating the savings of many in the ownership of railways has suggested similar concentration in other departments of industry; has in fact precipitated the growth of corporations without number. We see it imitated in the combinations and exactions of labor. Natural antagonisms will preserve the equilibrium of interest between these organizations, as it will between them and those they cater to. Legislative interference will only aggravate the evil.

It is said that the capital invested in railroads represents a tenth of the wealth of the world and



Carriage in India.

a third of its invested capital. Its preponderance over other industries is more likely to increase than diminish with time. If wisely governed, its growth will be rapid; if unwisely governed, its growth will be slow and uncertain. Each day adds to our experience and fits us to cope with greater problems. Thus, consolidation has succeeded the disposition of early companies to operate continuous lines under different forms of management. This amalgamation will go on as fast as we fit ourselves to cope with it. In time a few great properties will be formed out of the many that now exist.

Within the bounds of effective management concentration is a convenience to the public and a profit to owners. But it must be attended by enlarged and adaptable methods of administration. When a property passes beyond the immediate eye of its owner or general manager, when he can no longer watch each man and see what he is doing from hour to hour, responsible, co-operative government must take the place of personal surveillance. The trouble at the start is that those affected by the change do not know anything about responsible methods of government, or, if they do, will not always conform thereto. Such cases call for quick and energetic action wherever it is expected properties will be Permanently productive.

The benefits of consolidated properties have been added to by the practices of railroads of sending traffic through over connecting lines without changing cars. Such arrangements have, so far as the public is concerned, many of the practical advantages of a continuous line; they add to the convenience, comfort and profit of the people and stimulate their patriotism and broaden their understanding by leading them to undertake distant journeys that they would not otherwise attempt.

In the construction, capitalization and operation of railroads it is inevitable that unfair advantage should sometimes be taken of owners by their representatives. Such occurrences are a mere incident of the situation, neither frequent nor important. I do not make them a feature of my writings because such evils are unavoidable and carry within themselves the seeds of correction. They are well known, and the owners of railroads may be safely trusted to apply necessary remedies. It is idle to inveigh against them or formulate speculative remedies. They can only be reached effectively and finally by the owner; his self interest will prompt action and quicken his intelligence.

The capitalization of railroad properties may be safely left to those concerned,—to the corporation that sells, to those who buy. Public solicitude here as elsewhere is not only injurious but futile. When men are beguiled into unprofitable trades it teaches them wisdom; the wisdom thus acquired is a part of our commercial greatness. Business could not be carried on without it. It can not be obtained in any less practical way. Governments can not teach it, nor can laws render its possession unnecessary in life. The struggle between those who have something to sell and those who wish to buy is incessant; out of it the equilibrium of trade is secured and approximate fairness maintained. Great injustice is oftentimes done, but it can not be prevented by statutes or police regulations; good eventually flows from it.

In the capitalization of railway properties investors do not always get the security they think they do. This is especially true of mortgage bonds. In the United States it arises in one instance from the habit of building and equipping railways wholly with the proceeds of bonds. A mortgage, to be valuable, should be for a part only of the cost. Those who make loans on real estate only advance a portion of the value. The mortgage bonds of railways should be similarly supported. There would then be fewer roads in the hands of receivers, fewer disappointed bond holders. The precaution is a reasonable one. If there is any demand for a property, if it is likely to be profitable, those interested will be able to furnish necessary guarantees.

When properties are built wholly with the proceeds of bonds such securities are not as good as capital stock would be under similar circumstances. Such ventures lack financial elasticity. They can not adjust themselves to the vicissitudes of business, and because of this are likely at any time to occasion a crisis highly detrimental to owners. Reasonable safety requires that only a portion of the cost of a property should be covered by bonds or that such securities should be guaranteed by more stable properties. When thus supported, they offer greater attractions to the majority of investors than capital stock and may, therefore, as a rule, be sold to better advantage than stock.

The English generally divide their capital between bonds (debentures) and preferred and common stock. The value of this division, and the relation each part sustains to the other so as to secure the most advantageous results (especially in the case of established properties) is portrayed by an English writer on the subject.* He says:

"The smaller the percentage of bonds the greater the likelihood of some dividend being paid on the shares. Thus the proportion of capital upon which no dividend is paid is twice as great in the United States as in the United Kingdom.† A large percentage of bonds has another very important consequence, namely, that it renders the line more susceptible of becoming bankrupt or falling into a receiver's hands, or being wound up, as the case may be. A loss of earnings which in the case of a line with twenty-five per cent. of bonds would only involve a diminution of the dividend, might in the case of a line with fifty per cent. of bonds involve the appointment of a receiver. Now the defaults which have occurred on American lines have been one of the causes of the prevalent distrust of American railway securities. Thus a practical means of improving the credit of American railways would be by raising further capital, when required, by the issue of shares instead of bonds.‡ . . . . The

*Charles Eason, Jr., M. A.

†The reason, as he points out, is that in the United States a greater preponderance of bonds is issued to stock than in the United Kingdom. M. M. K.

‡The owners of bonds as a rule do not have any voice in the selection of directors, *i. e.*, are not allowed to vote. Interest, however, has to be paid on them before it can be paid on any other form of security. There are sometimes several mortgages

difference between English and American railways is marked. In the United Kingdom rather more than half the share capital consists of guaranteed and preference shares; while in the United States only about thirteen per cent. of the stock is preferred. . . The English companies consider it more beneficial to raise capital by the creation of preferred stock. A too large creation of preferential stock has disadvantages. It renders the ordinary stock more exposed to variations of dividend and the company more liable to the discredit of not paying full dividend on preference shares, and also impairs the control of the line by the ordinary shareholders, who are most interested in its successful management. It is not clear to me why the American lines have created so little preferred stock: for example, the Pennsylvania railway company has no preferred stock. Now, this company would find the same advantages from raising capital by means of preferred stock, as are obtained by, say, the London and North-Western. The advantages are (1) as against the issue of bonds it has the advantage of giving additional security to the payment of interest upon existing mortgages, and (2) as against ordinary stock, it has the advantage of not tending to reduce the dividend upon the ordinary stock, which a creation of ordinary stock would have unless the capital

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on the same property taking precedence in the order thay are named. Preferred stock has a voice in the election of a management, and dividends must be paid on it before they are on other stocks. Ordinary or common stock is allowed to vote in the election of directors, but the return on it (*i. e.*, dividends) comes only after all other securities have been satisfied in this respect. M. M. K.

expended yielded the full rate of dividend already being paid upon the ordinary shares. Thus, suppose $5,000,000 of capital to be required, the net revenue yielded will in no way be affected by the mode in which the money is raised, whether let us say by bonds at three and a half per cent. or preferred stock at four per cent., or ordinary stock on which a seven per cent. dividend is being paid.

Tartar Carrier.

Let us suppose that the expenditure yields a net revenue of $150,000. In case 1 the debenture interest is increased by $175,000, there is $25,000 less for division among preferred and ordinary shareholders, and the margin of earnings over interest is diminished to this extent. In case 2, the preferred stock requires an additional $200,000 per annum. Thus the sum available for ordinary shareholders is diminished by

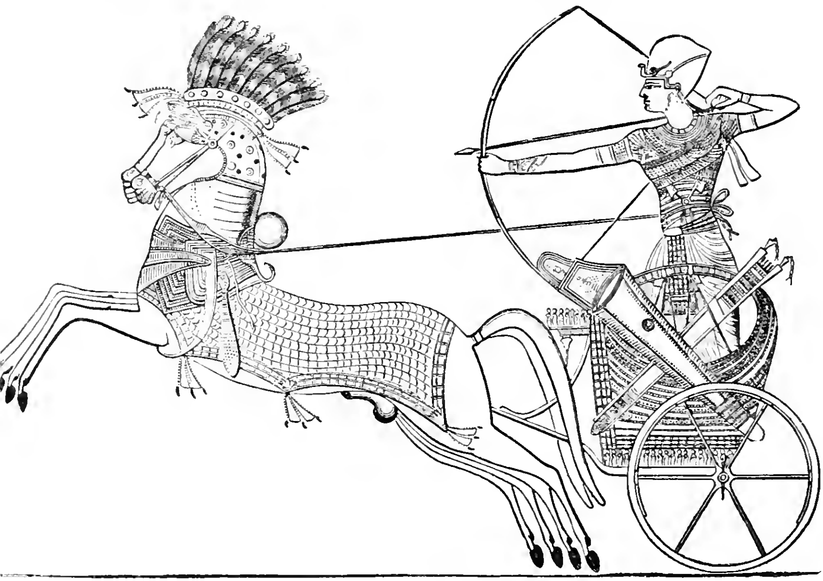
$50,000; but on the other hand the margin of earnings over interest is increased by $150,000. In case 3, the margin over earnings is increased as in case 2, but the net revenue is deficient by $200,000 of the sum required to pay seven per cent. dividend upon ordinary stock, and the dividend must therefore be diminished. The course to be adopted in any particular case must depend upon the proportions of the capital already existing and the dividends that are being paid. Taking the case of the Pennsylvania railway, a preference stock would be the best, for the proportion of bonds is large enough, and as it is not likely that the new capital will earn eight per cent. the creation of preference stock would tend to maintain the dividend. It is an obvious objection that a new stock might be less marketable on account of its novelty, custom having a great deal of influence in such matters; but the essential soundness of the policy would soon be perceived by investors. It is a *sine qua non* of a sound issue of preference stock that a dividend should have been for some time steadily paid upon ordinary stock, otherwise the *preference* is one in name only. . . . .
Fluctuations in receipts render the value of stocks uncertain, and thus fit them for being the subjects of speculation. It is the small proportion of stocks to bonds which enables a small combination of capitalists, or even a single capitalist, to control entire railways and to manipulate them at pleasure. The only practical way to mitigate such power is by operating upon the causes which form its basis. It is important to observe how the various circumstances combine to facilitate the acquisition of properties under

the circumstances mentioned. First the earnings power of railways is liable to great variation; second, this renders manipulation of the traffic and earnings difficult to detect; third, the small percentage of share capital renders the dividends very sensitive to variations in earnings; and, fourth, this causes a large proportion of lines to pay no dividends or very small dividends; fifth, the value of the shares being depreciated, and standing very much below par, only a small amount relatively is necessary to purchase a majority of the stock, and thus obtain control of a line; sixth, the non-existence of any large quantity of preference stock further facilitates such operations. Voting power attaches to preference stock, but not to bonds. Hence, a large quantity of preference stock would make it more difficult to get a preponderance of voting power."

The matter of fact way in which railways have been built and capitalized in the United States is characteristic of business men. The scant means there were to build with, the high rate of interest that prevailed, and the risk that attended such ventures, occupied the people much more than questions of future administration. Construction and capitalization were such as the resources of a versatile people suggested. The American method of capitalization has been good for America. It has resulted in the rapid development of the country and its unexampled growth in wealth. If it had not been generally fair and equitable this would not have been the case. Under the practice followed very generally in the United States of using more or less net earnings from time to time to add to or improve the property, the existence of preferred shares, pointed out by Mr. Eason, may appear to be objectionable, as the burden in such case falls for the moment perhaps wholly on the common holders. However, this may, it is possible, be avoided by an equitable division. But it is scarcely probable. The capitalization of these construction expenditures in preferred holdings at a low rate of interest may offer in some cases an escape from the hardships pointed out. But of the expediency of this no one can judge without knowing the particulars of the case. It is not a field for statesmen or writers, but a practical question for business men.

The peculiar environment of railways in the United States, coupled with the extreme conservatism of those who own them, first suggested the reservation of a part of the net earnings for use in improving the property. Many institutions have thus been saved from discredit that would otherwise have met with disaster. It is a simple, homely means, and such as only practical business men could be induced to adopt. Referring to it, Mr. Eason says:

"What are the advantages of carrying forward these balances, and how are they employed? They are required to give additional security to the bondholders, and are rendered necessary by the excessive proportion of interest bearing capital, and consequent interest charges. They are employed as capital, but as they do not bear interest, whatever they yield goes to increase the surplus for interest and dividend. . . . . . The effect is shown in the maintenance of the earning power of a line and in its power to maintain it in the face of competition of other companies. The value put upon the permanent way in the company's balance sheet is merely nominal; the true measure



Carriage in Ancient Egypt.

of value is the net revenue that the company can earn. In deciding upon the appropriation of net revenue and the method of providing the capital for further expenditure, whether on lines open for traffic, making new lines, or investments in securities of other lines, the important point for consideration is what will be the effect upon the net revenue. If the additional expenditure will yield net revenue sufficient to pay the interest upon the sum expended, there is no reason why it should not be provided for by the issue of an additional capital. If it is provided for out of income, the additional net revenue would become available for payment of dividend upon the existing stock, and the rate of dividend would increase. But it may happen that competition may so reduce rates that the earning power of the capital may diminish, so that the yield on total expenditure may not be increased. In this case, if the expenditure had been provided for by creation of fresh capital, the dividend must diminish, but if provided for out of income the rate of dividend may be maintained. . . . It may be that the capital expended has added to the earning power of the line, but the net revenue may remain stationary in consequence of a decline in rates, and it may well be that it was recognition of the liability to a loss of profit from this cause which leads a company to devote surplus income to permanent expenditure. The company adopting such a policy has a clear advantage over a rival company which has no surplus income and has to obtain the funds for construction by the creation of additional capital. This latter company may be gradually driven into default by competition with a strong company adopting another policy."

It is mainly to meet the eventualities of the future that the provident owners of railroads are led to invest a part of present income in strengthening their properties. The wisdom of their course has been proven too many times to need demonstration here.

Medieval Carriage.

CHAPTER V.

CAPITALIZATION—THE SO-CALLED "WATERED" STOCK OF RAILROADS.

Most of our literature in regard to railroads emanates from men unfamiliar with their affairs. It is as a rule severely critical. Men who have filled prominent railroad offices without being railroad men have also favored us. Their views are optimistic. They generally afford food for demagogues and serve to greatly alarm the ignorant. Up to this time railway men have had little leisure to devote to abstract thought. Moreover, the labor of correcting the misrepresentations of the class referred to has appeared as too Herculean a task to be undertaken. Time alone seemed equal to it.

What is needed in railway discussion is common honesty based on experience and knowledge of economic laws. The last above all. Faithful portrayal is impossible otherwise.

The belief (more general formerly than now) that the stocks of American railroads are generally watered is due to lack of information. The subject is much harped upon. It is a fad. As a pleasantry it is well enough, but seriously is all wrong. It is not true. The securities of American railroads are, as a rule, *bona fide*. Indeed few properties are fully capitalized. The small average cost per mile is sufficient to prove this.* But it is probable that the charge will continue to be made so long as railroads are run and people may acquire popularity by misrepresenting them. The theme is an endless one for those who seek to catch the public ear through its passions and prejudices. Hundreds of millions of dollars to them are as soap bubbles, and particular instances of wrong have the force of universal custom. If an individual sins, they fasten his crime, like a blanket, on the whole human race. It becomes a rallying cry and a means of spreading distrust. Actual instances of wrong doing are, however, few in number and unimportant. However, their misrepresentations are made the subject of unjust accusations and outrageous demands. They afford an excuse, an entering wedge. They are used to create dissatisfaction between carrier and patron and between employer and employe.

Warfare on property takes on many aspects. It is never open and manly; always insidious and covert; always cowardly. Whatever its aspect,

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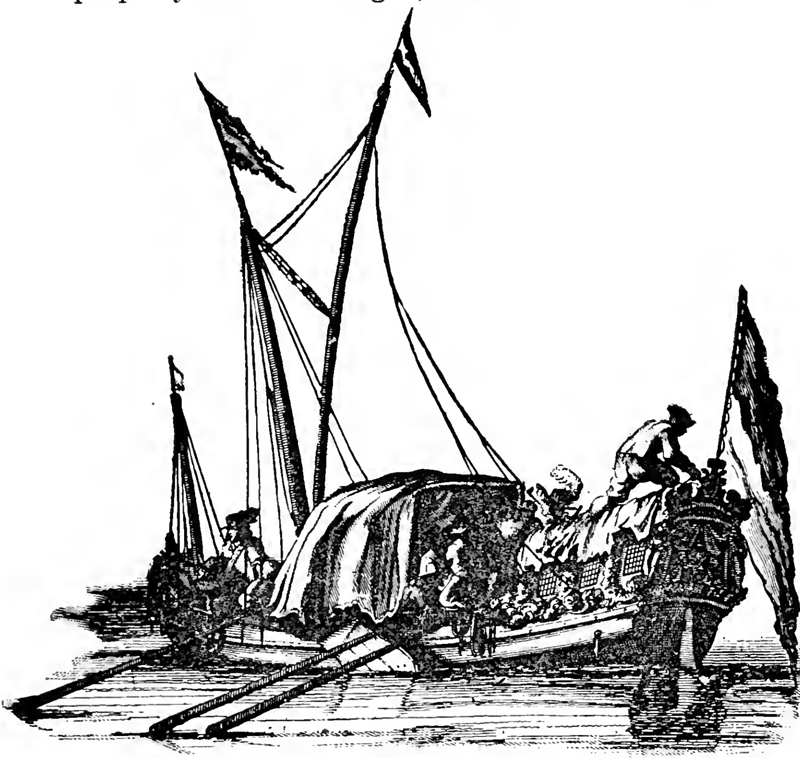
*The total capital expenditures for railroads of the world in 1883 (the last year for which I have the figures) amounted to $25,013,745,000, or an average of $94,489 per mile. The total mileage of the world was 264,728 miles. The cost of the railways in the Unitied States averaged $55,460 per mile and the mileage in the United States was 120,551 miles. This shows an average saving per mile of road to the people of the United States, compared with the average of the whole world, of $39,029. This does not indicate the presence of "water" in the securities of American railways, but the greatest business shrewdness and pinching economy upon the part of those who built them.

its purpose is bad; its aim the aggrandizement of the improvident at the expense of the industrious and saving. It can not be restricted to railway property. If encouraged, it will extend to man-



Dutch Carrier, 16th Century.

ufactures, newpapers, banks, farms and other industries. As we sow, so shall we reap.

The issuance of stocks and bonds in England is jealously guarded by the state. While great laxity has existed in the United States, the forbearance of the government has as a rule been respected. Good business usage has governed in this matter, as it must and does in all things where men deal on equal terms with each other.

The capital stock of American railways does not bear the authoritative stamp of the government. This fact has undoubtedly had its influence in determining owners to use their income to improve and strengthen their properties. It has made them conservative and circumspect, as responsibility always does. The practice is peculiar to America; those who own its railroads have sought in the cases referred to, to make assurance doubly sure. Undoubtedly cases of wrong doing have occurred and will continue to occur. They can not be prevented. The parties in fault are the greatest sufferers thereby. Sins of this kind react on properties just as sins react on men; atonement must be made in like manner.

Many makeshifts are necessary in connection with railway development in a new country that are unknown in older and wealthier communities. Thus, bonuses must be offered and discounts suffered that are unnecessary in the latter case. But no man thinks of repudiating a note because he has to sell it at a discount. In old and established communities, when money is not forthcoming on easy terms, it is evidence that the field is not ripe for its use. It is different in new countries. It must be eagerly sought.

Those who will study the methods and needs of a railway company will in every case end by becoming warm admirers of its adaptability and skill. The practices of railway corporations of buying up the stock of other companies and issuing their own in lieu thereof (depositing the stock of the purchased company with a trustee as collateral), while much criticised, are business-like and have been found eminently useful. Dividends are paid only on one security. It is a common practice for a company in extending its lines to organize a new company, the stock and bonds of the parent company being issued in lieu of those of the new company. The securities of the older corporation, being known, can be sold to much better advantage than the new. Now, while the stock and bonds are technically duplicated, they are only represented in the market by one kind of security. No one is injured, while everyone is benefited. I cite this particular practice of railroads as an illustration of many others that are assailed without reason or justice.

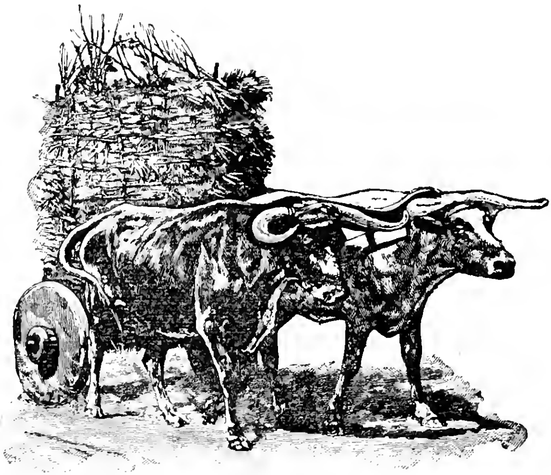
In some instances the so-called watered stock of railways represents the premium paid for the risk involved. To illustrate, we will suppose that money in British Columbia is worth four per cent. per month; in London it is worth four per cent. per annum. Why the difference? Because money is scarce in British Columbia; the risk is also greater, or not equally well known. But the transactions that occur in British Columbia are just as fair and equitable as in London; must be respected the same. And so it is where stocks are sold at a discount or indeed given, when necessary, as a bonus to purchasers of bonds. The obligation is as *bona fide* as if a premium had been received. The instances where the capital of railroad companies is not representative, where it is not *bona fide*, are so few in number and unimportant that they are not worthy of notice, save as exceptions to a general rule.

Much of the misunderstanding that exists in regard to so-called watered stock is due to the imperfect bookkeeping of railroad corporations. In the main, however, it is due, as I have frequently pointed out, to the conservative practices of those who own railroads; in other countries where the issue of stocks or bonds is co-existent with the improvements they represent, no one dreams of denying owners such representation or of referring to the securities thus issued as fictitious.

While we are accustomed to look upon railroads long in use as finished, they are ever in a state of evolution. Sometimes the transformation is so rapid and of such magnitude as to attract attention. Great outlays, it may be, are singled out and embraced in the returns under the head of construction and capitalized. This is generally supposed to be the extent of a railway company's construction account proper. As a matter of fact, however, the principal additions to a property are made up of myriads of petty improvements so small as to escape the attention of all but the accountant. The use of two nails where only one has been charged to construction is an improvement, and affords the basis of further capitalization.

No railway is so perfectly constructed in the first instance that it is not improved by the adding of new ballast; by adjustment of grade; by widening of cuts and ditches; by better alignment; by improved bridges and culverts; by greater weight and better quality of rail; by added office, station and yard facilities; by new machine shops; by filling up of grounds; by accumulation of personal property, and, generally, by the substitution of appliances of modern construction for those of an old pattern. Thus properties grow. Their growth, however, may not be noted in the returns; may, for the moment, have been wholly at the expense of the stockholder. He may have loaned the needed money, instead of receiving it in dividends. Manifestly it is his right and privilege, at his pleasure, to require a return of the amount thus loaned.

In those cases where the capital of a railroad has been watered, the conservative instincts of subsequent owners generally lead them to make good the amount; to supplement it with actual expenditures for construction. The cases are extremely rare where a return is earned on watered values. Such securities are generally worthless so far as income is concerned and are so esteemed. If profitable, they invite the construction of new lines, of active competition. They have no effect on rates whatever. The competition of carriers and markets, not the actual or assumed cost of a property, determines these.*



Carriage in Chile.

The enormous bonuses that must be paid for railroads and other improvements in a new and poor country cease when the momentary risks, real or imaginary, that attend such ventures become normal and money grows plentiful. The embarrassments that attend the opening of railroads under such circumstances necessitate peculiar practices that are not known in wealthy

* See "Economy of Rates."

countries or in the case of established and productive properties.

Whenever earnings are used for construction purposes, not only is the owner entitled to representation therefor, but also to interest thereon, as in the case of the original investment. He should be free to capitalize the outlay at his pleasure; whenever, in fact, his interests will be best conserved thereby. It is purely a practical question, and he should be allowed to meet it in his own time and way. We have no more right to deprive him of this privilege than we have to rob him of his watch. So acute, however, is the feeling on the subject that the most absurd laws have been passed regulating so-called watered stock. Thus, one state forbids railroad companies issuing capital stock to cover disbursements for construction, but allows them to issue bonds therefor. Was ever greater inability to deal with an economic question shown?

Carriage in Arabia.

CHAPTER VI.

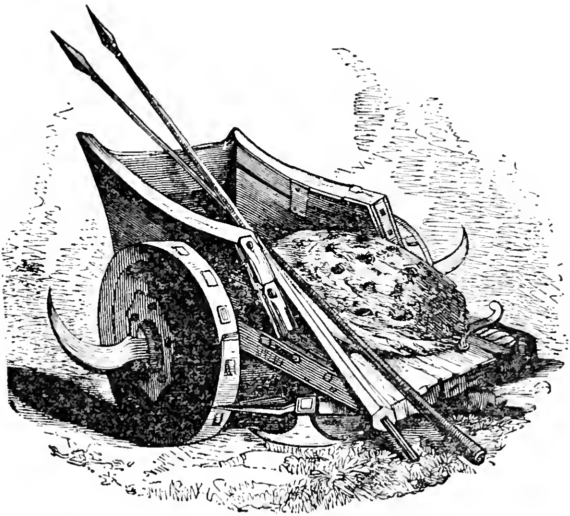
CAPITALIZATION—ADVICE TO FOREIGN AND OTHER INVESTORS IN RAILWAY SECURITIES.

Money makers are the same the world over. They have not changed for three thousand years. Their practices conform within the law to their desires. Persistent, aggressive effort to achieve fortune is commendable. What one possesses others strive to obtain. This is called enterprise. Acquisitiveness is the animating cause of commercial activity; possession of wealth the goal of mankind. If these truths were more generally kept in mind, men would be more wary in making investments; more painstaking in looking after investments already made.

Those who have money to invest in railroad securities should not buy without investigating, nor hold without guarding. Men who own valuable horses do not leave them unguarded. Investors in corporations will be wise if they exercise equal foresight. It will be only common business prudence.

So long as men will buy securities without intelligent investigation, so long will they be disappointed in their investments. I do not say that securities selling below par or at merely normal rates may not be valuable; they may be more desirable than those selling at a premium. But wise men will not touch a security without careful investigation. Those who do are the most reckless of gamblers and unworthy of sympathy if their ventures turn out unfortunately.

Those who have money to invest will also be wise in avoiding a state or country that does not



Chariot, Ancient Britain.

accord corporate capital the same treatment as other property. A country animated by such a spirit is as unsafe as a powder magazine infested by children.

In making investments in railways the property into which it is proposed to buy should be scanned with reference to its particular merits and demerits. It must be considered generally and particularly: the country it supplies, its extent, popularity, condition, the amount of its bonds, stocks, leases, floating debt, contracts, agreements, and so on. The nature of the management, its adequacy, fitness and trustworthiness, are also all important. A railway with an inadequate or defective plan of government is as untrustworthy as a corrupt or weak civil government. All these details must be carefully looked after by investors in every country.

Investors in new countries are more apt to neglect necessary precautions than in older communities; they lack the wisdom that comes with experience. In England shareholders in corporations consider it a duty to be present at meetings; their commendation or sharp crticism is heard in every meeting. In America the owner of railroad stock rarely, if ever, goes to a meeting of shareholders unless he has sufficient holdings to control the board or is a director; to do so is thought to be effeminate, weak, intrusive. This feeling is assiduously cultivated by his more robust, aggressive and powerful brothers who have control; his absence is grateful, his presence irritating. This is natural. Criticism is always offensive. However, stockholders should not be deterred from doing their duty because of this. No one should ever give a proxy if he can be present personally. It is common sense, simply business prudence not to do so. The practice should not be waived in the case of railways any more than in the case of manufactories, breweries and banks. It is a duty property holders owe to society, but above all to themselves.

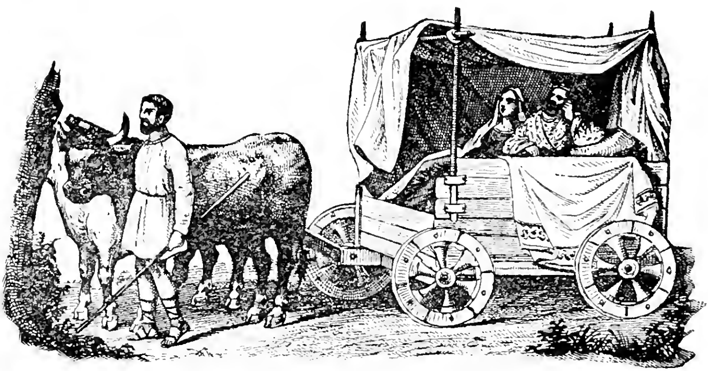
While men should not buy railway securities without investigation, they should not sell without reason. Mere rumor should not disturb them. Stocks and bonds are ever the subjects of manipulation. The effort to induce the public to sell when the market is going up and to buy when it is going down never for a moment ceases. Representations conform to these ends and markets are manipulated accordingly. Speculative classes are kept alive by the dupes who believe their misrepresentations.

Much good advice has been given the English, Dutch and Germans in reference to investments in other countries, especially America. I do not remember, however, to have noticed any reference to a safeguard of the utmost importance to them, namely, proper representation on the ground. The losses foreigners have suffered in America have not been the result so much of dishonesty or trickery on the part of local owners and manager as of the rascality and gross stupidity of those who represent foreign holders. These representatives are generally of the same nationality as their principals. They, as a rule, know nothing about American methods or men, and are not in sympathy with its people. If not foreigners, they are not generally trusted at home. The honorable exceptions to this rule only make it the more noticeable.

As a rule the representatives of foreign capital in America know little about the business they are hired to look after and their avenues of information are neither influential nor trustworthy; not such certainly as to secure the objects they have in view. Foreigners investing in America will find it to their interests to select their agents from among Americans; from among its reputable, practical business men, and generally from among those who do not solicit such trusts; from men already employed in similar positions. In order to find fit agents, foreign investors must visit the country and select their representatives from among those who have had experience and who possess the confidence of the business world. Such men do not go abroad to solicit trusts or to place loans. Nor are they to be found in the lobbies of hotels. The same rule must be observed that is followed in selecting a cashier or superintendent. If investors will do this they will not have to complain of being over-reached by local speculators.

The men that English, German and Dutch investors have sent abroad as agents have not been such as to justify a reputation for shrewdness or common business knowledge. Their investments will never be wisely placed nor securely held until they change their methods in this respect.

In many cases the representatives of foreign holders in America have been knowingly or unknowingly the dupes of those who are not trusted by their own neighbors. When foreigners have controlled stable companies in America they have not been able to maintain them; when they have controlled weak companies they have grown weaker. In the majority of cases their purchases have been such as were designed to attract the credulous and unwary, those who look for exorbitant returns, who seek a royal road to wealth, or who do not observe the precautions of business men.



Frankish King and Queen, 8th Century.

But if those who represent foreign investors in other countries lack ability, experience, adaptability, and oftentimes common honesty, how shall we characterize the majority of Americans who visit Europe to negotiate loans or sell property? They are rarely, if ever, representative men. They are not generally trusted by their own countrymen. Birds of passage, their migratory errands indicate a lack of capital at home that does not really exist. While many honorable men go upon such errands, the majority of them are unworthy to be trusted. They sin doubly, first in inducing people to invest, and afterward in representing them. They first fleece the public by misrepresentations and rob it afterward as agents. What are we to think of the commercial acumen of people who have been so systematically imposed upon as the English, Hollanders and Germans have in this respect in America?

Generally speaking, foreign investors will always exercise a wise discretion if they decline to buy into enterprises to such an extent as to give the properties the reputation of being controlled by them. Such reputation attracts unfavorable attention. The more unobtrusively foreign investments are made and held, the more likely they are to be satisfactory; the less likely they are to occasion owners anxiety. Not that there may be any special enmity towards foreigners, but nationality and patriotic prejudices run high among every people, and wise men never run counter thereto in business matters if they can avoid it.

Carriage in Agra, India.

CHAPTER VII.

CAPITALIZATION—CAPITAL STOCK AND SHAREHOLDERS.

As I have already pointed out, the practice in England in capitalizing railway property is for the stockholders to put such a quantity of money into the enterprise as to constitute a substantial investment and a material security to bondholders. It will be a good general rule to follow in America hereafter, in the inauguration of new companies not backed by old and well established corporations. The practice has been to pay a nominal sum on the stock and issue bonds to cover the balance. The custom was a necessity, and under such circumstances will always be proper. I have no criticism to make. Other countries can not go far wrong in handling railway enterprises if they follow, under similar circumstances, the lead of the United States. Its railroads have been admirably managed and their officers compare favorably with those of other countries. A very clever Englishman * has written a book of advice to his countrymen who have investments in American securities. He might have claimed for it a wider field. It

* John Swann, M. A.

is in the main good. But there is no cut and dried formula that can be followed in capitalizing a property or in making investments in it afterward. I have referred to this phase of the subject very fully in another chapter.

The total cost of a company's property, including the supplies and working fund required in its operation, is the proper basis of its capitalization. In the United States this is represented

Burmese Carriers.

largely by mortgage bonds and what is called capital stock. The latter should more properly be called shares capital. The term capital stock in the sense it is here used is misleading, because applied to a security that represents only a fraction of the cost.

In England they speak of the capital stock of railways; never of cost. The former at one time implied the latter.

Every company should be empowered to cause its cost to be represented either with interest bearing bonds or shares.* Any excess of cost over such issues should stand upon the books under the head of capital account until such time as the proprietors see proper to give it life. It is a part of the capital as much as the first dollar paid towards the venture.

Whatever a company may earn over its liabilities for operating expenses, taxes, rentals, interest, and other accounts chargeable against income, belongs to the owners of its shares and should be equitably apportioned among them. It is called a dividend. This division is frequently delayed. In some instances it is never made, but withheld by the owners for use in building up the property. But, however proper such action may be, it is in the nature of a forced loan. It should not, therefore, be covered up in the accounts or lost sight of, but should be paid over to the shareholders the same as if it were a note of hand, if the exigencies of business will ever permit.

A majority of the shares of the capital stock of a property, or a majority of those voting, according to the by-laws of the company, elect its directors. These control its operations for the period of time for which they are elected. In the event of foreclosure and sale of a property the shareholders (who are the company) possess the right of redemption, but in the event this

*The English speak of the obligations of governments as stocks; the securities of railroads as shares.

right is not exercised their shares become invalid.*

The par value of a share of capital stock in a railroad is usually one hundred dollars. In some cases the shares are fifty dollars each. Frequently two kinds of shares are issued. Their printed form is substantially alike.† But they have different rights and privileges. The higher grade is called preferred stock or preference shares, the subordinate grade, common or ordinary stock. The rights these shares severally enjoy, and the maximum amount of each that may be issued, are set forth in the articles of incorporation, and this limit can not subsequently be exceeded without formal consent of the parties in interest.

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*The par value of the shares of capital stock of the railroads of the United States amounted in 1889 to $4,251,190,719. Upon much of this capital no dividends have ever been paid; upon much of it no dividends are likely to be paid during the lifetime, at least, of the present generation. The dividends declared in 1889 amounted to $82,110,198. There is no means of ascertaining what proportion of the dividends of 1889 was paid in cash and what proportion was paid by new issues of certificates in lieu of cash used in improving the property.

† Form of certificate of capital stock—100 shares:

No. 980. PREFERRED. 100 Shares.

Capital Stock. Shares $100 each.

MINNEAPOLIS & SOUTH PACIFIC RAILROAD CO.

STATE OF MINNESOTA.

THIS CERTIFIES that JOHN DOE is the owner of ONE HUNDRED Shares of the Preferred Capital Stock of the Minneapolis & South Pacific Railroad Company, transferable on the books of the Company on surrender of this certificate.

WITNESS the signature of the President and Secretary.

Dated April 19, 1880.

HUGH GRAY, Secretary. C. G. PHILLIPS, President.

The certificates for common shares are similar to the above, except that the word Common is substituted for Preferred.

Many companies have more than two classes of shares.* The relation they sustain to each other and to the property is determined by the peculiar circumstances that necessitated the diversity of interest. When a company in poor credit is compelled to raise money, the best terms attainable are accepted. Sometimes mortgage bonds are created; sometimes new shares are issued (at a large discount, perhaps), which shares, by consent of the holders of existing securities, frequently take precedence. It is in ways such as these that different classes of shares and bonds are brought into existence. The rights enjoyed by holders of preferred and common shares, on different roads, are rarely the same.†

Where there are two classes of stock, preferred rights usually extend no further than a division of net earnings. Or, in other words, while the holders of a preferred stock may be entitled to a certain return before inferior shares can receive

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* The Grand Trunk Railway Company of Canada has five classes of stock, viz: Ordinary Stock; Ordinary Stock, new issue of 1873; First Preference; Second Preference; and Third Preference. It has, besides, various kinds and grades of bonds.

† The Chicago, Milwaukee & St. Paul Company's preferred shareholders are entitled to an annual dividend of seven per cent. before a dividend can be paid on the common shares. The preferred shares of the Lake Shore & Michigan Southern Railway (which amount to only $533,500) are entitled to an annual dividend of ten per cent. on their par value before the ordinary shares can receive any return. No dividend can be paid on the common shares of the North-Western road during any year, out of the receipts of such year, until seven per cent. has been divided among the holders of preferred shares. Other differences, still more marked, might be cited.

anything, still, in the event the property is foreclosed or sold, the surplus, after satisfying the mortgage and other debts, is divided equally among all classes of shareholders. In some cases, however, the rights of the preferred shareholders extend to a division of the property.

Dividends are declared by the board of directors. The meeting at which a dividend is declared must be legally convened and must in all respects conform to the statutes and the company's by-laws.* The amount of the contem-

Rural Carriage, Turkey.

plated dividend being fixed by the board, it declares how it shall be paid (whether in cash, in shares or in bonds) and when. It also fixes the date when the books in which transfers of stock are recorded shall be closed and when they shall be reopened.

Dividends are paid to the order of the persons who appear upon the stock ledger as owners at the time the books are closed.

*Usually a week's notice must be given by the Secretary of a meeting of the Directors; when, however, all the Directors are present, this formality may be dispensed with.

A period averaging from ten to thirty days usually elapses between the declaration of a dividend and the closing of the books. The reason is that there are many shares passing from hand to hand (as they are bought and sold) without being transferred on the books. When a certificate is sold by the original holder the power of attorney on the back is signed, in blank, by him.* This enables the holder, whoever he may be, to take it to the office of the registrar at any time he pleases and have it transferred. But shares frequently change hands many times without transfer of ownership appearing on the books. So far as the latter show, they are still in the hands of the original holders.

When a dividend is declared, every person who owns a certificate registered in the name of some one else usually (but not necessarily) has it tranferred. It is in order to facilitate these transfers that a period of time is allowed between the declaration of a dividend and the closing of the books. While the books are closed details regarding payment, such as the drawing of checks, etc., are performed.

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*Form of Transfer and power of attorney printed on back of certificate of stock:

For value received........do hereby sell, transfer and assign to...... ... the within mentioned Shares of Stock, and do hereby constitute and appoint ....as.... ...Attorney, irrevoeable, to transfer said stock on the Books of the within named Company, and to make and exeeute all necessary aets of assignment and transfer required by the regulations and by-laws of said Company either in person or by sueh other Attorney or Attorneys as .... may appoint or substitute for that purpose.

Witness........hand and seal this .... day of ....18....

Signed and Delivered in the presenee of

(*Thos. Robinson.*) JAMES JONES.

Corporations are required to give timely notice of the payment of dividends; also of meetings of stockholders. They are not allowed to close their stock books without giving public notice in advance, specifying the date the books are to be closed, when they will be reopened, and the reason why they are closed. A period of from thirty to forty days generally elapses between the closing and reopening of the books for a meeting of stockholders. The stock books are closed preparatory so such meeting in order that a correct list of those legally entitled to vote may be made. Holders of stock are entitled to one vote for each share standing in their names when the books are closed. During the time the stock books are closed no transfer of shares can be made thereon.

CHAPTER VIII.

CAPITALIZATION—DETAILS OF MORTGAGE BONDS, LEASES, ETC.

The amount of the bonds issued in the United States with which to build and equip railroads is called the Funded Debt. A mortgage is an absolute lien and, in the event the interest or principal is not paid as agreed, may be foreclosed and the property sold to the highest bidder. Bonds representing the funded debt are commonly signed by the president and secretary and countersigned by the trustee. The latter is a contingent agent of the bondholders.

Bonds vary in amount from one hundred to one hundred thousand dollars.

When there is more than one mortgage upon a property, the relation of the mortgages to each other is indicated by their designation, as first, second, third, and so on. It frequently occurs that a mortgage will be a first lien upon one piece of road and occupy a secondary place elsewhere. Each bond recites upon its face the property it covers and the rights its holders possess.

Owners are called bondholders. Sometimes a company sells its bonds directly to investors, but frequently through brokers. In the latter case a

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commission is usually paid. Bonds run for various periods, from one year upwards.

To enable bondholders the better to protect their interests thay are sometimes allowed to vote at annual and special meetings the same as stockholders. Such a course naturally insures a

Carriage in Lower Egypt.

very conservative management, as it is the interest of bondholders to divide as little of the surplus as possible among stockholders, and expend as much as possible in improving and building up the property, every dollar thus expended adding, of course, so much to the security of the bondholder.

The necessities of a company are sometimes such as to compel it to mortgage its surplus income—*i. e.*, the balance left after meeting existing obligations. The securities thus issued are called Income Bonds. Specific articles of property, such as a building, bridge, engine, car or piece of machinery, are also sometimes separately mortgaged. Mortgages of this character, as well as those based on income, generally run only for a short period.

The extent to which a road may be properly encumbered depends, of course, upon its net receipts. Great conservatism is usually exercised. The multitude of properties that have passed into the hands of receivers represent, generally, risks well understood from the start.

There are sometimes as many as five distinct mortgages upon a piece of property. A fifth mortgage does not seem to be a very valuable security; yet it may be preferable in every way to a first mortgage in another case. Its obligations may be promptly met and it may command a premium in the market, while a first mortgage in another case is discredited. The various mortgages on a property represent its different stages of progress and are usually evidences of prosperity.

The objection to a mortgage on a railway is its lack of flexibility. It makes no distinction between a property destitute of value in itself and one requiring only time to build it up. Many of the mortgages that have been foreclosed and the properties sold at a deplorable sacrifice, would ultimately have been paid in full with interest if the owners had been compelled to wait. For this reason a mortgage is too rigid, too exacting, to meet the exigencies of the situation. Instead of protecting its holders it may be made the means, under false representations, of freightening them into sacrificing their investment.

Every mortgage provides for one or more trustees, whose duty it is, if the interest and principal are not paid when due, or within a specified time thereafter, to advertise and sell the property, if called upon by the holders of the bonds. The manner and form of action are prescribed. The minimum amount of bonds required to compel action upon the part of the trustee is also indicated. This amount is commonly made so small as to protect all the holders. In the event of default the trustee may, of his own volition in many cases, go ahead and foreclose without being called upon by holders. He is supposed to act always in their interests.

Mortgages take precedence according to their dates. Thus, the foreclosure of a third mortgage does not affect those of a prior date. But the foreclosure of a first mortgage invalidates all others; but if there remain any surplus over and above the amount required to satisfy such mortgage, it must be divided among the holders of the next succeeding mortgage, and so on until it is exhausted. In the event of the foreclosure of a first mortgage, or of any mortgage, the holders of the next succeeding mortgage usually redeem the property if its worth justifies.*

Debenture stock is a favorite form of security in Great Britain. It has a fixed rate of interest and is a positive lien upon the property, but there is no trustee, no definite form of procedure involving the whole issue in case of default. A holder can, if his interest is not paid, levy upon the company's property wherever found and place his name upon it and hold it until his claim is satisfied. Co-operation with other holders is not obligatory and the sale of the property proceeds no farther than is necessary to reimburse the disaffected holder.

In some portions of the United States mortgages must be recorded upon the books of the recorder of deeds or other desiginated officer for each county in which the property is located. In other cases it is only necessary to record the mortgage at the state capital. An unrecorded mortgage has no value as against a recorded mortgage or the judgment of a court.

Attached to every mortgage bond issued by railroad companies are diminutive notes of hand

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*In the event the requirements of an inferior mortgage are not satisfied, the holders of such mortgage have in some cases the right to compel the holders of prior mortgages to become parties to the foreclosure proceedings, thus forcing the holders of such prior bonds to accept payment for the same in advance of the time originally specified.

called coupons.* Each installment of interest covered by a bond, whether annual, semi-annual or quarterly, is represented by one of these coupons. The number of coupons attached to a bond is sometimes very great. A coupon when due is in the nature of a sight draft on the company issuing it.

Every bond specifies on its face where the interest and principal are payable; also in many cases the form of payment, whether gold or silver.

Registered bonds are somewhat different from coupon bonds: both principal and interest are payable to order. A registered bond can only be collected by the person in whose name it is registered upon the books of the corporation; this name is inserted in the body of the instrument. No coupons are attached to registered bonds. When interest matures it is forwarded to the address of the person in whose name the bond is registered. The expense and annoyance of transferring registered bonds when they change hands detract somewhat from their marketable value. They are, therefore, never issued except upon request.

The bonds of railroad companies and those of the government are much alike in form. The

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* On the first day of January, A. D........

THE MINNEAPOLIS & SOUTH PACIFIC RAILWAY COMPANY
Will pay to the bearer hereof THIRTY-FIVE DOLLARS, IN GOLD COIN, at its office or agency, in the city of New York, or, at its option, SEVEN POUNDS STERLING, at the office or agency of the BANK OF MONTREAL, in the city of London, England, being SIX months' interest due on that day on its ($1000) First Mortgage Gold Bond, No. 236. Dated JUNE 21st, 1879. L. C. JONES, SECRETARY.

$35 £7 1

manner of paying interest is also much the same. The interest on different issues of bonds does not all fall due at the same time; no rule save the convenience of the company or of proposed purchasers of bonds is followed in fixing the date and place for paying interest. In some cases interest is paid only once a year; in some cases quarterly; the general rule, however, is to pay it semi-annually.

Interest on bonds constitutes a separate item in the income or profit and loss account.* It is called with rentals and guaranteed dividends, a fixed charge.

Such are some of the details connected with mortgage bonds. Where properties are leased, the amount paid as rental takes the place of interest on bonds in the accounts and returns of the lessee. In some cases, however, the interest on the funded debt of the property leased is assumed by the lessee, in which case it may thus appear in the returns in lieu of rental or as part payment of rental.

The same diversity that is noticeable in other operations of railways characterizes their leases.

* The returns of the United States government require that the amount shall be entered on the books of a company each month as it accrues, estimating the interest for six months in advance, from the commencement of the fiscal year (July 1st) on the basis of the bonded debt at the time the estimate is made. In this way one sixth of the interest for the half year is entered up monthly; any differences that may occur in consequence of bonds being withdrawn and cancelled or new bonds issued during the half year being considered in the charge to "Interest on Bonds" for the sixth month. Many companies, however, do not bring the interest charge on to their books until it falls due.

A description of the basis of the latter is, therefore, impracticable. Their scope and purpose find expression in the provisions that hedge them about. The consideration is never the same in any two cases. The manner of paying rentals for leased lines also varies. Sometimes a fixed sum per annum is paid. But more frequently the amount is dependent upon the earnings of the property or is based on the number of passengers and tons of freight transported. Sometimes on the earnings per train mile. Whatever the basis, the instrument fixes the manner, time and place of payment. As the value of a railroad is dependent upon the fidelity and skill exercised in its maintenance, the obligation of a lessee to operate so as to secure the best results is usually set forth in the instrument at great length.* Arbitrators are usually provided for in every lease

* I find the following in reference to this phase of the subject in an old lease: "And the lessee agrees that at all times during the existence of this agreement he will faithfully maintain and efficiently operate said railroad, and keep the same in good repair and condition, with appurtenances and incidents . . . furnish and supply at all times a sufficient and ample amount of motive power, and passenger and freight and other cars, to do advantageously and in a proper manner all the freight and passenger business which may be offered or procured for said road, and which may be secured to the said line . . . and will in all ways furnish all needful and proper facilities for the increasing business of said line, and the growing demands of the country by its increasing production, or by the extension of said railroad communication; and will further adopt such judicious and efficient measures as may tend to make the said line a main and prosperous line; the lessee further agrees that during the term hereby granted, he will operate, maintain, and keep in repair the said demised premises, pay all

(in the event differences arise), the manner of their appointment and the rules governing their action being carefully prescribed. A lessee usually pays the taxes on the property leased and makes full returns of its affairs to the lessor. It is customary for the latter to reserve the right to examine the books and accounts of the lessee at pleasure. It is a duty of the lessor to keep up the legal organization of the property.* He is also required, as a rule, to maintain the lessee in peaceable possession and pay all liens or incumbrances on the property, including the expenses incident thereto.† In addition to the

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taxes assessed upon it, and indemnify and save harmless the said lessor against and from all costs, expenses and damages growing out of the maintaining, repairing, operating and using the said road."

* "And the lessors hereby covenant and agree that they will, during the term in which the provisions of this indenture shall be in force, preserve and continue the legal organization of said leased road; will hold meetings, keep records, pass votes, and appoint officers, so far as necessary to enable the lessees to carry into full force and effect the objects of this instrument; and that they will give such further assurances as may be necessary therefor, and that they will at any and all times hereafter, when thereunto requested by the lessees, use their corporate powers, and do and perform in their own corporate name, any and all acts and things that may be necessary fully to protect said lessees in the full enjoyment of all the rights and privileges herein granted."—*Extract from old lease.*

† "And the lessors further covenant and agree, that they will at all times protect the lessees in the quiet possession and enjoyment of the premises and rights hereby granted, or intended so to do, on said line of ——— miles, and will assume and pay all liens and incumbrances at any time found to exist thereon, with all costs, damages, and legal charges by reason thereof."—*Old lease.*

leasing of railroads as a whole, many leases are made to cover particular things, such as use of tracks, terminals, buildings and docks. In this way two or more companies frequently use properties in common.

Transportation in Greenland.

CHAPTER IX.

CAPITALIZATION — PARTICULARS OF SINKING FUNDS.

A majority of people have only a vague idea of what constitutes a sinking fund. Many who are otherwise attentive to what transpires about them refuse to consider the term at all when they meet it in print, but dodge it as they would a weak spot in the ice. They look upon it as an enigma of finance that only a few favored mortals may understand. Webster, defining the verb "sink" says, "To cause to sink; to put under water; to immerse in water, as to sink a ship; to depress; to make by digging or delving, as to sink a pit or well." This explanation, though lucid, affords no clue to the term used in the vernacular of corporations.

A sinking fund is something set apart for a particular purpose. It does not necessarily consist of money. We will suppose that a government or railroad company has certain bonds that will become due at a specified time in the future; to insure the payment of these bonds, a fixed sum is laid aside annually, or semi-annually. This sum, or the proceeds thereof, can be used in the payment of the bonds specified, and for no other purpose. The sum thus laid away is called a sinking fund.

The custodian of the fund is the trustee. Sometimes there are two or more of these officers.* In many cases a trust company acts. The last named practice is growing more and more in favor. It offers many advantages.

The value of a security for which a sinking fund is provided, is dependent somewhat, as may readily be supposed, upon the character of the trustee. His discretion is oftentimes large; he may rigidly enforce the provisions of the instrument or he may evade them. No penalty usually attaches to him for neglect. In the case, however, of trust companies they are usually held to a more rigid responsibility than individuals; their duties are better defined; they are better paid.

The holders of a security, for which a sinking fund is provided, are permitted to call upon the trustee to ascertain if the requirements of the trust are complied with, but this is rarely, if ever, done. People who think about such things at all take it for granted that the trustee is performing his duty, and so let the matter drop.

Another phase of the subject presents itself. When a sinking fund is payable in cash, as it is in many cases, what is to prevent the trustee, if a private person, from appropriating the amount to his own use? His honesty! He rarely, if ever, gives a bond.

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*Provision is usually made in the instrument creating the sinking fund, for the appointment of trustees in the event those specifically named die or cease to act.

Frequently no provision is made in a mortgage for a sinking fund. As a rule, however, if the amount is large, the most careful forethought is exercised to protect holders in this way. Under ordinary circumstances the creation of a sinking fund is esteemed imperative by investors. The

Indian (American) Carrier.

object sought is, of course, to strengthen the security; to insure the fulfillment of all the obligations of the mortgage, including the payment of interest and principal when due. The company issuing the mortgage binds itself to place a specified sum at fixed periods in the hands of the trustee. Sometimes these payments are in cash; sometimes in bonds of the issue for which the fund is created; sometimes in other specified securities. Provision is also made, or should be, in regard to investing the accretions of the sinking fund, *i. e.*, the interest and premiums that accrue on the amount in the hands of the trustee.

In case uncancelled ("live") bonds are deposited, the provisions of the fund usually require that the interest on such bonds shall be collected by the trustee and added to the fund. Whatever the amount the trustee of a sinking fund may have in his hands at the time the bonds mature he uses in the payment and cancellation of the mortgage. To prevent any improper use of bonds thus deposited, the fact that they are held in trust should be plainly stamped upon their face.

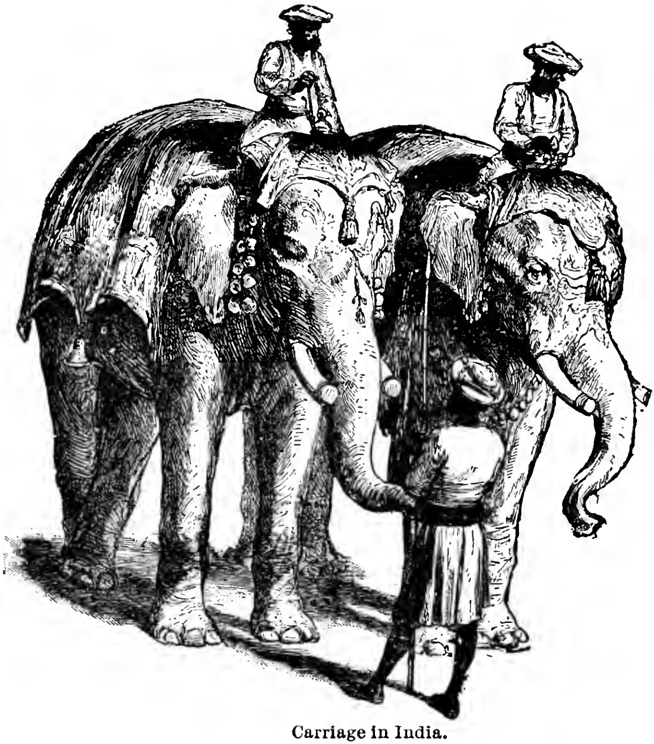
Sinking funds should never be paid in cash. Either the bonds for which the fund is created should be purchased, or in the event that is impossible, then government or other stable securities.

In many cases it is provided that in the event sufficient bonds can not be purchased at a specified price in the market to satisfy the sinking fund, the trustee may draw by lot the number of bonds required, the holders of such bonds being compelled to deliver the same at a stipulated rate. This plan is a very good one, but is objectionable to the holders of bonds as it makes the duration of their investment uncertain. This lessens its market value. Such provision is, therefore, held in the place of a stable security, as undesirable.

Of the various forms of sinking funds, that which requires the keeping alive of the bonds and the collection of the interest thereon, and investment of the same by the trustee, affords the greatest security.

But whatever method may be adopted, it is necessary that the trustee should give guarantees for the faithful performance of his duty. Trust companies should afford this in their subscribed capital and in the character of their officers and stockholders.

In reference to the treatment of sinking funds in the accounts they are in the nature of unrepresented capital. A sinking fund takes the place of obligations that at one time represented cost. It has, therefore, the same rights as the original investment; the right to be represented by bonds or shares. It is not chargeable against income account any more than any other capital expenditure. The reason why we so often find it included in the income account, is because of the extreme conservatism of proprietors. This is another way they have of strengthening their properties. It is similar in effect to making improvements with net earnings. While it appears to trench on the rights of stockholders, it is not to be hastily condemned. The fact that it is done by sagacious and practical business men is, in itself, sufficient evidence that it is necessary, proper and wise.



Carriage in India.

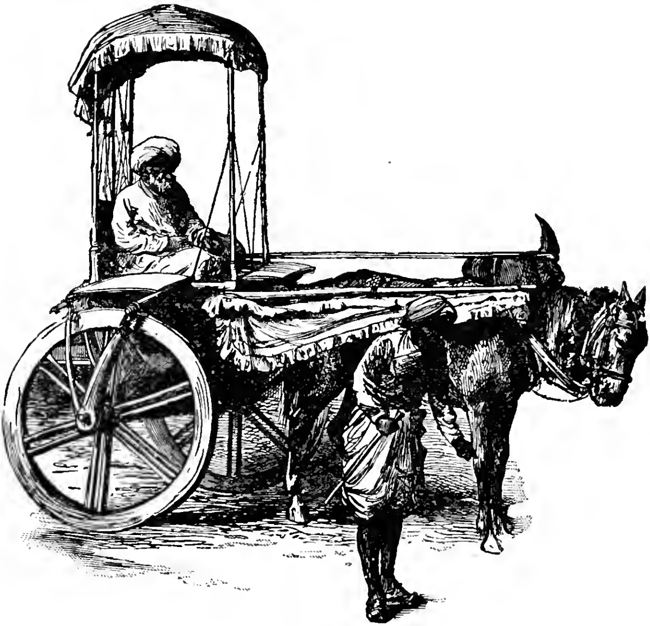
CHAPTER X.

CONSTRUCTION—RAILWAY CONSTRUCTION AND EVOLUTION.

That form of railway construction is most to be commended which best answers the commercial wants of a community; that restricts cost to the narrowest practicable limit. Anything beyond this is a perpetual burden on a country.

It is the dream of idealists that particular kinds of engines or cars should be used; that cars should be lighted or heated in a particular way; that tracks should be straight or level; that bridges and buildings should be of stone or iron; that ballast should consist of a particular kind of material; that rails should be heavy; that ties should conform to a particular pattern; that crossings should be above or below grade; that trains should run fast; that artistic features of construction or landscape gardening should receive greater attention and outlay. All these questions are purely practical ones, however. Sentiment has no proper place in the economy of railway construction or management any more than it has in developing or operating farms. They are matters of business merely; of good judgment and common sense; of freedom from bias; of making outlay conform to income.

That the disposition will grow to add items of luxury to railroads without reference to their revenue producing qualities, there can be no doubt. Estheticism, sentimentalism, idealism, will contribute to bring about such a result; but



Carriage in Bengal.

let us put it off as long as possible. It is not in the interest of the people; of their good or the good of railroads.

Railroads should be constructed and operated solely with a view to handling traffic. Ideal questions should not be considered. At least not now. Questions of need and practical utility should alone receive attention. In any event the operation of railroads should harmonize with their income the same as with individuals. An extravagance not in accord therewith is paid for with multiplied usury. Luxuries accompany a plethoric purse, not an empty one. In the case of railroads extravagance in this direction is generally the outgrowth of excessive competition, and may not, therefore, be avoided at will.

The wise location, economical construction and efficient management of railroads are all-important.

Railway economy acts and reacts on the commerce of a nation. Railways if managed efficiently and economically, greatly stimulate the commercial growth of a people; if mismanaged, greatly retard it.

The impossibility of telling in advance exactly what is needed is apparent. It is especially difficult in a new or undeveloped country. The most glaring contrasts everywhere present themselves. Thus, India with a population equal to twenty thousand people per mile of railroad transports less freight per mile than Canada with a population of only five hundred per mile of road. The latter is the home of a virile commercial race; the commerce of the former is light.

The trading capacity of a people is evinced in the use it makes of its railroads. George Stephenson, speaking of England, said that "the making of the railroads would be the making of the country." The truth of this has been evinced in every land where the industrial thrift of a people has warranted the construction of a railway system.

Railways were known in the time of ancient Rome. The rails were of stone. Tramways were of later invention. They possessed no extended value, however, until the introduction and utilization of the locomotive. Stephenson first accomplished this in 1829. The first railway in England is thought to have been constructed about the year 1600 to aid in moving coal from the mines near Newcastle on Tyne. The rails were of timber, straight and parallel to each other; on these, carts made with four rollers fitting the rails, traveled, the carriage being so easy that one horse is said to have been able to draw "four or five chaldrons of coal."

Stephenson was a machinist and an engineer. A genius. He did not construct the first locomotive (the Rocket) but he made it useful. He devised the apparatus by which it was made to generate steam at will and in sufficient quantities. The relation that the weight of the locomotive of sixty years ago bore to the load it could haul, as compared with the weight and carrying capacity of the locomotive of today, shows how much it has improved. Formerly it was only able to haul ten times its own weight; today it can haul fifty times its own weight, even more.*

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*The Rocket weighed four tons and hauled forty tons. Locomotives of today weigh sixty tons and haul three thousand tons. Nor is the limit yet reached.

The locomotive followed naturally a suitable roadbed, as the wagon and carriage followed a suitable highway. The railway track was first suggested in connection with the handling of coal. The bulk of the latter, and the necessity for cheapening its price, made some simple appliance for transporting it absolutely necessary. "The earliest railways were laid in the coal mines and from the mines to the adjacent watercourses. These ways consisted of squared timber rails laid in the ground, held to gauge by cross timbers, to which they were fastened by wooden pins."* Horses were used. The cost of transportation over these tramways was about ten per cent. of that over the turnpike.

Rails were first cast; afterward, early in the nineteenth century, they were rolled. At first a wooden rail was used. Then one of wood and iron, a strip of metal being laid on the wood to support the wheel and save wear and tear; this was called a "strap" rail. The present form of "T" rail, with its supporting base, was, it is said, devised by Robert L. Stevens, of the Camden and Amboy Railroad, in 1830. The especial value of his rail consisted in the fact that it rendered the use of cheap wooden ties practicable. It also obviated the necessity of the expensive chair and other devices then in use. Inability to pay for these appliances in America necessitated adopting something whereby the expense might be avoided.

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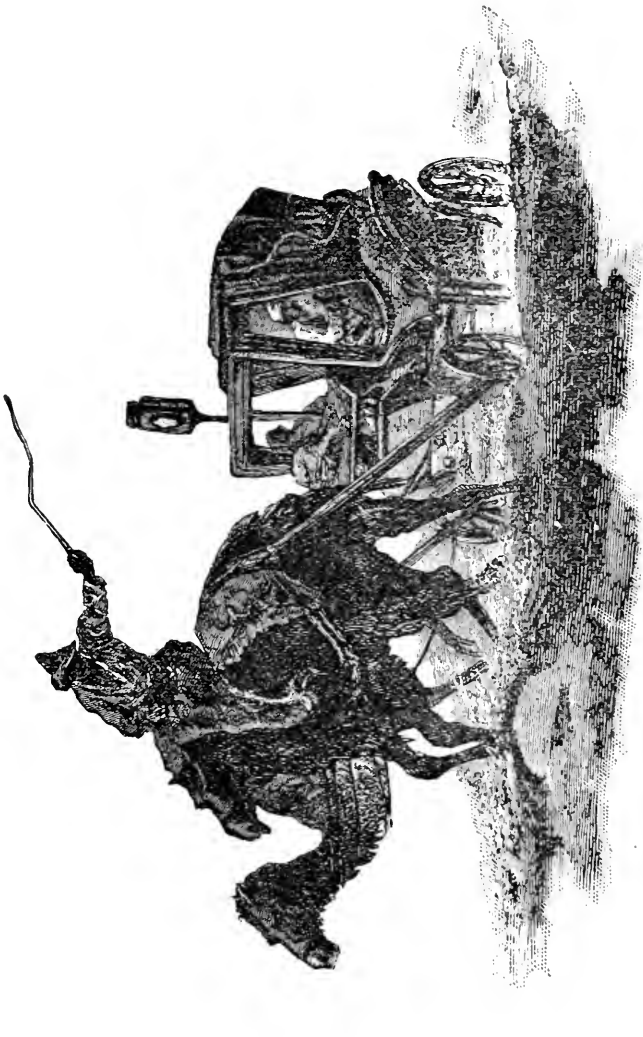
* "The Development of the American Rail and Track," by J. Elfreth Watkins.



Carriage in Central Asia.

However, notwithstanding its wide base, the rail is found to cut more or less into the tie. With the constantly increasing weight of equipment and load this defect is accentuated. One of the means of overcoming it is the use of a "chair," or metal plate, placed between the rail and its support. Another the use of a metal tie.

The evolution of the rail, with its support and fastenings, is both curious and instructive. Illustrations tell the story better than words. These will be found in a subsequent chapter. They afford a connected study of various forms of rails that have been used, the different kinds of stone, wood and metal supports that have been tried, and the splices, chairs and fastening that have been invented and used from time to time.

No single item of construction equals in importance the track rail. It has been the subject of study and experiment by chemists, manufacturers and railway managers and operatives since railroads were first opened. And while the texture and pattern have been greatly improved, they are yet far from satisfactory. No particular form has been adopted that is everywhere recognized as superior to all others. Uniform patterns for different uses are, however, of the greatest importance on many accounts. They would cheapen manufacture because they would lessen the machinery of manufacturers and render it unnecessary to keep a great variety of patterns on hand. Once a uniform pattern had been agreed upon, the manufacturer could carry it in stock the same as other standard material. It would furthermore assist those in making selections who know little about such matters.

Rails differ widely in form, texture and weight. The strain they are subjected to is constantly changing. Each year the tendency is to increase the load. The speed of trains also grows greater. There must be harmony throughout. A rail that will answer for light use will not do for great weight or high speed.

The adoption of standard rails, while having advantages, would also have disadvantages. Unless engineers and others fitted for the work should continue their experiments and studies afterward with fidelity and zeal, there would be great danger that progress would be stayed. But if enquiry and experiment could continue unabated, the danger that always attends the adoption of standard forms might be measurably avoided.

Railway development is influenced by the demand that exists for its product and the treatment that such properties receive from the public. Unfriendliness on the part of a people affects unfavorably the construction of new lines. Railways are the natural adjuncts of civilization, and their growth is assured wherever protection is accorded them; wherever they are allowed free scope to prosecute their business within necessary and proper limits. Refusal or neglect to do this will prevent their construction, except in those cases where prospective gain outweighs possible risks.

Railways, like other industries, adjust themselves naturally to the countries they serve; to the instincts and habits of a people. Their construction depends upon the demand there is for them, the plentifulness of money, the rate at which it can be obtained and the protection accorded them.

Where wealth is plentiful, where a people are accustomed to stable conditions and permanent structures, where industries are grounded in the soil, so to speak, the physical structures of railroads usually conform thereto. In new and poor countries, makeshifts are the rule; the ingenuity, the genius, of man is taxed to the utmost to lessen cost, to avoid expense, to be economical where his inclinations lead him to be profuse. The marvelous railway development of the United States is a demonstration of the truth of this.

Every invention that lessens cost is a gain to a community. We are indebted to such devices, not only for the marvelous growth of railways in the United States, but also for the great reduction in rates that has attended their progress.

It is noticeable of railways in different countries that the particular patterns or devices they first take on cling to them afterward. The form of equipment adopted in Great Britain shaped the gradients, curves, bridges and tunnels of its railroads. They can not now be changed. In the United States, where money was scarce and credit poor, it was necessary to adopt something less expensive. The effect was to change the English method of construction and at the same time simplify and cheapen it. Railroads were made to conform to resources. They are different from those of Europe in alignment and grades; in the protection afforded at stations and crossings; in bridges, culverts and tunnels, and finally in the roadbed itself. While European companies built their permanent structures of stone, America built of wood; piling took the place of great embankments, trestles of arched masonry. While cheaper in the first instance, the cost of maintaining in America was somewhat greater. However, such practices nurtured economical habits and the exercise of prudent foresight; expensive roads were not built where cheap ones were sufficient. The roads that were cheaply built are now being improved out of the earnings of the property or by increased capitalization, as circumstances render desirable. In this way great properties in the United States have been built up; others are being built up. Canada, Mexico and South America are, in many respects, following a similar policy.

Particulars of railway construction can not be described. They are not exactly alike in any two countries. The devices of one differ from those of another. Thus the wooden bridge, so familiar to Americans, has never been known in Europe. The wooden structure is being replaced, not with stone, but with steel.

The word "permanent," while much used in railway nomenclature, has no proper place: change is the rule. It was suggested in the first instance by the solid wall, coped with smooth cut stone, used to support the rail, in place of the cross tie that we use today. It was called the permanent way. It was as nearly permanent as anything could be. But it lacked elasticity and so was quickly abandoned.

Preliminary construction work is interesting. An excursion is first made over the proposed railway line by a competent person or committee and the topography of the country carefully noted, necessary enquiries are made and statistics collected. The route having been determined upon, it is methodically surveyed and the right of way obtained. Afterward the plans and maps are passed upon and such alterations made as circumstances suggest. Sometimes repeated surveys are made. The importance of a proper location is supreme; upon it depends cost of construction, the load that may be hauled, the business that may be secured, the expense of maintenance and operation.

After a line is agreed upon, the next thing in order is to prepare specifications of cost for use of engineers, contractors and others. In many cases the owner himself builds the road, especially in the case of extensions of old lines. But in every instance the duty of supervising the work falls to the engineer. It is his duty to stake out the proposed line, make estimates of work done as it progresses and arrange for payments. This is his natural field and in it he is supreme. His duties are at once laborious and of the highest responsibility. They entail close application, long hours of work, exposure, and the attendant hardship that progress through an open country away from comforts and conveniences naturally entails.*


Carrier of Morocco.

The exact location of a railway and the wise and economical expenditure of the money used in its construction depend largely upon the engineer. The growth of his office has been great and marked. In no other branch of the service was there less conception originally (especially in new countries) of just needs than in the engineering department. It was extravagant, ill advised and self sufficient. This condition of affairs did not long continue. From being an abstractionist or a creature of formulas merely, the engineer has added to his acquirements adaptability, practical knowledge, financial skill, business training. The status of the engineer in the early history of railroads was

* The duties and peculiarities of the civil engineer are referred to more fully in the volume "Organization and Forces."

much misunderstood. He was supposed to be wise above his fellows. The contrary was the case. In America responsibility for location and, largely, of method, was early taken out of his hands by men who studied the means as well as the ends to be achieved. But as he has grown in worldly wisdom and commercial sense, the work has been given back to him and he has gradually resumed his natural and proper place:

"In its earliest development, engineering was hardly more than an art, a trade acquired by example and experience progressing slowly by small degrees from precedent. . . The dominant spirit today is scientific; the application of principles without much regard to precedent. Only conclusions derived by logical methods from exact data and applied to conditions which have been fully valued, inspire respect. Experience is also demanded, that experience in the application of forces and materials which gives practical skill and confidence, but not in the nature of that precedent, which is too often a handicap under different conditions. . . The profession is losing its transient character. Tenure of position is more secure and work on many lines is done throughout wide sections by engineers from a central office or headquarters. The engineer is assuming more the position of counsellor, is more the executive factor in the conduct of large operations, is retained more as an adviser on the staff of industrial enterprises. All this gives stability, material rewards and independence; gives the engineer a fixed abiding place and makes him a factor in the community in which he lives; enables him to develop the social qualities he needs and leads to that preeminence enjoyed by our profession in older lands."*

In locating railways, the nearer level they are, or can be made without too great outlay, the cheaper, relatively, it is to operate them; the greater the load they can haul, the greater their ability to stand the strain of competition. This last every company, to a greater or less extent, sustains. If anticipated, it may be met with less embarrassment. Every obstacle that will impede traffic or the continuance and rapid movement of trains is, so far as practicable, avoided. The speed of trains, directness of route, the load that may be hauled, and cost of maintaining and operating, are determining factors. These the engineer is required to keep constantly in mind.

Under all well established and stable governments, save ours, no road is allowed to be built that does not answer a possible want; that does not open up a new field; that will not presumably have sufficient income to pay cost of maintenance, operation and fixed charges. The exception is the case of roads built to meet military or political aims. In America, however, from the start railway construction has been free. Whoever could raise the means might build.†

In our day the location of railways determines the center of communities, just as the highways

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* L. E. Cooley, C. E.

† This phase of the subject is referred to in the volume "Economy of Rates."

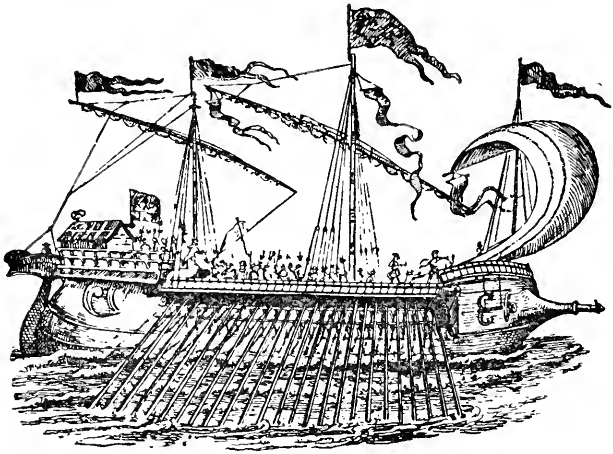
of the past did. An animated contest has been waged by railways with the watercourses of the would from the start. At first it was for supremacy. Afterward for revenue. At the present time, so far as rivers and canals are concerned, it is a fight on the part of the latter for existence.

The construction and operation of railways invite speculation and have occasioned many grave financial crises. Such evils, however, carry their own cure. Legislation can do nothing. The uncertainty of the business of railroads invites more or less speculation. This is especially true in their earlier stages. Within certain limits it is not harmful. Except for speculation, no great enterprise attended with uncertainty would be carried out. We owe the development of our railroads to men who are willing to take certain risks because of the prospect of large gains. "Speculation is a necessity of modern life. Modern business involves large risks. . . . It rests with individuals to learn the lessons of each crisis, and protect themselves as best they can from a recurrence of the same evils. . . . A new permanent investment is almost necessarily speculative."*

Each year that a railroad exists it becomes more and more a permanent geographical feature. In time it will become like a navigable river or inland sea which supplies a particular territory

*Arthur T. Hadley. "Railroad Transportation," pages 49, 50 and 51.

or affords intercommunication between far distant places. It can rarely, if ever, be considered distinctively as a local enterprise. But whatever complexion it may take on, the property interests of those who own it can never be disregarded. The original interests that fostered its growth must also be remembered.



Spanish Form of Carriage, 16th Century.

The political importance of railways can not as yet be fully estimated. In the easy intercommunication they afford between widely separated peoples, all prearranged ideas of local environment or national exclusiveness vanish. Their effect on exchanges and the habits of mankind is marked and progressive. Their tendency is to foster great enterprises, to swell the volume of business, to increase the importance of trade, to obliterate political lines, to create new social conditions. In time the means of intercommunication they afford and the common markets they create will tend to make the commercial world a unit; to make possible the visions of philanthropists and dreamers.

In the inception of railways expectation ran high as to the probable speed trains would attain. These expectations have not been realized. On the other hand, rates are much lower than it was supposed they could be. Growth of traffic has contributed especially to this. Rates are always and everywhere dependent upon the amount of business; a great traffic makes possible a low rate.

Low rates are also accelerated by cheapening appliances, improved methods, better management and increased facilities. Under these co-operating influences the impossible has become possible; isolated and struggling villages, otherwise unimportant, become great cities; primitive continents have in a decade become settled and civilized.

In the location of American and English railroads their military value has been little regarded; this feature has, however, been a distinguishing mark on the continent of Europe. In all countries, it is probable, railways will afford the lines upon which the battles of the future will be fought.

In the early history of railroads, legislation concerned itself almost wholly in fostering their growth. Latterly it has turned its attention to their control, to an attempt to regulate their business, to prescribe their methods, to say what they shall do and what they shall not do. Wherever these efforts have not conformed to economic laws they have been hurtful both to the owners of railroads and the people. Mistakes of this kind have been numerous and glaring. Their correction is exceedingly difficult; it requires time and a juster appreciation of the rights of property and the regulations of trade.

CHAPTER XI.

CONSTRUCTION—METHODS OF CONSTRUCTION.

The term construction has a well understood meaning in railway parlance. It embraces the original or first cost of a property; all disbursements, expenses, costs, commissions, salaries and debts incurred in connection therewith or incident thereto. It also includes all interest that accrues while the property is in course of construction and before it has been opened for business; all disbursements and losses suffered in the sale or disposal of bonds, shares, securities or assets, the proceeds of which are used for construction; also all expenditures on account of rights, franchises and appurtenances. These constitute the first cost of a property—its construction expenditures.*

Some of the the differences noticeable in railway construction upon different roads are inherent; others, again, are of method merely. The

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*Construction *accounts* and *classification* are treated of in the volume "Fiscal Affairs, Disbursements." *Construction* is also referred to more or less extensively in connection with the *Maintenance* of railways in the last part of this volume. The two subjects are so inseparably intertwined that a description of the maintenance of railroads incidentally involves a description of many important features of construction.

loam ballast, for instance, that answers upon the upland roads of Colorado will not do at all in India, where rains are heavy and prolonged. Such differences are inherent. On the other hand, the use of wood and metal ties are largely differences of method, although it is true that the destruction of wood by ants and dampness in hot, humid climates renders the use of something less destructible highly desirable.* The practice of one engineer to lay rails with broken joints and to anathematize all who do differently is an instance of method merely. Others claim both ways may be right. One engineer advocates supported joints for rails, while another does not; both may be right here also. On one railroad fish plates forty-six inches long will be used, while on another eighteen inches is esteemed sufficient. Both practices may be right, taking into account roadbed, speed and weight of trains, shape of rail, plate and so on.

Variations in construction that are not necessary entail added cost and should be avoided if possible. Such differences arise from lack of experience and study. They are oftentimes the result of prejudice or indisposition to learn. Ignorance is especially arrogant, supercilious and self sufficient. I remember once spending three months writing rules and regulations govern-

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*It is noticeable in railway operations generally that the wooden tie each year costs more and more. Limitation of supply occasioned by the destruction of forests occasions this. This will bring about the use of metal ties ultimately.

ing a particular phase of railway business. An officer of a road adopted the method they covered, but said he had not adopted the rules and regulations, indeed had not read them be-

Chinese Emperor's Carriage, 16th Century.

cause he wished to adopt something original. This spirit too often animates corporate officers. It is the result of arbitrary exercise of power without financial risk; of overweaning egotism;

of jealousy and narrow mindedness. As the service fills up with men of education, they will esteem their own wisdom less; will avail themselves of the knowledge of others more. That is where an educated man has the advantage of those who are not. It is in the main useless to attempt to teach an ignorant man; he is superior to books; he can not appreciate how superficial his knowledge is; how much we may be benefitted by study and comparison; he is all sufficient; that is his proud prerogative.

Uniformity in railway construction and method, while desirable wherever possible, can not be enforced arbitrarily. That would, if nothing else, stifle interest; would put a stop to invention; would retard advancement. That is the objection to standard forms and methods of all kinds. Wherever introduced they must be attended by continued inquiries and experiments; by systematic provision therefor. Unless such a course is followed, interest will quickly die out and with it hope of further advancement.

In constructing a road much depends upon the topography and business of the proposed line, much upon the financial ability of the company. Necessary things are oftentimes long delayed for lack of funds. After the opening of a line further work is only undertaken after the most searching enquiry. After being passed upon by local officials it is referred to the board of directors for authorization, unless the expenditure is an unimportant one.

The circumstances attending the expenditure of money for new construction work are the same in different countries, except that the scrutiny of the directory is more minute in some instances than in others. English directors are noticeable in this respect. They require to be kept advised of everything. Englishmen possess an especial aptitude for working in committees. Their political wisdom and adaptability they also evince in the government of private corporations. Their practices in regard to improvements and additions to railways are thus described by one skilled in such matters:*

"Recommendations for increased accommodation at stations and depots undergo a very searching examination before any effect is given to them. We will suppose, for example, that a goods [freight] agent conceives it to be neccessary for an additional siding to be laid at a station. He makes a report to that effect to the manager of the district; the latter enquires into the facts on the spot, and, if he concurs with the necessity, reports his recommendation to the general manager. The latter consults, in the first instance, the chief goods manager or the superintendent of the line, as the case may be, and, if his report be favorable, authorizes the engineer to prepare a plan and estimate. The plan, when ready, is subjected to the criticism of the district officer, the chief officer, and of the general manager, and if all are satisfied the directors are next asked to

* Colonel George Findlay, "The Working and Management of an English Railway," page 19.

authorize the necessary outlay. But even this is not all, for, finally, the plan has to be signed by the chairman of the company before the engineer commences operations, and that gentleman, who keeps a watchful guard over the company's purse strings, has to be convinced that the expenditure is not only desirable, but actually unavoidable, before his signature is obtained."

This is substantially the practice of railway corporations everywhere. So manifest is the waste where proposed improvements will not be remunerative that they are never undertaken except after the most careful enquiry.

The managers of American railroads have no superiors in the world in constructing and operating railroads. This is evinced in many ways. America differs from Great Britain. The railroads of the latter are costly and the rates high; her roads are, however, well built and efficiently managed. So far as faithfulness in the discharge of trusts reposed was concerned, it is probable that the owners of English railroads had less cause to complain, in the early history of these enterprises, of their agents than owners in other countries where business methods were not so well systematized, and fiduciary responsibility not so well enforced. The cases were very rare indeed in England where the servants of railroads laid themselves open to the suspicion of improper practices, of having taken advantage of their position to enrich themselves at the expense perhaps of their employers.

So far as railroads as a whole are concerned, rates are dependent on cost to the extent that if not remunerative no more roads will be built. A remunerative railroad system means multiplied construction. Unremunerative railroads mean cessation of railroad building. In respect to low capitalization America has the advantage of Europe. The first cost was less, while subsequent charges to construction have been more discriminative. The owners of European railroads have generally charged every improvement to construction, capitalizing the amount from year to year. America, on the other hand, has used a portion of its surplus to improve and strengthen its properties, charging the amount to operating. Abroad the surplus has been devoted to dividends. The result is capital account has increased until many railroads are unable to make an adequate return thereon; the resources of others are greatly strained, while the system, as a whole, approaches the danger line. Under the American system of paralleling and constructing railroads not needed, the competition engendered has in many cases prevented maintenance of rates or the payment of dividends. The monopoly that the railroads of other countries have possessed has enabled them to maintain rates and pay interest on gross cost from the start. They may be able to continue this. The situation is, however, such as to excite apprehension in the minds of many familiar with the subject. "On a survey of the whole matter, there would appear to be too much reason to believe that the financial position and prospects of English railways are going from bad to worse. Our railway boards have not as yet adequately realized this great fact, and have consequently done little or nothing to stem the tide of insolvency that threatens to overtake them."*

Carrier of Constantinople.

In the building of railways America had the advantage over Europe in this, that she was not wedded to any particular kind of work; had no theoretical standard to attain. Her aim was to make cost conform to means in hand and Probable Earnings. The result is a comparatively cheap railway system. In order to accomplish this, owners found it necessary to avail themselves of cheap appliances in every direction, of wooden bridges, wooden culverts, wooden piling and trestles, cheap buildings, light rails, scant ballast. These necessitated slow trains, but trains in the main quite on a par with their ability to earn money. The engineers of Europe could not, if they would, have constructed such a railroad. It was too flimsy, too ephemeral; too repugnant to ideas acquired by hundreds of years of stable construction and progressive work.

* J. S. Jeans.

Nevertheless, the American system is the proper one, if a doubt exists as to the productiveness of a property. First cost should be adapted to possible income and improvements made afterward as events justify.

Another means of lessening first cost has been the construction of narrow gauge roads. Whether this device has on the whole been a good one or not is doubtful. In many cases it has not. Where there is a prospect of through business requiring a standard gauge a narrow gauge road is in many respects an expensive device to cheapen cost in the first instance.

Whenever practicable railways should be perfectly built before being opened, *i. e.*, they should be suitably built to accommodate the work they are expected to do; the speed trains are expected to make; the loads they are to haul. The extra expense that attends the wear and tear of track and machinery on a poorly constructed road required to run fast and heavy trains is out of all proportion to the saving in interest on the added cost needed to have put it in proper condition in the first place.

In new countries men are satisfied to get through today safely; tomorrow is left to take care of itself. It is necessary oftentimes to disregard permanent interests to save present outlay. Thus, cheap temporary structures are built and rebuilt over and over again at an expense so near what it would cost to construct first class edifices in the first place, that inability to build durably at the start is paid for many times over with usurious interest. Such makeshifts are not necessary in old countries. Practices tend to the other extreme.

In constructing a railroad there is no fixed ratio of cost to gross earnings that it is safe to follow, even if we could tell in advance what a road would earn. It has been stated as a safe guide, however, by those who profess to be versed in such matters, that cost should be limited to ten times the earning power of a property and that equipment outlay should be limited to the amount of the annual gross receipts. Capitalization in the United States is, in both instances, less than these estimates.

The people of England and Eastern and Central Europe may be said to have no cheap railroads. Their methods of operation are also, generally, expensive as compared with those of America. They are, therefore, so far as cost governs, at a disadvantage. The conditions that attend freight traffic in the United Kingdom are directly the reverse of those in the United States; the speed of its freight trains is great, while the paying load is small. In America the speed is moderate, while the paying load is great.*

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*"The average English freight car carries a load of eight tons, and weighs five tons, being 1.6 to 1; the American box freight car carries fifty thousand pounds and weighs twenty-three thousand pounds, being 2.13 to 1."—*Edward Bates Dorsey.* The difference at the present time is still greater in favor of the American car. M. M. K.

The cost of maintaining an English railroad is, in some particulars, much less than maintaining an American road. This is because it is better built.* The English companies pay lower wages than American; but the number of employes per unit of traffic handled is much greater. Generally their methods are such as Americans would call extravagant.

Economy in railway construction and operation has been greatly facilitated in America by the use of what is called the bogie truck; a device that adjusts itself easily and naturally to the track, rendering shorter curves possible and producing much less friction than the rigid wheel base in use abroad.

The practice of loading freight for various points in one car and unloading same from station to station as the train proceeds has also decreased the cost of handling traffic in America. Its methods of accounting are also much simpler and cheaper than any other. There is less red tape, greater directness.

The cost of operating English railways is much increased by the exclusiveness on the part of patrons that they permit and encourage. Also by the retail business they perpetuate. The small carrying capacity of their cars and the practice of allowing shippers to partially load vehicles, is a burden that American companies are exempt from.

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* However, cost of maintenance is greatly increased in England because of certain peculiarities of equipment, noticed elsewhere.

The wide differences that exist in cost of operating railways in different countries will, in many respects, grow less and less marked as they are able to adopt the best appliances of each other. But no two systems will ever be exactly alike. Differences in construction and environment will prevent this. But so far as inherent differences of circumstances, places and men will permit, the good points of each system will be finally adopted by all. Business men are not tenacious of their methods when the effect is to deprive them of income. The difficulty in the way will not be with the business man, the owner, but with his agents. The latter will be more or less stubborn, more or less firm in the belief that their systems are the best, more or less intent upon devising and dwelling upon something original.

It is a necessity that rates should be lower in America than in Europe in order to move traffic over the vast distances that must be traversed. This has been realized from the start and has resulted in lessening construction outlay and cost of operating; in the adoption of simple substitutes in building and in keeping down the number of employes and in increasing the efficiency of such as were employed. The result is that cost of operating in America, taking everything into consideration, is the lowest in the world.

While rates have steadily tended downward in America, railway property has appreciated. Carriers have met decreased rates by increased loads;

by multiplying the capacity of their equipment and by better appliances generally. The limit of low rates, however, can not be far off, if not already reached.

While active railway competition increases expenses in some directions and lessens earnings in some particular instances, it is not without advantages. To its stimulating effect we owe all the substantial advances that have been made since railways were first opened. Had there been no competition, had not men been incited to invent and adopt better appliances to secure the favor of the public and lessen cost, there can be no doubt but that we should be using substantially the same appliances that were adopted in the first instance. Men progress, not because they love to progress, but because of strife and friction; because of rivalry; of a desire to secure advantages, to distance neighbors, to acquire and retain property.

In comparing the equipment of England with that of America we find that the type used in England is not susceptible of economical construction:

"Stephenson and his colleagues mounted the old stage coach body on car wheels, which became the type of passenger cars; the coal wagons that were then in use in the collieries were put on the railroad, and became the type of freight cars; and before the conservative English character thought that they ought to be improved, and should be changed, the trunk lines had been built, adapted to this narrow and low type of rolling stock. To have made it wider and higher later would have required the removing and reconstruction of the masonry platforms, the raising and widening of bridges and tunnels—in fact, almost a reconstruction of the road. This will prevent the use of high and wide cars. It is not fair to blame the modern English engineer for continuing the use of this description of cars, which he can not change at any justifiable expense. . . The English railroads have cost per

Carriage in the Arctic Regions.

mile more than three times as much as the American. . . One of the principal items of the greater cost is the necessity of having much straighter alignment or easier curves, so that it can be safely operated by the rigid and long wheel-base rolling stock in use there.* The Baltimore & Ohio Railroad is a sample of what can be done with the American rolling stock.

* It has been estimated that the long rigid wheel base of the English equipment makes the cost of maintenance of way, locomotive power, and repairs and renewals of cars double what it is on American roads for like service. M. M. K.

This road is built through a very difficult and rugged country, which compelled a very poor alignment, with nearly one half of the entire length in curvature, which curves run up to six hundred feet *radii*, and long grades running up to one hundred and twenty feet per mile. The country affords no natural advantages whatever. Yet, with all these drawbacks, this road does a very large and profitable business and operates its passenger trains safely at very high speed. All this is done on a road that could not be operated with rolling stock built on the English system. The extra cost of enlarging these curves to adapt them to English rolling stock would be so great as to be commercially impracticable. It is not difficult to appreciate the great difference in cost of construction, in an extremely rough country, of a railroad with curves six hundred feet, or twenty-six hundred and forty feet *radii*. Unquestionably the American system of construction is the best for new countries, or where cheapness of construction is desirable. The American rolling stock, with the bogie truck, will run safely and rapidly over roads of inferior construction, or sharp curves that would be impossible for rolling stock constructed on the English type of long and rigid wheel base. The American type is especially adapted for military purposes. . . . . Through an ordinary rough country, a railroad to be operated with the American type of rolling stock could be constructed in one-fourth of the time and for one-fourth of the money that one suitable for the English rolling stock could be built.*

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* Edward Bates Dorsey, "English and American Railroads Compared," pages 2, 76, 77 and 78.

America, in the construction of her railways, was happily free from many prejudices and habits that operated to the disadvantage of older countries. Its railways were made to conform to practical needs. If a road was not expected to do a large business, its cost was made to conform thereto. If it was not expected to require more than one train a day, it was built to accommodate one train. This adjustment of outlay to income, however, is seriously threatened in some sections of the country. Thus the railroad commission of Texas assumes to fix arbitrarily the number of trains that shall be run; to make in fact a political tribunal the judge of the commercial situation. Actual needs, paying loads, profits, precedent, all go for nothing. Capitalists may not, if this spirit is to spread, hope longer to build railroads based on traffic, but must consult the peculiarities, passions and ambitions of politicians and parties. However, capitalists need not make investments under such circumstances, and that the action of the Texas commission will tend to keep them from making investments in Texas there can be no doubt. But where this spirit does not prevail, capital will continue to seek investment in railways so far as traffic needs warrant. But no further. Nothing has heretofore been allowed to interfere seriously with a proper business conception of railroads in America and it is not likely to permanently in Texas. Supply and demand have, in the main, gone hand in hand. Expenditures have conformed to income. There has been no straining after theoretical objects in any direction; estheticism has been allowed to lie on the shelf; trains have been run to accommodate traffic, to conform to its profitableness; everything has been practical. In Europe, on the other hand, and more particularly, perhaps, in England, railway operation has had to conform more or less to custom, to firmly fixed habits, to preconceived ideas of what was needed. Thus, in constructing railways very little distinction has been made between productive and non-productive property. Everything must be stable and of the first class. "Unless it be in lighter rails, there is, in England, practically no difference observable in nature of construction between a short branch line, on which a small train runs to and fro three or four times daily, and the main line carrying numerous fast expresses. There are the same substantial bridges over and under mere country cart tracks, and all the usual culverts, fences and expensive station building, out of all proportion to the amount and nature of the traffic. Expensive brick freight sheds are found at many stations where the traffic is almost *nil*, and these, which can not possibly be paid for by the volume of traffic they serve, must go very far in the way of swamping the returns from the larger towns."* Extravagances like these are the penalty men pay in business affairs for permitting old time prejudices or preconceived notions to govern instead of practical needs.

* W. H. Booth, in "Railroad Gazette."

Carriage in Terai.

CHAPTER XII.

CONSTRUCTION — PARTICULARS OF CONSTRUCTION.

The cost of constructing railways has been greatly reduced by the cheapening of appliances and the introduction of better methods and implements. To enumerate these would involve a history of railway evolution; particular mention of every article used, because every article has been changed, bettered or cheapened. The object has been to lessen cost, to save work, to expedite business, to render it generally more satisfactory.

Every device that the ingenuity of man could suggest has been brought into requisition to lessen cost of constructing and operating. Generally speaking, mankind are in accord in devising ways to reduce the number of men engaged in building railroads; in cutting down cost of labor; in substituting therefor mechanical devices. But such is not the case everywhere. Men can sometimes be had cheaper than machines; cheaper than horses. This is the case in India. There myriads of men, women and children take the place of steam dredges, shovels and other devices for preparing the roadbed. As a rule, the work is carried on by hand, a common hoe and wicker basket being used. The natives often work in families; the head of the family digging the earth and filling the basket while the wife and children carry it away. There are sometimes two or three thousand people thus engaged on a mile of track. Labor is plentiful and cheap and the progress of the work rapid, unless the supply of food fails or an epidemic breaks out. The latter not unfrequently happens on account of the lax habits of the natives. Cholera is common.*

The means for building railroads seldom come from the localities where the properties are situated. In America a part comes from other countries. Local interests, however, gather the

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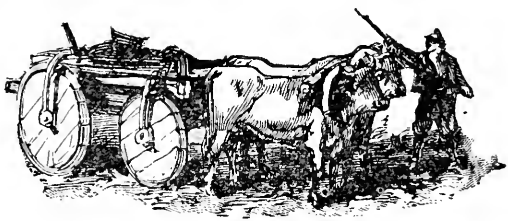
* The embankments of the Indian railways are allowed to settle during the rainy season before use; they sink one to two inches per foot according to the quality of soil. Wooden bridges and cast iron girders are never used. The bridges are built with stone or brick abutments and wrought iron girders. The waterway allowed is very large because heavy rain falls and floods are frequent at certain seasons, when little streams become wide rivers in a few hours. Stone ballast is generally used. Sandstone, slate and other soft ballast becomes useless within a few years, but burnt clay has been used successfully. Steel rails are generally laid, the best roads using thirty feet rails of the double headed type; the weight varies from seventy-two to eighty-two pounds a yard. Steel or iron ties are very generally used, as wood is scarce and high priced. No oak is used for this purpose; the best wood is a native timber called *sal*, but it is scarce. Creosoted fir from Norway has been successfully used, but as the price continually advances recourse is being had more and more to metal ties. Especial care has to be taken to provide for the expansion and contraction of the rails in track owing to extreme changes of temperature, and devices for rail joints are adapted to this end. Suspended joints opposite each other are the rule.

rich fruits that follow the construction of a railroad; they feel the stimulus of increased population; of new industries; of general appreciation of values, including land. They are the principal beneficiaries. And this without any risk; without the expenditure of a cent.*

As the capital of railroads is raised outside of the immediate community where they are located, it follows that it adds so much to the wealth of the community in which it is disbursed. This accession of wealth, with the new



Carriage in Servia.

enterprises, increase of population, and general enhancement of values it brings, the community receives in consideration of certain rights, of no

* In reference to the enhancement of values consequent upon the introduction of railways in Great Britain, Sir Rowland Hill says (Royal Com. p. cviii.). "The possessors of land and other fixed property in all districts traversed by railways have been enriched by the increased value of their possessions to the extent, probably, in many instances of four fold." While the increase in the British Isles may not have exceeded Sir Rowland's estimate, it falls much below the appreciation realized by property owners in America; this difference, it is hardly necessary perhaps to state, is occasioned by the greater extent of country, its comparative newness, and the meagre facilities it enjoyed for inter-communication previous to the introduction of railways.

particular value to it, which it confers in exchange. The most important of these is the right of eminent domain. This right is made much of by railway critics and superficial writers on railway subjects. It is not a gift. Those who exercise it pay for everything they get. Nor is it an exclusive privilege, where railway construction is free. It is general. Moreover, its exercise by railroads is much more valuable to the community than to those upon whom it is conferred. It is like widening or deepening the channel of a river before unnavigable; or opening a passage through a mountain previously impassable. Its exercise creates new sources of supply, new markets, new lines of travel, new means of intercourse, new sources of wealth. Those who provide the capital for constructing the railroad by which these results are brought about derive no other benefit, as a rule, than a reasonable (oftentimes meagre) return on their investment. Their gain is slight indeed compared to that of the community at large.

While the first cost of a road is generally in the nature of new capital brought into a community, the expense of operating, taxes, improvements and additions also adds annually a large sum. So that practically nothing is ever taken away. What is not disbursed for expenses is reinvested. Thus the community is benefitted in every way.

These simple and suggestive facts occur forcibly to those who study the railway subject in the light of the public criticism and condemnation that so often assails these corporate properties. However apparent they may be to students, they do not receive from a large class of the community the consideration they merit.

In considering the disbursements of railroads, those relating to the cost of the property are naturally the first to receive attention. The expenditures on this account embrace several distinct objects, all subservient, however, to the main purpose. Let us consider them in their order, and first we may note the cost of the charter or permit to build; the outlay for legal advice, notarial expenses, the company's seal and other items of a like character. These disbursements vary greatly with different companies. In some of the states of the Union it is required that a company shall procure a charter from the legislature; this charter is the substance or embodiment of a law specifying the duties and prerogatives of the company and the territory it may occupy. This is the manner of procedure followed in the United Kingdom. There the authorization of parliament must be secured in every case. It is both expensive and tedious. In some of the states of the Union railways are built under a general statute. There is no limit to the number that may be organized. It only requires a permit; the expenditure of a few dollars. The cost is much greater for a charter than a permit. Where a special charter is required the expense varies in proportion to the necessity for the pro-

Rural Carriage.

posed road, the fidelity and skill with which the matter is pressed upon the legislature, and finally the industry, intelligence and good intention of the latter body. A law must be drafted, and men skilled in the arts of legislative practice employed to press it. This requires time and necessitates a considerable outlay.

Where railroads are organized under a general law, the process is very simple. A company has only to perfect arrangements in conformity therewith, and file for record the necessary papers. In return it receives a formal permit to build. A certain percentage of the capital stock is required to be paid up before a railroad company can go ahead to construct, but the proportion of capital stock to the total outlay may be ridiculously small.

After the procurement of a charter or permit the amount necessary to be disbursed to perfect the organization is very small. However, it forms a part of the cost of the property and is placed to its debit with other items of greater consequence.

Preparatory to the location of a line, one or more preliminary surveys are made, as I have pointed out elsewhere. It is sometimes necessary to explore several routes before it is possible to decide intelligently which has the greater advantages or, perhaps, which is the least objectionable. This labor requires time and skill and frequently involves the expenditure of a large sum of money. Under the most favorable circumstances the work of locating a property, if conducted intelligently and with a view to ultimate outlay and income, requires the exercise of patience and judgment. Not only must the engineer prepare a general description, or profile, of the different routes, but he must determine the approximate cost of the various structures, embankments, cuts, tunnels, bridges and culverts; the amount and quality of the earth that must be moved and the distance it must be moved; the cost of track and other supplies, including ballast; and, finally, the maximum load that may be hauled in either direction over the whole line and over its different sections; in connection with the cost of each route surveyed, traffic advantages have to be carefully studied.

Expenditures for surveys involve disbursements for implements, wages of men, clerical and supervisory force at headquarters, and the incidental expenses of the men in the field. This outlay belongs to the engineering department.

While the surveying parties are still engaged, or preliminary thereto, the capital outlay incident to the construction of the proposed road must be considered by its projectors. There are two ways of raising money; by the sale of mortgage bonds and capital stock.* Both are usually employed, but not in equal degrees. Ex-

*These methods are frequently supplemented by a large floating debt before the road is opened.

penditures incident to the preparation of mortgage bonds and shares capital and the placing of the same on the market, vary greatly. Among them may be embraced printing, engraving, registering, commissions, exchange, and expenses connected with the sale and delivery of the securities. The discount suffered in the sale of securities forms, in many cases, a very large item. It is chargeable to cost of property. Ability to dispose of the securities of a corporation upon favorable terms depends upon the probable value of the proposed road, familiarity with the subject by capitalists, the condition of the money market, the character of the men in charge or the credit of guarantors.

An important item, chargeable to construction, is interest on the capital while the road is being built. It varies greatly, of course, but is considerable in every instance. Up to this point it is apparent nothing of a tangible value has been secured, although the disbursements have been large and continuous. We now come to the outlay for real estate, for roadway, station houses, supply depots, shops, yards, gravel pits, sidings, docks and offices. In the procurement of its realty a company requires agents possessing especial aptitude and men withal of approved integrity and discretion. The successful and honorable fulfillment of their duties requires patience, tact, skill and fidelity.

Except in isolated cases it is the experience of every company that the price put upon the land which it buys or condemns is much greater than its actual value. The price is based upon neighborly accommodation, interest and thrift; rarely, if ever, upon *bona fide* sales to private parties.*

Railways never strive to acquire land at less than its value; all their efforts are directed to escaping the payment of grossly fictitious sums. The expense of procuring the realty the company requires, aside from the cost of the realty itself, varies greatly. In new or sparsely settled districts the number of transactions is comparatively small, and the general desire of the com-

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* This is probably the case in every country where railways are built except in those cases where the appraisement is made by disinterested and capable officers of the general government. The disposition to exaggerate the value of property required by railway companies has been the subject of frequent public complaint in Great Britain. Sir Rowland Hill, in his report referred to elsewhere, says: "In the purchase of land for railway purposes the amount actually paid is, as already stated, often several times the antecedent value." Mr. A. Sinclair, C. E., in his interesting notes on British railways says, in reference to the excessive demands made upon the English companies for the land they require and for land damages: "In the cost of British railways, right of way has proved an expensive item. As the land is mostly divided up into large estates, a company negotiating for right of way has not a multitude of property holders to contend with. But if the land owners are few, they are perfect Trojans to fight for compensation. There is a curious laxity of principle among a great many people in their dealings with railway corporations. Noblemen who are popularly credited with the possession of sentiments as elevated as their titles, clergymen with reputation spotless as their neckties, have been known to swear that a railway going through their grounds would inflict an amount of damage exceeding the market value of their whole estates."

munity to have the roads constructed renders the holders of land more tractable. Where the population is dense and the people wealthy, the outlay to which a company is put for land and the expenses of juries, commissions, arbitrators, experts, witnesses, and other court costs, is a severe tax on the wealthiest corporation.

To avoid imposition as far as possible railway companies do not, when they can avoid it, definitely locate their lines until the realty they require has been contracted for. Thus many acts of extortion are avoided or alleviated.

Those who procure the right of way for a company require to be allowed wide discretion to enable them to secure the most advantageous terms possible. It will be the policy of these agents, as it is of the company employing them, to represent that the location of the line is dependent (as it should be) upon the facilities afforded and the amount the company is required to pay for right of way, depot grounds and yards; also upon the general friendliness and fairness of the people. Under a method so discreet property owners will perceive that the benefits they hope to derive from the contemplated enterprise will not be realized if they are unreasonable in their demands; public sympathy and interest will be excited and thus the more rapacious of the community will be held in check. Disbursements for notaries, registers, attorneys, clerks, abstracts, deeds, and kindred items, swell the cost of a company's property. Aside from these are the salaries and expenses of the agents engaged in procuring the land. This outlay may be determined approximately in advance, but it will vary with different localities, periods and circumstances.

Matters relating to the lands of a company are rarely, if ever, fully closed at the time of the opening of its line. Years sometimes elapse before court proceedings and private negotiations are brought to a close, and requisite deeds passed.

Transportation in Gibraltar.

Whenever a company finds it impossible to come to an amicable arrangement with the owners of property, proceedings of condemnation are instituted and the work of building pushed on, leaving the matter of compensation to be determined afterward by the courts or boards of arbitration.

Disbursements for construction increase in volume as the work progresses. At first small and infrequent, they grow in number and magnitude with the lapse of time, just as a storm oftentimes progresses from a few preparatory drops to a blinding tempest. With the active inauguration of the work of construction, those who provide the capital must meet the cost of grading and ditching; protecting the roadbed; building bridges; constructing culverts; boring tunnels; excavating cuts; raising embankments; clearing away impending objects; constructing dykes; laying ties and rails, and, finally, ballasting and surfacing. Concurrent with these expenditures, or following them, the work of constructing fences, telegraph lines, depots, warehouses, platforms, sidings, engine houses, workshops and machinery and supply depots progresses with more or less activity. Finally, the vast panorama is closed for the time being by the purchase of necessary furniture and fixtures for offices and buildings and the procurement of needed equipment and supplies.

All the expenditures enumerated, or incident to them, form a part of the cost of a property and appear in the returns as construction. In some cases the work is done directly by the company, but more often by contractors. At one time it was the custom to let railway work in small contracts, but this has latterly given place to the practice of letting the work to one contractor of large experience and means. It is thought the work is thus simplified, cheapened and expedited.

The cost of railroads per mile varies greatly in different localities and under different circumstances, as I have had frequent occasion to explain. It is affected by climate, the character of the soil, the cost of labor and supplies, the profile of the country and the changes it undergoes.*

The excess of cost of European railroads over all others is occasioned in part by the expense they were subjected to for right of way and station and shop grounds. The railway companies found the land occupied, and the great bulk of it highly improved. In new countries vast tracts were still but sparsely inhabited, while prices in the most densely settled localities were comparatively low. Differences in cost are further explained by the fact that European roads were constructed in a more permanent manner and with greater reference to the possible wants of the future than the financial condition or judgment of owners warranted elsewhere. Difference in nominal cost is further heightened by differences in bookkeeping. In one instance everything has been scrupulously charged to construction and capitalization, while in the other a large part has been charged in many cases, as I have explained, to operating expenses. The

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* This last mentioned feature is illustrated in the report of S. S. Montague, chief engineer of the Central Pacific Railroad: "Changes are taking place in the regimen of many of the streams crossed by your lines, notably the Yuba river at Marysville. The channel of this stream has been filled to a depth of twenty or more feet in many places, and at the point of crossing by the railroad, it has shifted its position several hundred feet since the construction of the bridge, the main channel being now near the northern or Marysville bank. Two additional spans were constructed last year to provide for this channel, and it is probable that a further extension will be required." Such changes are common to many streams.

extent of the latter practice has been very great. I can not better describe it than by quoting what the railroad commissioners of Connecticut have to say in regard to the additions and improvements railroads are making in that state:

"A comparison of the present with the former condition of the railroads of the state enables us to realize the extent and importance of the improvements being made from year to year. Take, for instance, the size, appearance, cost and convenience of the station buildings in most of the important business centers as compared with those which preceded them. The old structures still remaining in various parts of the state emphasize this contrast. Still more striking is the contrast between the strong, permanent stone and iron bridges which now span most of our large waterways, and the wooden structures which were displaced by them. Even the long pieces of pile bridging, which must necessarily remain for a long time to come, are gradually being floored and guarded in such a manner as to increase their strength and safety in case of derailment. Heavier steel rails than those formerly used are being laid upon those doing the largest amount of business. The amount of stone ballast is yearly increasing. In no one particular is the progress being made so apparent as in the character of the passenger equipment now being brought into use upon our important roads. This is made forcibly evident when it becomes necessary, on some special occasion, to bring out and use the equipment which was in use many years ago. The amount expended by the various companies during the past year for repairs of roadbed, track, bridges, buildings and for new equipment, indicates that substantial progress has been made in each of these departments. The increased weight of the locomotives and other equipment used and the increased tonnage of freight cars require a more solid roadbed, heavier rails and bridges of larger safe carrying capacity than were formerly needed, and the companies are realizing and meeting these requirements." *

What is being done in Connecticut is being done in every state of the Union.

The total disbursements of railroads for construction purposes can not be accurately determined. Upon the books of no company probably is cost fully set forth. There are difficulties of accounting that prevent it, even in those cases where there is the greatest desire to ascertain and make known the amount. Figures, therefore, that profess to give these facts, are incomplete.

But in every expenditure that a railway company makes for construction purposes, no matter how charged on the books, no matter whether capitalized or not, the community is deeply interested. All classes are favorably affected by it, from the man who digs coal to the dealer in pins; from the common laborer to the banker; from the manufacturer of scientific instruments to the farmer who plows his ground or tends his flock.

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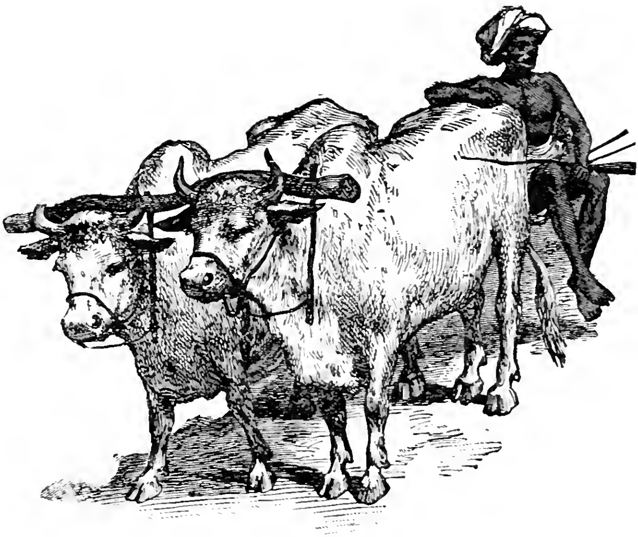
* Report 1888.

A railroad is never completed; the community's interest in its disbursements for construction never ceases. It is always growing. New wants are constantly suggested by the needs of business and the discovery of cheaper and better appliances. These involve further outlay and will do so as long as men continue to invent or railroads are needed.*

*In this connection I beg to refer the reader to the volume on the "Economical Purchase, Care and Use of Material." It treats of a subject that affects construction and several of its chapters are devoted wholly to construction work. The subject is also referred to in the volume on "Fiscal Affairs, Disbursements."



Carriage in India.

CHAPTER XIII.

CONSTRUCTION—ELEMENTS OF CONSTRUCTION.

Cost of construction is dependent upon the character of the road, the nature of the country, season of the year when built, distance from source of supplies, kinds of material used, amount and kind of business to be accommodated, cost of labor, the ability and experience of the engineer, and the skill and fidelity exercised in procuring the real and personal property needed. A road built during a period of inflated prices will cost more than one constructed at a more opportune time. Certain portions of the year, moreover, are more propitious for work of this character than others; the work is more satisfactory and the cost of operating afterward, perhaps, less. Favorable surroundings govern cost; a road that may be built for a few thousand dollars per mile in Nebraska, with its peculiar soil, its monotonous level and cheap lands, costs more where circumstances are not so favorable. Character also governs cost; a broad gauge road is not only more costly than a narrow gauge line, but its machinery and equipment are correspondingly expensive. A road constructed to accommodate a large traffic has more elaborate and expensive facilities than a property built to accommodate a light business. The traffic that must be hauled to market over heavy grades requires larger and more costly engines than a line where there are no grades; the cost of constructing the road is also greater.

Roads are oftentime built to handle a particular kind of business; its nature may be discerned in the character of the equipment and the nature of the facilities provided. The appliances of

Carriage in Madras.

railroads are unique and exhaustive. Equipment is adapted to the traffic it handles. The supply from which to choose is large and varied. The expense of operating and the measure of profit are largely dependent upon the adaptability of equipment. If the load to be hauled is a light one, a light locomotive is employed; it costs less, consumes less fuel and lubricants, is less destructive to the track, less expensive to keep in order. If the load is heavy, the locomotive will, for many reasons, be made to correspond.

The roadbed, superstructure and rails of a line doing a small business are much lighter and, therefore, cheaper than where the traffic is large. Facilities are never the same in kind, quantity or cost; a company handling ores uses different cars from one handling merchandise; the necessities of the passenger business are different from those of the freight business. Upon one line expenditure for freight will be very light, while the outlay for passenger business will be very great; upon another line these peculiarities will be reversed.

The products of a country and character of its people fix the status of a property. "A densely populated district, occupied by a manufacturing or a mining population, has far different wants from those of an agricultural population. The mountain districts of Scotland or the sparsely inhabited portions of Ireland could be supplied with railway communication suited to their wants by means of a very different mode of construction from that necessary for South Staffordshire or the metropolis."*

Many lines are constructed wholly with a view to through business. Local wants receive little or no consideration. On other roads the traffic may be wholly local. When the traffic of a line is of a varied character it is discernible in the arrangement of station and yard facilities, in the character of the cars and the adaptability of locomotives.

*Royal Commission on Railways, Report, p. xliii.

A glance at a property is sufficient to distinguish a prosperous company from a poor one. It appears, first, in the nature of the construction work, and afterward in its condition. One will be well kept, the other lean; one will be vigorous and animated, the other feeble and lacking in purpose; the roadbed of one will be generous in proportion and of durable character, rails heavy and well preserved, cross ties broad and well together, bridges admirably proportioned and of durable material, culverts constructed of stone or iron and ample to meet the contingencies of tempest and flood, buildings large and well arranged, equipment extensive and well adapted for work; the other will be pinched and circumscribed, with a contracted roadbed, more or less overgrown with weeds, with light rails, ties wide apart, buildings small, cheaply constructed and mean in appearance, fences old and patched, gossamer like bridges, consumptive culverts, wheezy engines, cars scant and uncomfortable. When an unproductive line does not present these peculiar appearances, it is because the owner pays more than his share of the losses its operation entails. This last is frequently the case, especially where it forms a part of a generally lucrative property.

Many short roads are constructed from year to year to accommodate local wants. They constitute a class. They are cheaply built. Their wants are few and accommodations are limited and simple. They should, however, be built of durable material according to approved plans by men versed in such matters. Sometimes, however, their construction falls into the hands of inexperienced men. When this is so, the work is not likely to be such as to facilitate economical operations.

The opportunity for making money through construction contracts and otherwise suggested the building of lines in the United States that otherwise would not have been thought of. The community was at one time much harassed by enterprises of this character, and investors suffered great hardships. Neighboring enterprises were also greatly crippled for the moment. The construction of these speculative enterprises occasioned temporary activity, *quasi* prosperity, in the community, followed by corresponding depression. A railroad that is not needed absorbs the resources of a country without return, and until the amount has been restored by savings, hardship ensues. A country is probably never the richer for railroads that parallel existing lines; for a duplicate line. This benefit, however, is derived. It intensifies competition. It stimulates men to do their best; to invent new and cheaper and better appliances; to economize; to be more attentive in the discharge of duty; to be more circumspect, more anxious to please their customers; to do more and better work than they otherwise would. These benefits may compensate for the ills entailed. A road built by speculators is not usually

Carriage on Cabul River.

well constructed. Little attention is paid to the needs of the traffic it is to accommodate. It is built to sell, and the slight interest of its projectors in its future leads them to do many things that they would not under different circumstances. The securities of such properties are, moreover, frequently placed in the hands of agents and brokers, to dispose of at figures that would destroy their credit if known. Inferior material is used and the work slighted wherever possible. Large profits are also made by collusion with those who furnish construction supplies while the equipment is superabundant and poor. The full extent of the profligacy of the builders is, however, not apparent until after the property is completed and the cost of operating it compared, year by year, with gross receipts and the expenses of neighboring lines. Then defects are seen and the full amount of the wrong becomes apparent. At one time, in the heyday of railway enthusiasm, the construction of speculative railroads was a common thing. With lapse of time and greater knowledge, however, they have been rendered less frequent because of inability to dispose of their securities. The lesson was a severe one to the community, but has not on the whole been unprofitable.

The intelligence and experience of corporate agents are evinced in the purchase of needed property. Generally speaking, it is of a suitable character. When not, the fault does not necessarily imply action purposely inimical to owners.

It arises, in the majority of cases, from lack of experience or too much haste. As a rule, the agents of railroad corporations are men of keen appreciation and good judgment, acting only after mature reflection, and then wisely and well. Nor can they be accused of being too sanguine, too precipitate, overzealous. They fear the accusation of extravagance too much for this. They are extremely cautious, and because of this, opportunity is sometimes allowed to pass before action is taken. More frequently than otherwise, however, the owners, and not the agents, are to blame. Timidity or ignorance oftentimes leads the former to place undue restrictions on their representatives. The productiveness of properties is in this way sometimes seriously crippled. In many cases lack of credit or the limited fortunes of the owners render it impossible to do necessary work. In such cases there is nothing to do but to wait.

But leaving out of consideration the exceptional cases, the amount of a company's outlay for construction is generally governed by just needs; by the character, extent and profitableness of the business to be accommodated, and if for any reason property is acquired in excess of just wants, such disposition is made of it as is most advantageous to the proprietors.

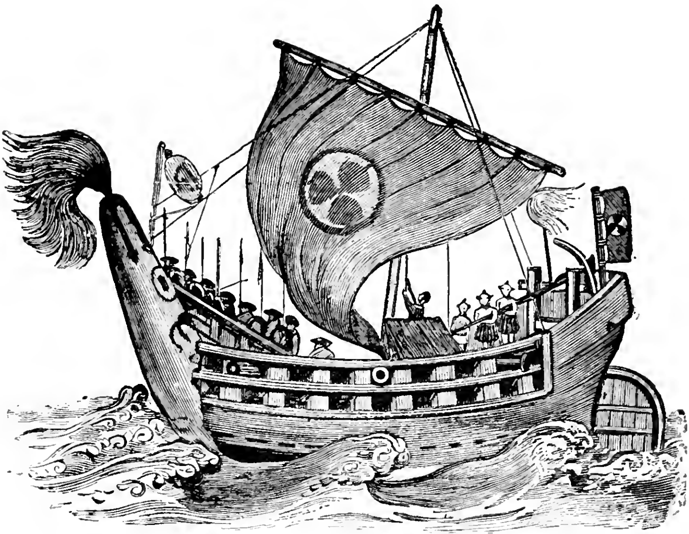
CHAPTER XIV.

MAINTENANCE—COST DEPENDENT UPON SUPPLIES, APPLIANCES, TRAFFIC, PHYSICAL CONDITIONS AND ORGANIZATION.

(NOTE: For a complete understanding of the subject of the maintenance and operation of railways, a knowledge of the methods of accounting employed in connection therewith is desirable. The reader will find this important branch of the subject fully elucidated in the volume "Fiscal Affairs, Disbursements.")

The cost of maintaining a railroad is dependent upon cost of material, fuel and labor, the condition of the property, the amount and nature of the traffic, length of road, climate, etc.; also upon the stability and permanent character of the bridges, culverts, buildings and platforms, nature of ballast, adequacy of drainage, weight of rail, and kindred things. Cost of conducting a traffic depends upon its nature, the gradients and alignment of the road, its sufficiency in both directions, nature of climate and cost of labor including its experience, interest, intelligence and loyalty. In no country is the price of labor, so high as in the United States; in no country is it so low as in India.

The general tendency of railway operations is to lessen cost. This is more noticeable in the



Carriage in Ancient Japan.

United States than in any other country in the world. It is because of this that we have been able to lower rates to such an extent that the stock raisers of Wyoming are able to send their products to market in competition with the producers of England and other countries accessible by sea. The rapid and favorable development of the United States is directly attributable to the intelligence with which our railroads have been constructed and operated; to the fortitude of railway owners, and the boundless ambition and skill of managers. This spirit must be fostered if we are to compete with other countries in the markets of the world.

A railway, like the human body, is constantly undergoing change, yet so gradually as not to be noticeable. Not only does everything wear out, but many things yet stable are put away to give place to something better. Thus light engines have been supplanted by heavy ones, small cars by large ones. These changes have necessitated structures capable of bearing the increased weight, heavier rails, better fastenings, stronger bridges. Thus track scales that answered every requirement in the early history of carriers have been replaced with others capable of handling greater loads and longer vehicles. In railway experience necessity has been the mother of invention. To want a thing has been to induce its invention. This is seen in the introduction of the truss bridge, the swivel truck by which railway vehicles adjust themselves more readily to the track, and the equalizing beams of locomotives by which their adhesion is increased and their hauling capacity multiplied.

Advances in railway appliances are not confined to any particular department of the service. They cover every field, from the kind of ballast used to the form of check with which dividends are paid. They are seen in the substitution of steel for iron; of the fish bar for the old fashioned chair; of sixty ton locomotives for those that weighed six; in improved forms of axles, springs, splices, spikes, signals, the tread flange and center of wheels, and all the multitudinous appliances of a railroad, each in its way tending to render transportation quicker, safer and cheaper.*

To know the gross cost of maintaining a particular property as compared with any other property, is not to possess anything of value to operating officers, unless we have the details. Greater cost one year may be offset by losser cost in a succeeding year. Differences may be occasioned by variations in the amount paid for material, or in greater mileage of trains. Use here, as elsewhere, occasions wear and tear and other increased expenses. A property that is used much wears out more quickly than one that is not. In order, therefore, to compare the cost of maintenance of two or more roads intelligently,

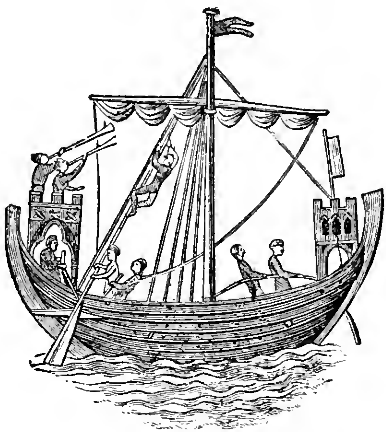
* However, knowledge of the exact worth of each appliance requires that its adaptability, cost and wearing capacity should be compared with other devices of a generally similar nature. This necessitates carefully kept records of breakage, use, time, facility, etc.

we must know all the facts that enter into cost; how far differences are inherent, how far they are the result of traffic, of bad management, or temporary causes. The cost of maintaining railway property is less and less, relatively, each year. This is in a measure, though not entirely, due to the better establishment of the roadbed. Better and cheaper material and labor have also much to do with it.*

Thorough effectiveness requires that the maintenance of a property should contemplate its ultimate perfection. This is the standard. Long delays may be involved and temporary makeshifts, based on the character of the business and the income of the property, adopted, but the building up of the property to the standard of a perfect model should be the aim. This involves systematic organization, a machine capable of intelligent and consecutive action. Nothing creditable or permanent can be attained in any other way. Work without system will involve the affairs of a railroad in the same confusion that similar work will involve other industries. It is not an unusual thing in the history of railway property to see the greatest perfection attained in one branch of the service while everything will be crude and unfinished in a neighboring field. This fact, while illustrating different

* In Great Britain there was a decrease of fifty-four per cent. in the cost of material per mile of road in 1885 as compared with 1876, and this notwithstanding the increased mileage of trains. The reduction in the cost of labor, however, was only fourteen per cent.

capacities, shows how distinct the different departments of a railroad are from each other while acting in common in the attainment of a general purpose. Men are not alike blessed with wisdom, experience or capability. The ignorant, the dull, the obstinate and vicious everywhere retard the efforts of their more amiable brothers. In the general progress of work on a railway



Carriage in the Middle Ages.

much depends on the general manager. But capability here can not supply the place of mediocrity, indifference or worthlessness elsewhere. To overcome the inertia of unfit men there must be active sympathy and co-operation throughout all the parts of a property. Supervision must be wise, intelligent and faithful. In no other way can a systematic organization be built up or the best results achieved. Unfortunately we have no present means of fitting men for the railway business as we have for lawyers and doctors. Men must be educated after they enter the service. This involves a long apprenticeship, capable instruction, competent instructors. Over every department of railway service there must extend active supervision by a single man, supplemented by capable and trusted assistants. Only in this way can responsibility and uniformity be secured. An organization thus effected must be supplemented by exhibits of results so that comparisons may be made between the cost of things generally alike. Without these comparisons it will not always be possible to distinguish between capable, industrious and economical men and those of a contrary nature.

In railway operations prevention is a governing factor. To stop the leak in the roof promptly, to strengthen the crumbling wall without delay, is to prevent the disintegration of the structure, perhaps an accident. This applies to the equipment, buildings, bridges, fences and other structures of railways as much as it does to private houses. Not only is the destruction of property prevented by such measures, but cost of maintenance is reduced. Moreover, if action were not prompt and minute, those entrusted with the work would quickly become disheartened because of the greatness of the expense involved and the immensity of the field to be covered.

The question of railway maintenance is by no means simple or limited; a proper understanding of it involves a knowledge of all the details of railway construction and operation—an intimate acquaintance with the topography of the country traversed and of its climate, population, financial resources and distance from the base of supply; knowledge must also be had of the methods of taxation in vogue, the personnel of the force, the extent and nature of the appliances available, the amount and kind of traffic, etc. The maintenance of a railway means something more than the preservation of the track, bridges, buildings and other structures. It means a competent and trustworthy organization and proper grouping of forces, without which a property is unwieldy, cumbersome and unprofitable. This phase of the subject finds reference in nearly every chapter and volume that make up these works.

A feature incidental to railway maintenance is the inherent differences in railway construction, in cost of operating and maintaining. They form a part of the great question of maintenance in its broader sense. The subject engages the constant attention of railway managers. Its thorough comprehension is necessary to a proper study of railways and a comparison of results achieved by them. Before entering, therefore, into a description of the more practical and mechanical details of railway preservation, let us glance for a moment at some of the differences, inherent and otherwise, between railroads.

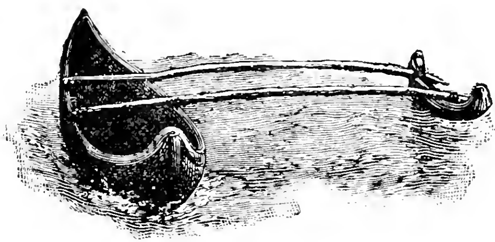
CHAPTER XV.

MAINTENANCE — COST OF OPERATING AFFECTED BY CONSTRUCTION FEATURES.

The disbursements of a railroad are influenced favorably or otherwise by the peculiarities of the country through which it passes, and until these are determined we can not estimate the cost of operating.

The circumstances surrounding the cost of constructing a road first, and operating and maintaining it afterward, change, moreover, with every succeeding mile of country; no two miles are alike. The distinction is more marked in some cases than in others, doubtless, but it exists everywhere and at all times. In one case it will be the difference between a road located upon the summit of a mountain and another located in a valley; between one that surmounts a steep and dangerous ascent and one constructed upon a perfectly level plain. In another case the difference will be less marked; it will depend, perhaps, on the elasticity of the roadbed, or the sufficiency of the drainage, or the quantity and quality of the ballast used, or the manner in which it is applied. But however small it may be, it will affect the cost of working the property and should influence, in a corresponding ratio, the price charged for doing business. The difference in cost will vary from a few cents per mile to hundreds of dollars. The extent of the difference can only be estimated after a careful and exhaustive survey of the property. In some cases it will be so marked as to make itself perceptible to the dullest comprehension, but many of the nicer distinctions will not be understood or suspected, even by those versed in such matters.

A road with costly bridges, high embankments, precipitous grades, sharply defined curves and



Carriage in the Society Islands.

expensive tunnels will, it is manifest, cost more to operate than a line devoid of these objectionable features. Casual observation will establish this fact; but where the differences are less clearly defined they will remain unnoticed.

In considering the relative cost of operating, as affected by the peculiarities of a country, we are only able to notice the more important differences.

Generally it may be stated as true that a road traversing a level country adapted to grazing and agricultural pursuits is more cheaply worked than a line differently located. Its drainage may sometimes be difficult and a sufficient supply of ballast will not be obtainable, perhaps, except at considerable expense, but these objections are more or less common to all roads, and are, as a rule, more than offset by the obstacles that must be surmounted in maintaining a line located in a mountainous or hilly country. The grades and curves of a road determine the load it is possible to haul under normal conditions. A company whose property is favorably located as regards grades and alignment can haul the maximum number of cars of which a locomotive is capable under the most favorable circumstances; the reverse will be true in proportion as the line falls short of this standard. Thus it has been demonstrated that upon a line located in respect to gradients and curvatures so as to present the minimum resistance, a machine of given power will perform three times the service possible upon a line presenting the maximum resistance.

Not only is a locomotive capable of hauling a greater load upon a line favorably located, but the wear and tear of equipment is less; the danger of accident is also diminished, while the expense of keeping the road in good condition is relatively smaller.

On the other hand, the drainage of a road that winds around the edge of a mountain range or passes over a light and sandy soil, differs in facility and expense from that of a line on an alluvial plain. The first named cases present the most favorable characteristics possible for economical and effective drainage; an advantage of the greatest consequence to a company and of greater importance than from a hasty or superficial investigation of the subject, would seem possible.

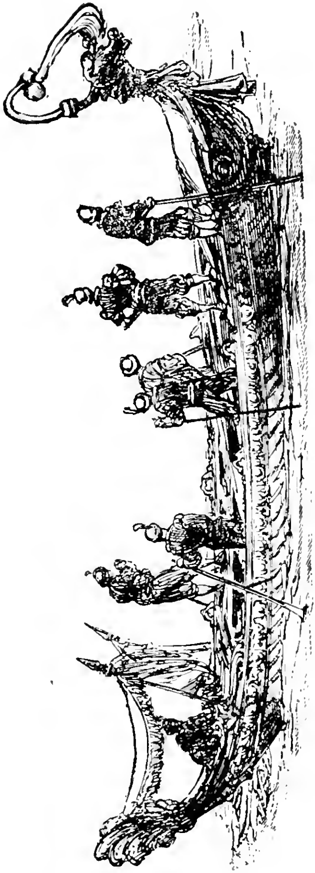
To the superficial observer the difference in cost of operation and maintenance between a track susceptible of perfect drainage and one that is not is trifling. He will class them both, very likely, under one head and impose common obligations upon them without reference to the differences they engender.

Imperfect drainage, besides being an evil in itself, implies many collateral evils. Thus, a road not susceptible of perfect drainage can not perform the service otherwise expected of it; the ties embedded in its surface will rapidly decay and its rails speedily become unfit for use. To counteract these and other evils a large force, supplied with necessary machinery and tools, must be kept constantly employed, and frequent renewals of the track itself will be required. Moreover, these expenses will spread in every direction, until they embrace practically every department of the service; they will not only appear in excessive disbursements for keeping the road in condition, but in the payment of lawyers' bills for defending suits for injuries and losses.

The cost of maintaining an imperfectly drained track is, it will thus be seen, indefinitely multiplied. For these reasons managers are especially alert to secure ample drainage. In many instances, however, the nature of the soil or the character of the country renders it impossible to secure this. In such cases the load becomes a permanent one.

No other phase of railway operations possesses so interesting a variety of aspects as the question of drainage, and none requires greater knowledge and skill. It is not only essential that the person in charge of such work should possess in a high degree practical qualities of engineering to enable him to utilize to the utmost the topographical features of the country, but he must understand the action of water upon different kinds of soil; he must be able to distinguish between that which will absorb water without especial detriment to the roadbed and that which must be quickly relieved in consequence of its density or retentive properties; he must understand the law of capillary attraction and take measures to remove beyond the reach of this influence the water that falls or is precipitated upon the roadway; he must, in fact, understand the subject both in its practical and scientific aspect. The instances noted are only the commonplace phases of the subject; it abounds in innumerable conditions, subtle in character and impossible of enumeration or description.

The question of temperature is also a prime factor. In a cold region the cost of generating



Carriage in Venice.

steam in locomotives is much greater than in a milder climate; the load hauled is less and the danger from broken and defective rails and machinery is increased. The absence of elasticity in a roadbed when frozen increases wear and tear of machinery, hastens destruction of the rails and retards active prosecution of business. To these must be added the cost of keeping the track free from snow and ice. The disbursements on this latter account are far reaching; they appear in the cost of snow plows and other appliances; in supplies; in wages; in the use of locomotives and cars; in the added cost of fences and snow sheds, and in loss of trade and delay of business. Beside these a multitude of petty disbursements, impossible to enumerate, will appear. Upon many lines located within the northern belt the expense of keeping the track free from snow and ice forms no inconsiderable proportion of the total cost of operating. From these and kindred expenses lines lying further south are happily free. On the other hand, however, they will have their own disadvantages, such as the rapid deterioration of material caused by influences peculiar to a hot climate, etc.

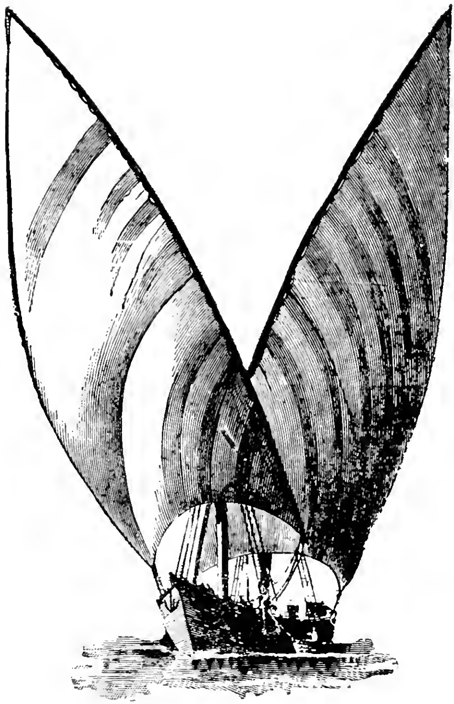
Difference in the cost of fencing also affects the relative cost of operating. Upon some roads no fences are required; upon others their erection is impossible; upon some lines, therefore, the outlay will be little or nothing, while upon others it will be very large. Moreover, when a company is contiguous to the supplies it requires for such purposes the cost will be much less than upon lines located at a distance. It may be noticed also that local laws defining a legal fence are not the same so that the relative expense for construction and maintenance is further aggravated by this cause.

The cost of maintaining and operating a road is greatly affected. as we have noticed, by the number and character of its grades. Every foot of ascent or descent entails an expense more or less marked according to its abruptness. A line so located as to necessitate the use of heavy and expensive engines can not be worked as cheaply as a line where light engines are sufficient. The cost in this respect varies enormously upon different roads according to the nature of the country, the judgment employed in locating the line. and the money expended in the first place in overcoming the obstacles that the surface of the country opposes to a level road; and while experts do not concur as to the ratio of expense that each foot of elevation attained occasions, we know that it is relatively much greater when the rise is abrupt than when gradual; thus the cost of operating and maintaining a line where the maximum grade is one hundred feet to the mile is much greater than where the grade is but fifty feet.

We also know that the collateral outlay which the gradients of a road entail are not relatively the same; thus the difference in the cost of maintaining a track, under the variable circumstances described, is not relatively the same for fuel, lubricants, wear and tear of machinery, etc. In each case the enhanced cost is governed by laws peculiar to itself and must be determined separately.

The curvature of a track, hardly less than its grades, affects the cost of maintaining and working, though the fact is not so generally recognized.

Another important feature in the economy of a road is its alignment. Defective alignment affects the cost of the property in the first place and the expense of maintaining and working it afterward. If the alignment of a road is bad the inconvenience and cost entailed continues without sensible modification until the mistake is remedied; but as defective alignment oftentimes involves questions of policy or purely scientific analysis of expense entailed, as well as the manner and cost of correction, it follows that defects of this kind are of much longer standing than they would be if they came within the easy comprehension of the practical men who look after the roadway and track; an abrupt or unnecessary curve in the line these men may see, and without much difficulty remedy, but errors in the alignment, affecting considerable sections of it, they do not discover, or if they do are unable to demonstrate them as such; and even if demonstrated the finances or convenience of a company may not warrant rectification.



Carriage on the Nile.

Many peculiarities or differences other than those noticed are apparent in the affairs of railroads, and affect directly the cost of operating them. Thus a company that is compelled, either by the nature of its traffic or the peculiarities of its lines, to sever and reunite its trains at frequent intervals, must necessarily include in its estimates of disbursements the considerable extra expense that this involves; an expense varying with the length of the haul and the amount and character of the load. Expenses of this kind represent, measurably, the difference between through and local business; many of the terminal expenses, however, involved in the latter are modified or wholly wanting. This is noticeably the case where the change occurs through the necessity of diminishing the burden or of delivering it bodily to some other line.

The relative cost of operating a road is greatly affected by the density of the population through which it passes, and the frequency with which towns, villages and cities occur along its line.

Cost of operation is also affected by the number and character of the tunnels, viaducts and road crossings or the necessity that exists for such structures. Every tunnel, viaduct and road crossing presupposes a state of affairs that increases the cost of doing business; a line thickly dotted with signals and crowded with watchmen can not, it is manifest, be worked as cheaply as a road running through a country where these precautions are unnecessary. Anything that interferes with the free movement of trains or that increases or diminishes the speed best suited to the load hauled adds to the expense of operating. Thus the amount of fuel used by a locomotive is greatly increased by the additional force required to start its load over what would be required to preserve its momentum when once in motion. Experts estimate the loss of power occasioned by stopping a train traveling at the rate of twenty-five miles an hour as sufficient to carry it a mile forward on its journey.* The consumption of fuel and the loss of power, it is also to be remembered, are only lessened, not avoided, while the locomotive is momentarily idle. Further than this, the wages of the men employed in connection with the idle machine experience no abatement; in addition to these items of expense involved we have the extra cost of wear and tear of road and equipment, besides other expenses of a miscellaneous character.

And in connection with this phase of the subject, it is proper to note that anything that retards business, increases its cost, multiplies the restrictions under which trains are operated, or heightens their expense, adds to the burden of the people by whom they are supported, for the reason that the cost must eventually be reim-

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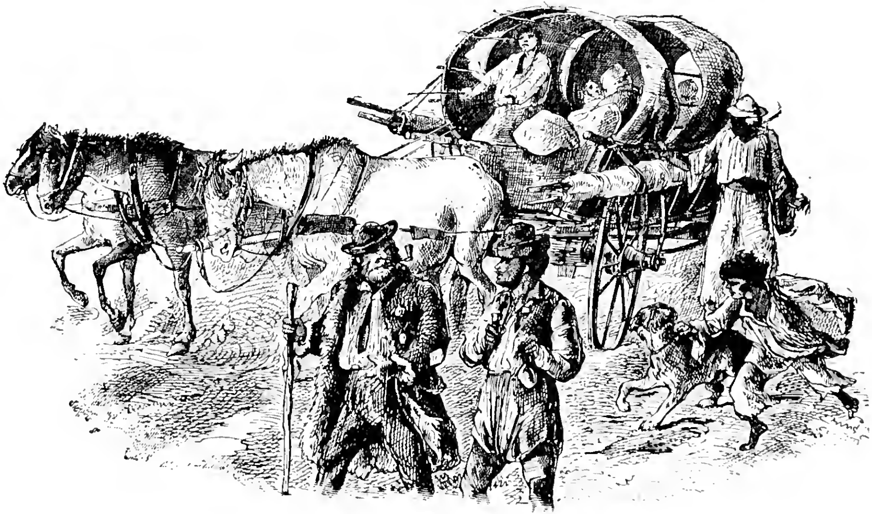
* "The direct loss of power in stopping a train running at a speed of twenty-five miles per hour would be sufficient to run the train over a mile." — *Arthur M. Wellington's "Economic Theory of the Locomotion of Railways," page 22.*

bursed by them. Whatever the cost of an article may be, that cost, we know, falls ultimately upon the consumer, and in the case of railroads (whether operated by incorporated companies or by governments) the general public is the consumer. If the latter, therefore, suggests or permits the harassment of its servant, the carrier, and thereby heightens the cost of doing business, it increases by just so much its own burdens. These facts always understood by the wise and thoughtful, are becoming more perceptible in communities where the principles of political economy are not well grounded; the lesson has been a very costly one; it is still but partially learned.



Carriage in Interior Hungary.

CHAPTER XVI.

MAINTENANCE — ELEMENTS OF COST OF OPERATING.

Construction acts and reacts forever on the operating expenses of railroads. The cost of operating is never the same relatively upon any two lines, nor is it the same, except by chance, for any two years, or other period of time, upon any particular line.

The same influences that contribute to swell the first cost of a road above the average, serve, in the majority of cases at least, to increase its operating expenses afterward.

In investigating the subject of railway economy each enterprise must be judged according to its environment, of which it is the creature. In no other way can its status be accurately ascertained.

The causes that produce differences in the cost of operating a property are so numerous and so complex in their character, that we can only notice the more important. A thorough analysis embracing a statement of the sequence they engender would require more space than can be given in a work such as this. But a partial analysis and explanation is within our ability, and it will be useful, not for the information and guidance of experts, but for those whose facilities for observing the multitudinous details of railway operation are limited.

The influences that occasion differences in cost of operating open up incidentally the whole vista of railway administration. I shall only consider one phase here. Let us take up this, and without attempting to give the subject exhaustive examination, notice some of its more salient features.

And first, in regard to supplies. In attempting to ascertain the cost of these, including fuel, we must not forget that to the first cost must be added the expense of handling and the cost of transportation. These may be said to constitute the incidental cost. Actual cost thus becomes dependent upon the expense of handling and the distance the distributing point is from the place of manufacture or supply.

To illustrate, the first cost of fuel is very small to many companies, but the expense of hauling and the absence of economical facilities for unloading from the cars into the storehouses, and afterward placing it upon the tenders, makes the actual cost of the article much greater than upon other lines; much greater even than is discernible from the accounts. The expense is aggravated in the case of many companies by their having no return load for their cars. Upon many lines the traffic moves mainly in one direction; when this current runs in the direction the supplies must be moved the situation becomes perplexing and adds greatly to the cost. Much of this cost, however, appears in the returns under foreign headings and thus remains unsuspected even by the most acute observers.

In describing the expenses of a railroad we can not, if we would, group in the accounts or elsewhere, under one heading, all the expenses incident to a particular article of material consumed.

To the first cost of supplies we must add the shrinkage, and in the case of fuel and oils this is very great, varying in amount from five to fifty per cent. The cost of substituting new material for old, when the former is used for purposes of repairs or renewals, must also be remembered. With many classes of material the cost of substitution equals or exceeds the first cost. It is considerable under the most favorable circumstances. The disbursements, for instance, that attend the substitution of new track material for old and worn out material of the same character are very great; this is noticeably the case with rails and ties. It is the same with machinery and fixtures that appertain to bridges, buildings and other structures.

In attempting to ascertain the cost of any kind of material we must also consider it relatively. Thus, in weighing the value of a particular quality of fuel we must consider its heating capacity and effect upon the locomotive. These, therefore, and not the price asked for the coal by the dealer, determine the value of the article and its availability.

To purchase an article without ascertaining the ultimate expense, as determined by its direct or collateral effect, would be, in many cases, to occasion a loss out of all proportion to the amount of the transaction.

Ability to pay for the material promptly affects very sensibly the price for which it can be bought.

Interest on the money invested in supplies forms a part of the cost.

The attention expended upon an article, and the accounting that it involves, must also be considered. Nor must the cost of storage room and outlay for insurance be overlooked.

It will thus be seen that a multiplicity of things are to be considered before the final cost of an article can be known.

Roads operated in the immediate vicinity of adequate markets, as a rule, buy more cheaply than lines located at a distance. Their presence in the neighborhood of the dealer exercises a favorable influence; they are, moreover, able to keep better posted in reference to the market.

A company that concentrates its purchases within well defined and responsible bounds can buy upon more advantageous terms than one that entrusts its purchases to a number of persons or to officers not skilled in the way of buying advisedly or cheaply.*

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* No one ever connected with a railway company in a responsible position, it may be said in this connection, can have failed to be impressed by the great importance which the responsible managers of railroads attach to the organization and performance of the duties connected with the purchase of supplies; to

The necessities of a company, real or imaginary, sometimes induce it to purchase supplies of an inferior quality. When this is so the loss occasioned thereby can only be traced indirectly, as in the case of fuel, already referred to. At different periods in the history of railroads the rails in the tracks of many of them were of inferior quality. Times were not propitious; business was unprofitable; the companies were poor and the desire to buy things at a low figure was strong upon them. This was so in the intermediate period between the use of iron and Bessemer steel. Manufacturers had lost the art of making the former cheaply and well and had not yet acquired the ability to produce the latter at a rate the railroads felt able to pay. The effect upon the companies of the use of poor metal in their tracks was quickly discernible in the consumption of the rails laid.*

It was also seen in many ways outside of the greatly increased cost of keeping the track in condition. It was perceptible in the account for injuries; in the fees of coroners and surgeons; in the account for losses and damages to property;

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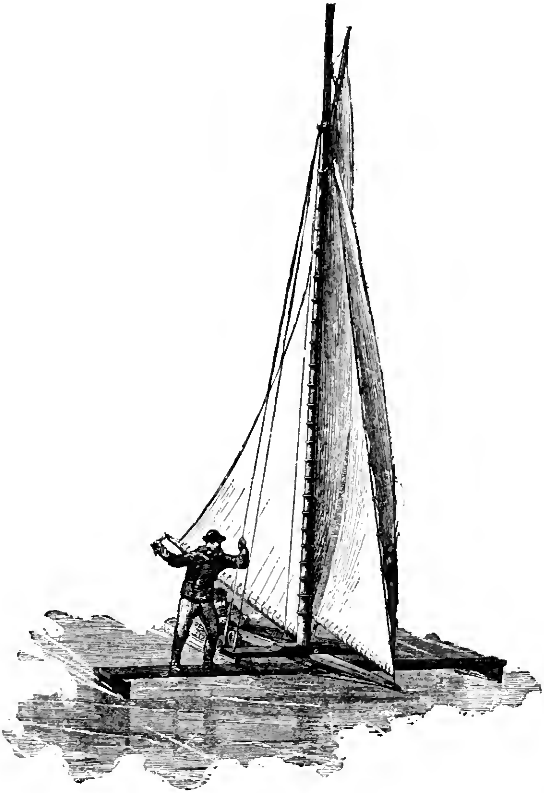
the limiting of the purchases to as few officials as possible, and to the placing in such positions only men experienced in the wants of railroads and in the knack of buying cheaply; men withal accustomed to the discharge of acts of trust and of long tried and approved integrity.

* The length of time a rail will last is dependent (even upon a line having a light traffic) upon its quality, the care with which it is laid, the number and quality of the ties and the character of the roadbed.



Carriage on the Hudson.

in expenditures for legal services, for nurses, medicines, etc.; in repairing broken down bridges and culverts; in repairs of equipment, machinery and tools; in labor of various kinds; in fuel used by locomotives; and finally in diminished receipts.

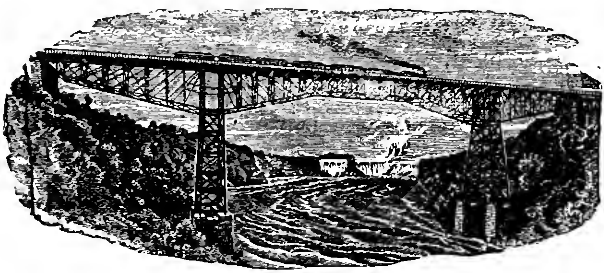
Many companies were slow in discovering the loss occasioned by the use of poor rails; not a few were dilatory in effecting a remedy after the discovery. Why? Because it requires a knowledge of railways that every proprietor does not and can not hope to possess, to enable him to appreciate the fact in all its bearings, that unless a company maintains a good roadbed and track favorable results will not long attend its operations. We can readily believe in such ignorance and can excuse it, but in all practical questions the proprietor should accept the judgment and experience of the management.

The smoothness and elasticity of a track affect directly the cost of keeping the rolling stock in condition, and the cost of a poor track is quite as apparent in expenditures for keeping the equipment in serviceable order as in the disbursements for the track itself.

Only an experienced manager can withstand the seductive glamour of an article of prime necessity offered at a low rate. The fact that its ultimate cost, if of poor quality, will be out of all proportion to the temporary saving is lost sight of. The immediate and visible reduction in the cost of operating and the glory of effecting the reduction is too strong for a weak man to withstand.

This would not be the case to the extent it is if so great a proportion of the loss which a company suffers in consequence of the purchase of inferior material were not covered up under foreign headings and remained, therefore, unsuspected. The track of a railway is its largest single expense, and it is in connection with this that the greatest, and in many instances the most unadvised, efforts at economy are attempted. The harm arises largely through collateral losses. It is impossible to determine these even approximately. We can only estimate the actual outlay for the track itself; it involves the cost of transporting the new rails and the movement of the old, the cost of loading and unloading, the expense of handling, the loosening of the old rail and the insertion of the new, the value of the chairs, spikes, plates and bolts destroyed during the process, the wear and tear of tools employed in connection with the work, the delay of business, more or less marked, and the expense incident thereto, the increased wear and tear arising from imperfect alignment of track which the change temporarily occasions, the injury to the ties caused by the change, and, finally, the destruction accomplished before the worn out and battered rail is taken out and a better one substituted.

The actual cost to a company on account of many of these items can not be ascertained, but whatever the amount may be it is supplemental to the first cost of the rail and recurs as often as the track is renewed. It is only by keeping these facts in mind that we can appreciate the importance to a company of purchasing good rails and of laying them properly. Only a wealthy company, it is apparent, can do otherwise without endangering its safety. Indeed, the importance of a durable track is so essential to the prosperity of a company that it is no exaggeration to say the introduction of the Bessemer process, whereby the duration of the rail is greatly pro-



Cantalever Bridge.

longed, has enabled many properties to earn fair and continuous dividends that would otherwise not have been able to do so.

The duration of an iron rail, whether new or rerolled, varies according to the usage and the accident of quality (the latter being quite beyond the control of the manufacturer), from forty-eight hours to five years; some will not last the stipulated forty-eight hours. It is manifest that the drain upon the resources of the company using such material can not but be out of all proportion to the infinitesimal saving effected in the first place by purchasing iron instead of steel.

What we have said in relation to inferior track rails applies with even greater force to inferior ties. A poor rail, when no longer of use, may be sold, but a tie is practically worthless when no longer available for use in the track.* Besides the fact that a worn out tie possesses substantially no value, its removal is, in many cases, much more difficult than the removal of a rail, and the alignment of the track more seriously disturbed.†

The expensiveness of a poor bridge is relatively much greater than of a poor rail or tie. The cost of removing such a structure frequently exceeds the original outlay, it being necessary (notably in the case of drawbridges) to build a temporary structure by the side of the one re-

*Huntington, in his unique treatise, page 100, on railroad track, however, points out, though in a somewhat forced way, some of the uses to which old and worn out ties may be put, namely: "To patch temporarily broken fences; to make footings for washing embankments; for temporary platforms for piling rails; fuel for drying sand at sand stations; fuel for section men. Sawing up old ties for wood is also profitable to a company in many localities." They may also be used by a company for fuel for starting fires, and other purposes.

†Ties manufactured from what we call soft woods are not only not able to withstand the wear and tear of a heavy business, but they decay much more quickly than oak and other hard wood ties. The cost, however, of transporting the latter and inserting them in the track is not greater than for the former; it is, therefore, manifestly for the interest of every company to use the latter when the difference in the purchase price is not greater than the subsequent difference in the length of time the ties will last.

quiring removal, while the permanent structure is being erected. Leaving out of consideration, however, all the peculiar circumstances immediately connected with the maintenance of cheap bridges, the incidental outlay they involve for persons killed or injured, for property destroyed or damaged, for injury suffered by the equipment, to say nothing of the loss of revenue a company suffers by the distrust engendered in the mind of the community, is out of all proportion to the saving effected by the erection of an unsafe structure of this kind.

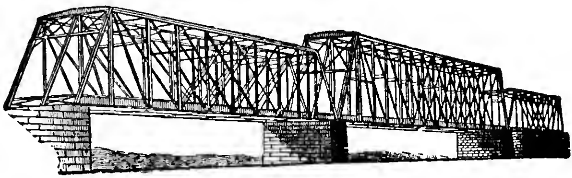
In reference to the structures of a temporary character, such as depots, round houses, work shops and water stations, that we find clustered about many new enterprises, the ultimate loss to the company erecting them is in many cases treble the cost of a first class edifice; makeshifts at best, their facilities are inadequate, the cost of keeping them in condition large, and their ultimate destruction or removal, with all the expenses incident thereto, inevitable.

It follows, therefore, that the erection of such structures is inexcusable, except in those instances, not so frequent as supposed, where the resources of a company render it unavoidable.

The injury that may be done to a company's rolling stock and machinery by the use of inferior lubricants well illustrates the folly of buying material of inferior quality. The difference in the first cost is so marked as to secure in many cases the purchase of the latter article. When this is so the direct charge upon the books and in the accounts for lubricants is greatly reduced. This reduction is quite likely to excite the admiration and astonishment of the directors and owners; it is the wonder of all except those who understand its significance.

The actual cost of lubricants when of poor quality is never known; comparisons will exhibit an increased consumption, perhaps, that is all. The destruction engendered appears in the returns under other headings, which seemingly have no connection with it, and remain, consequently, unnoticed. The extra outlay the use of unfit oils involves appears in disbursements for repairs and renewals of equipment, for new axles, brasses and other parts of machinery, and in all the accounts incident to the working of trains, such as repairs of equipment, disbursements for people killed and injured, for losses, damages, and for the services of lawyers and doctors. Nor does the increased cost end here, but may be traced step by step through all the labyrinths of the service, in the stoppage of trains, in the diminished usefulness of the plant, in the wages of unemployed men and in the myriad of expenses incident to the detention of business. All such expenditures follow in the train of hot journal boxes, broken axles, tracks torn up, trains derailed and kindred mishaps that attend the use of unfit lubricants.

In considering the cost of car and locomotive wheels, axles, frames, springs, bolts, nuts and kindred appliances, we find, as in the case of oils, that the relative cost of a good and a bad article is not alone manifest in the first price. It will appear in added disbursements for deaths and injuries, for losses and damages, for all the multitudinous expenditures that attend upon accidents to trains, including the cost of repairing tracks torn up by derailed trains, the interruption of business and its manifold losses, the swelling of the account for wages and, finally, the cost of repairing the injured equipment.



Truss Bridge.

Other interests, entirely foreign to the immediate purpose of the outlay, always attend the use of supplies. It also frequently occurs that the purchase of material is made to accomplish an auxiliary purpose, such as the securing of business or the placating of some one necessary to be reached. When this is so the price not only represents the value of the article, but the benefit derived from its purchase. Many other things, such as a desire to foster the growth of local manufactories and interests, affect the source from which supplies are drawn, inducing the purchaser, it may be, to pay a rate above the market price. In such cases the indirect gain is expected to reimburse the direct loss. Practices of this kind are of frequent occurrence. Generally, however, it may be said that the emergency that will warrant going out of the general market to purchase presupposes an extreme case, an event of more than passing interest and therefore not to be considered as a factor in any general review of the purchase of railway material.

The interests of a railroad are identical with those of the country in which it operates. It endeavors, consequently, in every way to advance the affairs of its co-laborers, the local producer and consumer. But this assistance, however valuable and real, never appears directly on the books of the railroad. When aid is extended, as we have shown, the added cost to the company can not be accurately fixed under any head in its accounts; the separation, therefore, is not attempted, the total price paid for the material being considered as the first cost, although a portion of such cost might with more propriety be charged to traffic, or something else. But as this is impracticable the gross amount is debited in the accounts to supplies and appears ultimately in the accounts to which the material is finally apportioned. These accounts are thus burdened with disbursements foreign to their purpose.

Before attempting to fix the cost of operating a company's property we must know all the circumstances attending its purchase and use of materials, including price, indirect purpose to be attained, the distance supplies are hauled, the cost of hauling, service of equipment, cost of substitution, storage, shrinkage, interest, insurance and literal and constructive effect.

The difference between railway affairs, as they exist and as they are supposed to exist in the purchase and use of supplies, illustrates very fairly the difference between practice and theory in railway operations. To the amateur the problem is like a shallow cistern, to be fathomed with a walking stick or dipped dry with a drinking cup; but to the practical worker and thinker it represents in its economy every problem of a highly civilized society.

The management of railroads requires that those who direct their affairs shall be men trained in the discharge of business, men fitted to govern, men whose judgment has been trained by years of observation, practical work and restraint, men that are self controlled and self contained, forcible, luminous in their conception of great problems and capable of employing the most simple and economical expedients; men possessing, in fact, the business ability of a trader with something of the executive force of a general or statesman. These men must be educated in minor capacities. No railway can afford to educate an officer in the position of an officer; it is too expensive and demoralizing; excites too much disgust throughout the force.

Carriage on the Coast of Normandy.

CHAPTER XVII.

MAINTENANCE — ELEMENTS THAT AFFECT COST OF OPERATING—TERMINAL CHARGES.

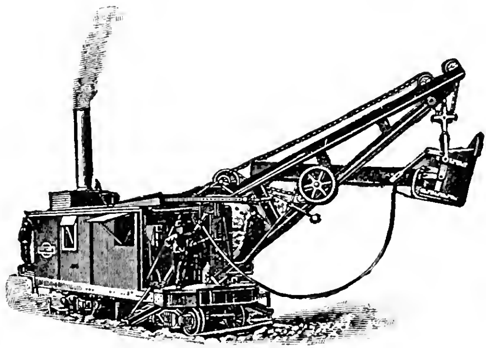
The cost of working a property is greatly affected by the quality of the traffic and the length of haul. This is, perhaps, more particularly the case with freight than passenger business, for the reason that the former entails current expenses unknown to the latter.

The expenses of railway companies for loading, unloading and storing freight are in some respects foreign to the original intent and purpose of common carriers and in many instances not necessarily a part of their office.

In many countries, notably in England, railway companies often contract with teaming companies or employ carts of their own for hauling light and valuable merchandise to and from stations. Much of the freight transported by English companies is loaded by the shipper directly upon the cars. Indeed, it may be said to be the exception where this is not the case.*

*The box or enclosed freight car so universally in use in America is little known upon English lines, the flat or open car being employed by them, merchandise loaded upon it being covered, when necessary, with a tarpaulin. This vehicle is much lighter than the box car, indeed it is much shorter and lighter than the flat or open car.

The rate charged by English companies is understood not to include either the cost of loading, unloading or covering the freight. When such services are performed by the railway it makes a special charge therefor; it also makes an additional charge in special cases for cost of building and working side tracks; indeed, I am not certain that this latter practice does not apply in all cases. In America, on the other hand,



Steam Shovel.

it is usual for the railroad companies to load and unload all kinds of miscellaneous freight, and while they do not attend in any case to collection or delivery of the freight at terminal points, they nevertheless place it in a secure warehouse, which they own and control.*

*The exception to this rule is in the case of express companies, who conduct what in England is denominated "the parcels traffic;" these companies not only collect much of the freight transported by them, but deliver it (in large towns) to the consignee, the charge for this service (within certain limits) being embraced in the general rate.

No direct charge is made in America for loading or unloading, no matter what the length of haul; nor is anything exacted specifically for the use of the company's warehouses except in those cases where goods are permitted to remain for an unreasonable length of time, say over forty-eight hours. A charge for demurrage is also made in the case of cars that are not unloaded within a reasonable time, when it is the duty of the consignee to unload the freight.

No specific charge is made by American companies against their patrons for the use of side tracks.

In England a special charge is made when traffic is hauled only a short distance. The rate for six miles, or any fraction thereof, being the same as for twelve miles; this is in addition to the supplementary charge for loading, unloading, etc. Our custom with respect to this class of business is doubtless in practice not materially different, but the basis for the charge is not generally so well understood; this omission doubtless operates in favor of the shipper.*

The practices in this country in connection with loading, unloading and care of freight have

*In reference to the manner of settlement between the different lines for through traffic, or that which passes over several lines of railway, it is said to be the custom in England to deduct from the gross amount charged for performing the service a specified sum for terminal expenses, varying in amount as between London and provincial towns; this sum is apportioned between the companies receiving and delivering the traffic, after which the balance is divided upon the basis agreed upon, whatever it may be, between the different lines.

assumed the habit of a fixed custom, though the duty does not properly fall within the province of a carrier. This is demonstrated, if demonstration were necessary, by the discrimination which companies make against particular classes of freight, which discrimination the public acquiesces in. It is perhaps true that labor can be performed by the railway to better advantage and at less expense than by its patron; but this does not alter the fact. It was, curiously enough, at one time supposed that the community would provide all the cars required to do business and would attend personally to the loading and unloading of freight, while the railway company would simply provide the necessary tracks, and in some cases, perhaps, the motive power.

It is the office of a carrier to transport the freight that is offered, not necessarily to load and unload it; that is the business of the owner. However, it is our purpose in this connection to notice merely the custom as it exists, not to suggest its change or modification.

Practices are not uniform as to the articles which owners must load or unload, but vary according to real or supposed necessities of business. Usually, however, carriers discriminate against only very coarse articles of freight such as are exceedingly bulky and not easily damaged or displaced, such as coal, grain, live stock, lumber, ores, pig iron and similar articles.

From the foregoing it is apparent that a company's outlay for station labor, warehouse and yard room is largely dependent upon the character of its business; if made up of freight that the carrier undertakes to handle the terminal charges will be much greater than in other cases.

Terminal charges are incidental in character and contemplate an outlay for grounds, tracks, warehouses, platforms, yards, elevators, depots and other machinery necessary to an economical and expeditious discharge of business, and vary so greatly that before attempting to compute the expense of conducting a traffic their cost must be carefully ascertained.

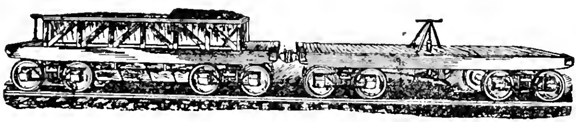
Terminal facilities, it is noticeable, that cost but little at one point involve enormous outlay at another. Thus the depot grounds and yard room that can be provided for a few dollars in an interior town will cost millions in a great city. The interest upon the capital invested in these facilities, whatever it may be, is a fixed charge upon the property and must not be overlooked in determining the cost of doing business.

In reference to the relative cost of handling different kinds of traffic, the greatest difference exists, but the extent of this difference is little appreciated. Thus the expenses upon one line for station labor in connection with the movement of fifty thousand cars of coal, earning perhaps a million of dollars, will hardly be more than that of a neighboring corporation for handling a few crocks of butter or the worn out effects of an itinerant preacher. Differences of this character continually occur in the operations of railroads and will ever confound those who would seek to make a law or institute a practice that will fit all alike or place them upon a common level. As soon might we prescribe a given quantity of food, drink, air and clothes for men without reference to their appetite, health, labor or size. But the laws of America have all been in this direction. Terminal expenses, permanent and incidental, are never governed by the revenue derived from a business, but are the same in all cases whether the traffic is desirable or otherwise. Nor are terminal expenses affected by the length of the haul; it costs as much to handle a consignment of merchandise destined to a neighboring town as to a point a thousand miles away; the number of laborers required is the same in either case, the clerical force the same, the facilities the same, the risk of accident and theft at the termini the same.

The through traffic of railroads may be said to represent the long haul in contradistinction to local business, which represents the short haul, and while the terminal expenses are the same in either case, local traffic necessitates frequent stoppage of trains, with all the expenses incident thereto, some of which are noticed elsewhere. They form a sensible burden, an unknown quantity in railway management, never to be lightly considered or overlooked in estimating the difficulties and expenses of operating.

Within certain bounds, therefore, it is manifest that the profitableness of a business is largely dependent upon the length of haul. It is an aphorism in railway management that the equipment of a company earns money only when in motion; anything, therefore, that retards that motion, or prevents it, acts to the disadvantage of a property.

To continue our illustration, the station facilities necessary to accommodate the suburban travel of a metropolitan road must be quite as elaborate as for a more profitable business—for a long haul, for instance. The expense that attends it is much greater than for ordinary traffic, because fixed in cities or in their immediate



Construction Cars.

neighborhood, where values have reached the maximum. This business, instead of paying a higher rate than traffic requiring less costly accommodations, is awarded a much less rate. This difference is oftentimes more than is justified by the increased quantities of business handled. It is occasioned by a desire to stimulate the growth of the traffic. It represents also the difference to a railway company between a wholesale and a retail business; the suburban residents represent an average haul each day equal to so many trains, a fixed and determinate quantity, while isolated passengers, gathered at widely separated points, in uncertain quantities, represent the retail element of trade.

While it is true that the terminal expenses incident to traffic are generally and carefully considered in fixing the rate, it is also true that heretofore no recognized or uniform practice has been observed; the judgment of the compiler of the tariff, the peculiarities of the business, and in some cases the law of the state, determine the rate without reference to terminal expenses. Perhaps a more formal basis is not practicable; however that may be, the length of the haul and accommodation afforded, in conjunction with the terminal expense, should in every case govern the rate.

Wherever this principle is disregarded it can not but result in a company doing business frequently for less than the revenue derived. Much of our local traffic, having only a short haul, does not pay its *pro rata* proportion of the cost of the facilities it enjoys; this has been markedly so since the introduction of cumulative tariffs.

Few or none of our great companies could provide the terminal and other facilities they do if their trade were wholly local; the profits they derive from through business render it possible. Through business has ever contributed more than its just proportion.

It has been a generally accepted belief that the local business of a road is the more remunerative, for the reason that it is not subjected to the disturbing influences that surround through traffic. This might have been the case at one time, but has long ceased to be so. The multiplicity of roads in operation, paralleling and intersecting each other, compels them to compete for their local business quite as much as for their through traffic; and where this is the case the rates re ceived for local business are not more satisfactory than for through traffic.

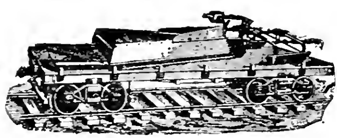
The relative cost of soliciting business, which may be briefly considered here in connection with the terminal expenses of railroads, varies greatly upon different lines.

It also varies greatly for the different kinds of traffic.

The expense of one line for advertising matter and for soliciting agents, for illustration, may be treble that of another. This difference may be occasioned by the disadvantages of a company's lines as compared with those more favorably located. Or it may be occasioned by the special character of the business. In the former case it is necessary, perhaps, to ignore the expense in fixing the rate, but in the latter case it is certainly pertinent, for the reason that the traffic sought is dependent upon the effort made to secure it. This is especially the case in reference to such business as excursionists', colonists', tourists' and pleasure seekers' generally.

In so far as the practice of advertising, or otherwise soliciting business, is carried on upon just principles of business, the expense incurred ought, it is clear, to be considered in fixing the rate charged.

From the foregoing brief and imperfect consideration of the subject it is apparent that the cost of handling and soliciting traffic is an important element in the economy of railway management not to be overlooked in studying the extent, object and usefulness of railway disbursements and the return they may be expected to render the companies making them. This fact should be remembered by legislators and others in fixing the rate railways may charge. Each company should be considered apart and its cost and the conditions attending its traffic duly and exhaustively considered.



Ballast Car.

CHAPTER XVIII.

MAINTENANCE—UNALTERABLE EXPENSES OF OPERATION—FIXED EXPENSES.*

Expenditures do not grow relatively with a traffic. The outlay upon a heavily worked line is not proportionately as great as upon a line less busy. One of the reasons is that a large proportion of the disbursements of a company come under what are called fixed expenses. Many of the expenses of this character are not affected at all, or only remotely, by an increase or decrease in business; these expenses are never the same relatively upon different roads, but they are large in every case.

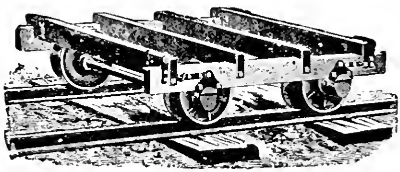
Fixed expenses may be termed the minimum cost of operating; after they are provided for every dollar of income that a property can be made to earn without increasing such expenses, represents, obviously, a profit; this fact is well

* The term fixed expenses or charges is used in a double sense in railway nomenclature; first, it applies generally to the operating expenses, interest and rentals of railroad companies, and second, to those expenses connected with the immediate working of the property that are not affected at all, or only lightly, by the amount of its traffic, such as superintendence, salaries of station agents, flagmen at crossings, bridge tenders, etc. The last named should be called "fixed operating expenses" or "fixed expenses," while the former should be called "fixed charges."

understood and represents a principle that lies at the foundation of the practice of granting a reduced rate when the trade offered is unusual in quantity or can be handled without adding relatively to the cost.

The difference in the relative fixed expenses of roads varies in proportion as their business approaches the maximum capacity of which the property is capable.

A brief summary of these expenditures may properly be given here; and first, we may men-



Rail Car.

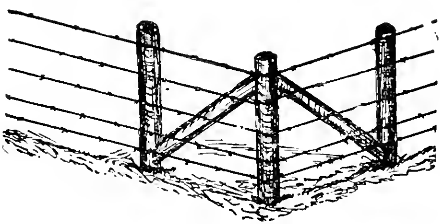
tion those relating to organization. This must be maintained with little, if any, reference to the amount or profitableness of the business done; all of a company's affairs are immediately dependent upon the preservation, unimpaired, of its legal status. This obligation is imperative, and while the disbursements on this account may be small compared with many other expenses, they are, nevertheless, considerable each year.

Many expenses incident to the conduct of business intervene, without much, if any, reference to the amount of the traffic; thus the mail must be carried and delivered punctually, no matter how small it may be; the convenience of the public must be studied and provided for at stations and elsewhere; the number of trains which the custom of the country or the charter of the company compels it to operate must be run each day, and so on. In matters such as these the discretion of a management is very limited indeed.

The outlay incident to the movement of trains, so far as they are operated, is the same for wages of men engaged whether the cars they contain are loaded to repletion or travel comparatively empty; this is also true, relatively, in reference to other train expenses, such as fuel, oil, lights, attendance, wear and tear, etc. Some one, also, must be on hand at stations to open the company's waiting rooms, see that they are kept clean and comfortable; to preserve order in and about the buildings, keep the platforms and track unobstructed, ticket such passengers as present themselves, receive and discharge goods, and answer the questions asked by the patrons of the line.

The wages paid the incumbents of these offices must be such as to secure faithful men, competent to perform the maximum amount of service required. And so it is with the organization of the force as a whole; with the general and local officers, the superior and petty heads of departments, and the foremen and persons in charge, including their principal or chief assistants. Each of these must, in his place, be competent to perform, at a moment's notice, the greatest amount of service that the necessities of the company may at any time exact; an exigency arises and passes like the flight of an express train; there is no time for consultation, no time to study text books, no time to examine rules and regulations, or to write to superior officers for instructions; the company must have some one on hand competent to act. These necessities must be provided for without reference to the general run of business, and in so far as this is so, constitute a fixed expense.

An agency that may, at any moment, be called upon to handle a hundred carloads of freight can not with safety be entrusted to the care of a person who could perhaps manipulate half that number with facility but would break down under the greater responsibility. The agent must, in his turn, select subordinate servants with a view to like contingencies. What is true in this respect of the agent and his assistants applies with equal force to conductors of trains, foremen of shops, track bosses and superintendents of bridges. It applies with redoubled force to the corps of managers. The exigencies of railway service require men of special training, of peculiar qualifications, of minute practical knowledge. There are no important exceptions to this rule in any department or branch of the business. Supervisory officials, and especially those in immediate charge of the property, must be relatively as well skilled as the directing manager. They must possess a general knowledge of the offices they fill as well as a particular acquaintance with the immediate position they hold. This general and particular knowledge involves an intimate acquaintance with the property, its defects, resources and peculiarities. This intimate acquaintance presupposes long association, years of observation and thought. Its attainment is impossible otherwise. Without this prolonged association the knowledge officials



Wire Fence.

bring to the discharge of their duties is incomplete, oftentimes unwise and impracticable.

The personnel of a railroad organization may not, therefore, be changed hastily or unadvisedly without detriment, for the property is largely the creature of the operative and its value dependent upon his capacity and fidelity; he must consequently ever be considered in forming an estimate of its present or prospective value.

In every department of railway service we discover carefully selected men, men of capacity and resources; the superiors of their fellows, singled out with reference to emergencies, either present or prospective. From the character of these men we may judge intelligently of the discernment and trustworthiness of the managers in charge.

The importance of the duties, present and prospective, performed by the various classes of officials is, as we have stated, apparent in the compensation allotted them. The official in charge of a pass high up on a mountain side, or having the care of a difficult morass or hazardous piece of track, no matter where it may be located, is paid a higher rate of wages than his neighbor, whose skill and responsibility are less. Selections in every case are to be based upon fitness. A track foreman who might be trusted with safety in the absence of danger could not be depended upon to act with intelligence and precision in case of a wreck or the washing away of a roadbed; a bridge superintendent who, perhaps, understands how to keep in repair the property entrusted to his charge under ordinary circumstances, might be exceedingly awkward if called upon at a moment's notice to construct an entire structure; in the same way a conductor who might know how and when to start or stop a train, might know how tickets should be collected or cars received into or detached from a train, would not, perhaps, know what to do in case his train was thrown from the rails or had lost its right to the track. All these things have to be thought of and anticipated; and the carefulness with which this is done illustrates the talent of those in charge.

In the selection of men to fill petty offices of responsibility, as well as those of greater degree, each varying circumstance that governs must be carefully considered by the appointing power. The selection of the fittest and the continuance of an incumbent in the service require, frequently, the payment of extra wages. And thus extra wages are paid oftentimes to meet exigencies that never arise, just as expenditures of a similar character are unavoidably incurred in other branches of the service. These we may term constructive expenditures. They are much the same upon all lines, without particular reference to the business done.

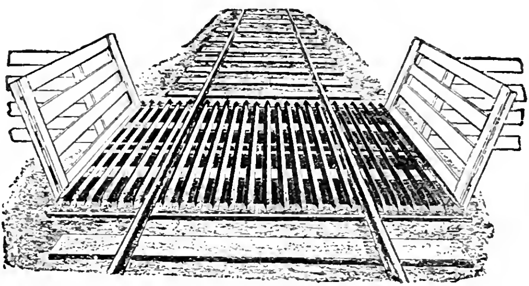
The cost of caring for a property is not affected by what it earns to so great an extent as we might suppose. A competent and trustworthy manager must be employed to look after its affairs and preserve its integrity. The amount paid him for such services is of necessity dictated by the extent of the property and the ability and faithfulness of the man, rather than by what it earns. This is true to a certain extent of all the officers of a company. The salaries of minor officers are more dependent upon the business done than those of their superiors. This is also true of many subordinate servants, but a large proportion of the amount paid is a fixed expense, not dependent, except remotely, upon the business done.

At the headquarters of every company a complicated and expensive force must be maintained in addition to the officers; it is the second or subsidiary brain of the enterprise, without which the organization would fall to pieces of its own weight. It consists of skilled assistants, clerks and others. They carry out the determination of the company as expressed day by day by its officers. They must be experienced and discreet, disciplined in their office and capable of exacting respect from others. The number and salaries of these assistants are not materially influenced, either favorably or otherwise, by the fluctuations of trade, except when it extends over a considerable period of time. They may be said to be fixed in the offices they occupy. Increase or decrease of traffic does not affect them. The explanation of this is found in the difficulty of filling their places. The knowledge they possess is the result of laborious training, of years of familiarity with their particular duties, and therefore not easily acquired. Except where business is depressed for a very considerable period it is inexpedient as well as expensive for a company to make any change or reduction in its general office force. A reduction of their wages is practicable, but not a reduction in their number.

The traffic of a company may be paralyzed by a great storm, or its business partially disturbed by the failure of a crop, by the diversion of trade, by the occurrence of a disastrous epidemic or from any other of many causes, but its fixed disbursements remain undisturbed. And herein lies, as we have said, a partial explanation of the ability of a company to lessen its rates, when necessary to meet the exigencies of trade. Up to a certain point addition to traffic is not followed by corresponding increase in either the number or wages of employes. There is no perceptible increase in the number or pay of watchmen at crossings and bridges, track patrol, persons in charge of tunnels or bridges; no increase in the number of agents at stations, of the principal ticket sellers, of the men employed in connection with the customary trains, of foremen and their assistants busied in keeping the track in order, or of the minimum force at shops and round houses and at depots of supply, and so on.

When, however, the traffic of a company increases beyond a certain point, expenditures for wages will increase, temporarily at least, beyond what the comparative profitableness of the traffic warrants; this relative increase will continue until the traffic again reaches a point where the maximum amount of labor possible is exacted of the force.

Within certain limits, not possible to clearly define, the elasticity inherent in every organization enables it to accommodate an increase of business without any addition to its machinery or the number of its servants. Just as a considerable increase is possible in the number of guests at a hotel without any addition to the force of attendants; let us suppose the maximum of this increase to be fifty guests; this number may be added without increased cost for service to the proprietor; but at this point the addition of a single guest will necessitate, we will say, the employment of an additional clerk, another waiter, an assistant porter, and so on through the list of attendants. This outlay is, of course, out of all proportion to the income



Cattle Guard.

derived from the additional guest and has besides the further effect of increasing the relative cost of operating the house; but it is unavoidable. And so it is in the working of railroads. We will suppose a passenger train is added to the list of those already operated by a company. Only a small percentage of the patrons of this new train, we may suppose, is made up of new passengers. The traffic of the line has simply readjusted itself to conform to the increased facilities afforded it. The convenience which the new train offers the public may add a few passengers more or less, but there has been no marked addition to the business in consequence of it, and until there is an increase of traffic commensurate with the added facilities, the company is a loser by the transaction, for the reason that under the new order of things its train service is performing only the minimum labor of which it is capable, while before it performed the maximum amount.

The same rule applies with equal force to freight trains and is noticeable in all departments of the service.

At a certain time in the growth of a traffic the outlay it induces is much greater than the immediate income from it justifies. The subsequent growth of business may warrant the increase, or it may not; in determining such questions, and they are of continual occurrence in the operations of a railroad, the judgment of the officer upon whom the reponsibility rests is sometimes colored and confused by influences of a more or less personal nature, so that intelligent action is not to be expected in every case. The average sagacity the officer displays must be the test of his fitness; so far as the writer's observation extends the only definite means of testing the possibilities of a company's traffic is to continue to put on trains as long as they continue to fill up, *i. e.*, to bring increased business.

There is this, however, always to be remembered in connection with additions that are made to the force of a well appointed railway company in contradistinction to a new enterprise, its disciplined organization enables it to utilize the cheapest quality of labor of the kind needed; an impossibility in the other case. The increase in the number of its operatives is not attended with a corresponding increase in the wages paid, its organization requiring an increase of mechanical force, not of constructive ability. The effect of additions under such circumstances is, of course, to reduce the average cost of doing business, a consummation every manager labors unceasingly to accomplish.

I have pointed out above the influence certain determinate expenses have on the relative cost of labor. The effect is quite as marked in other departments of the service. Thus disbursements for interest and dividends are not affected even remotely by fluctuations of business. This is equally true in many states with local taxes, assessments being based on the value of the property rather than upon revenue.

Many of the guarantees also which the vicissitudes of business compel a company to enter into are not affected one way or another by the amount of earnings.

The amount paid for rent of buildings and grounds is only nominally affected by an increase or decrease of earnings. Any permanent decline in a business of course in the end necessitates a readjustment of contracts and leases, but as the buildings and grounds are usually imperative, and the agreements connected with them entered into for a series of years, the expenses they entail can not be lightly or hastily diminished.

The cost to a company of keeping its fences, gates and crossings in order is not increased or diminished, perceptibly at least, by the business it does. The amount disbursed for these purposes is dependent upon other causes, over which a company has comparatively little control.

The expenses of keeping up the permanent structures of a company depend quite as much upon natural influences as upon the business done; under the most favorable circumstances bridges and culverts will crumble to pieces, buildings will fall to the ground or become unfit for use, fences, gates and crossings will succumb to merely climatic influences, embankments and cuts will become unsafe, ditches will become clogged or filled up, the roadbed will become worthless for lack of ballast and careful attention, and ties will decay, while the rails they support and hold in place will become unfit for use; all these things will be brought about by natural causes alone, whether business be light or heavy, if a constant stream of money, proportioned to the extent of the property, be not poured out from day to day.

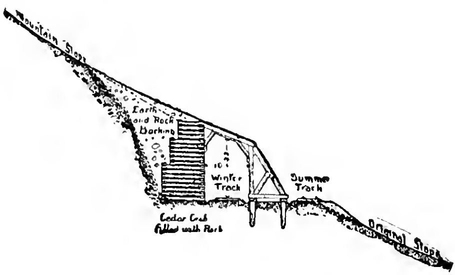
The expenses of a company depend largely upon the nature and extent of renewals; these are influenced by the length of time the property has been in operation and by the thoroughness with which it was originally constructed.

At first the expense will be very light upon a well constructed property, but with the lapse of time it will steadily increase, the maximum being reached at the point at which the average life of durability of railroad property may be said to reach; this period will vary in different sections and under different circumstances, according to the climate, the nature of material used and the amount of business done. Under ordinary circumstances this average should not be reached under eight years, the average durability of rails, ties, spikes, equipment, platforms and fences being in that neighborhood, while the durability of buildings, permanent bridges, culverts and similar property will be longer.

Generally, it may be said that the amount of business done will determine the duration of the machinery employed, while the weight and velocity of the load will measurably determine the duration of rails, ties, roadbed, etc.

Turning to another feature of the case, the machinery of railroads, we find that the difference between the wear and tear of used and unused machinery is not nearly so great as it would seem at first glance. The expense of preserving unemployed property of this description in good order is not noticeably less, as every manufacturer is aware, than the cost of keeping it in good condition when actively employed.

The subtle influence of idleness is as destructive in this case to man's work as idleness is to man himself. The machinery he constructs with such infinite care and labor requires the occupation and attention designed by him, and without it rapidly deteriorates in value and usefulness. The amount of fuel necessary to haul the minimum load is a fixed charge; and we know that the fuel consumed by a locomotive hauling thirty cars is not relatively as great as when hauling one third that number, while all the appurtenances necessary to the successful operation of the train are practically the same. The



Snow Shed.

lubricants used upon the locomotive are substantially the same, whether the number of cars hauled be ten or thirty. The lights and furniture are the same. The conflagrations which the locomotive causes are the same. The accidents are practically the same. The same number of incautious people are killed or injured. The same number of vagrant cattle are run over and crushed. The same number of switches must be turned at meeting points. The wages of the train force are the same. The telegraphic orders that pass back and forth between different train officials are the same. All the varied expenses connected with the use of water are practically the same, from the cost of the fuel used for pumping to the amount of alkali expended in cleaning the boilers of locomotives.

As we have stated, the expenses for keeping up the organization of a company are not noticeably different, whether business is large or small, productive or otherwise. All the varied expenses which the complicated laws require must be met without much if any reference to receipts; bulletins must be exhibited as the law prescribes; tariffs must be promulgated, agreements must be made, notices of elections posted, trustees remunerated, traveling expenses met, numerous complicated and expensive exhibits and returns rendered the state, lawyers employed, and such insurance as the nature of the property demands duly provided.

These expenses are inherent and in nowise dependent upon the volume of business or its productiveness.

When, therefore, we observe a partially loaded train winding its way across the country, or remark a storehouse or yard filled with idle equipment, we must not jump hastily to the conclusion that the owner thereof has reduced his expenses so as to make them conform to the amount of business he is transacting, or that it is possible or practicable for him to do so; on the contrary, we may truthfully believe that the bulk of his expenses have not been abated at all, being so circumstanced and governed in their nature as to render any reduction impossible.

And we may properly remember the further fact here that the owners and managers of a property are never disregardful of the circumstance that profits arise out of business carried on after fixed expenses are met, and hence in the securing of such business and in fostering its growth they need no spur; to them may be safely left the development of the business properly belonging to their lines, because out of it grows their profit and without it their roads are worthless. No one, therefore, can be so much interested in the situation and its development as they, nor so wise in its proper and equitable solution.

Carriage in Central Asia.

CHAPTER XIX.

MAINTENANCE—COST OF OPERATING AFFECTED BY FACILITIES.

Cost of operating is affected favorable or unfavorably according as the facilities are ample or otherwise.

To enable a company to secure the most favorable results possible it must be able, for instance, to carry forward its repairs and renewals at the most convenient season of the year and must possess the appliances best fitted to their economical and rapid performance; in other words, it must be in good condition financially and must possess machinery amply fitted to its wants and adequate to carry on its work with the least outlay possible.

The differences so noticeable in the cost of working railway properties are in a measure attributable to differences in facilities enjoyed.

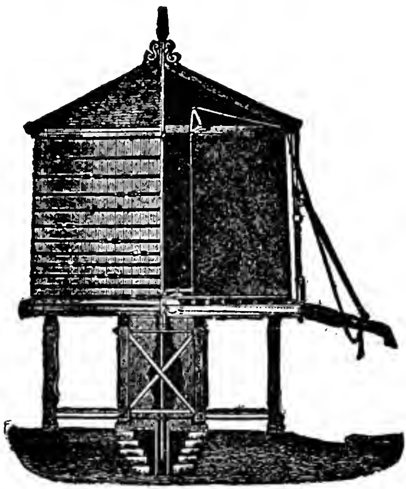
A company that does not make adequate provision for transporting its traffic as it arrives, that is not provided with adequate equipment for doing its business, will be compelled to suffer many expenses and losses that might, under different circumstances, have been avoided. It will not be able to perform the service at the opportune moment, and will, in consequence, be put to such additional expenses as the delay entails. In addition to this loss, the traffic that is for the moment without accommodation will, when it can, seek other channels and the revenue from it will be lost. Thus current expense of working will be increased in many cases, while the loss of business will swell the proportion of operating expenses to revenue.

A superabundant equipment, on the other hand, is a source of expense to its owner; its possession involves an annual loss of interest on cost, also the current expense of keeping it in order and the outlay incident to its care and storage. In addition to these simple and direct losses the effort to give it employment is quite likely to lead its owners into excesses, thus adding to cost of maintenance losses arising from a more or less ruinous competition.

The disposition of railway companies, we may say in passing, to encroach upon the territory of each other, coupled with a belief inherent in the breasts of those who serve them that they can create business of a profitable character by expenditures or concessions, has been the cause of many of the disasters that have wrecked railway properties.

What we have said in reference to the necessity of restricting the machinery and rolling stock of a company within necessary and proper bounds, applies equally to its property as a whole. While a property must be maintained at a point commensurate with the wants of business, it should end there. Contingent wants that may perhaps never occur should, under no circumstances, be anticipated, but should be left for the exigency as it arises.

While the owners of a property must thus restrict themselves in reference to indefinite wants they will remember that prosperity can not be



Water Tank.

maintained without adequate accommodation. When wants are inadequately or improperly provided, revenue that should be available for extending or strengthening the property or that might be divided among shareholders will be required to meet current expenses. A company thus unhappily placed can not, it is needless to say, compete successfully with a more alert rival;

it will be avoided by people who would, under other circumstances, give it encouragement and support, while its expenses will be swollen by the usury that ever attends improvidence.

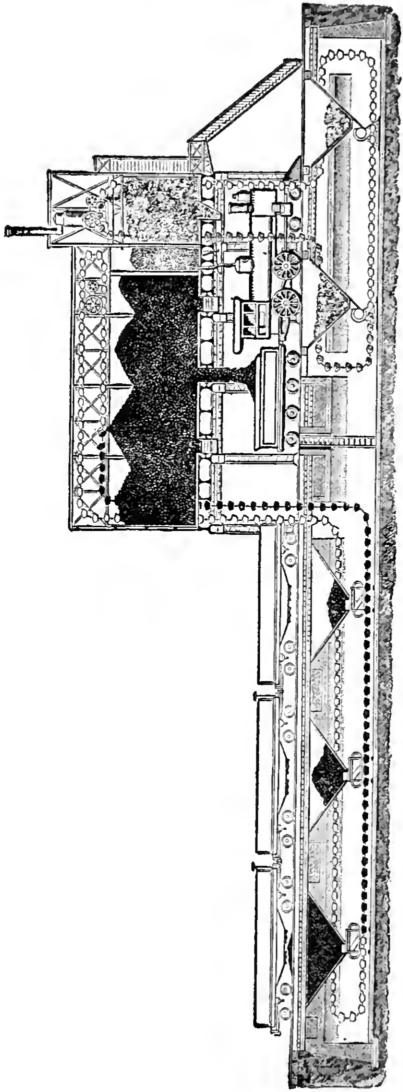
There are but few railway managers, it must be said, who do not understand the importance of keeping the property entrusted to them in good condition. The difficulty is, and always will be, to make the owners equally alive to the fact. Absorbed in the prospect of a dividend, secure in the belief that the management will provide the necessary ways and means for meeting improvements, they frequently lack apprehension and interest. They do not refuse to make provision for the company's wants, they simply ignore the matter. To meet together from time to time and authorize an expected dividend, is the consummation of earthly bliss and responsibility. They listen with approval to the remarks of the chairman, congratulate the manager upon his energy and efficiency and disperse, leaving him to get along as best he can. Thus the wishes of managers are often disregarded and their strength wasted. The truthfulness of this is apparent in many ways; it is needless to say that the losses resulting therefrom (when want of action results in tieing the hands of the management) are always disproportionate to the temporary saving effected

Innumerable instances might be cited, if necessary, to illustrate the necessity of a company supplying itself with every auxiliary appliance.

A company, it may be said, that does not possess adequate tracks, convenient sidings and sufficient yard room can not handle its traffic with the celerity and economy it could if it possessed such facilities. The company that is able to make its track repairs and renewals at the period of the year most advantageous for such work will be able, manifestly, to do so more economically and effectually than its less fortunate neighbor.

It is essential, above all things, to the prosperity of a company, that it should be able to make its repairs and renewals as occasions for them arise; an unsafe bridge, an insecure culvert, or a defective axle or car wheel may involve the destruction of a train which, with the losses collateral to it, will amount to hundreds of thousands of dollars, extending over a long period of years. The losses that result to a company from accidents of this kind, whatever they may amount to, can never be known, even approximately, for the reason that they entail loss of confidence in the safety of the company's property and in its methods of business; thus to the known losses there must be added the indirect losses occasioned by diversion of traffic and other causes.

It is in details of operation, however, that losses accruing from improvident management are most marked; this is especially apparent in connection with the road of a company; thus, a worn and battered rail left in the track of a busy line will so disturb and rack the equipment passing over it that the cost of repairs to the



Modern Locomotive Supply Station.

Arranged so as to coal, sand, water and dump ashes of four locomotives simultaneously. The coal, sand and ashes are carried in large pockets, suitably arranged over the tracks, and when the engine stands in position the coaling chute comes over the tender, the sand being over the sand box and the fire box of the locomotive standing over a hopper into which the ashes are dumped.

latter which it necessitates will many times outweigh the value of a new rail required to replace it; the same is true of a line imperfectly ballasted, or one where the alignment is faulty.

The cost to a company of keeping its locomotives and machinery in good condition will depend very much upon the carefulness with which they are kept cleaned and housed when not in use. The rolling stock that is kept well painted and in good repair will not be so expensive to maintain as the equipment that is neglected; and, while present outlay for cleaning, housing and painting may be a tax upon a company, its due observance can not but result in more satisfactory returns to owners than a contrary course.

And what we have said in reference to machinery and rolling stock applies to every branch of the service. The increased disbursements, to illustrate, of a company to meet interest on money expended for overhead bridges and viaducts at busy points will, in many cases, be more than counterbalanced by the increased economy of operation that will follow, in the saving in wages and other expenses at crossings, and in freedom from accidents of all kinds and the outlay they involve.*

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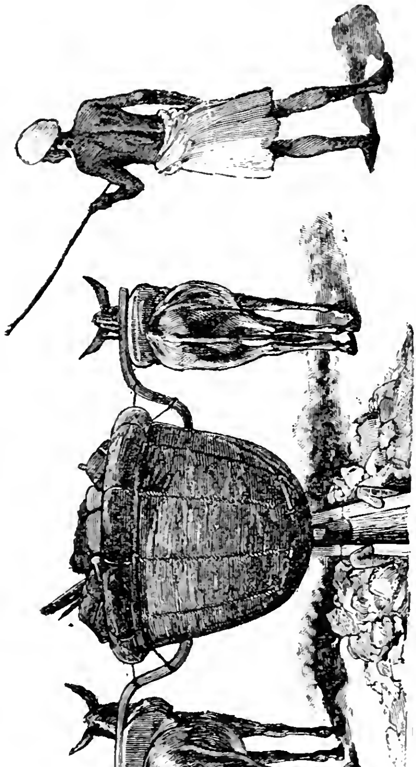
* These facts are well understood by railway managers, and wherever the finances of the companies will admit of it, and the circumstances of the case warrant, the officials in question are as a rule everywhere busy correcting the mistakes of early construction.

The wisdom of providing the best appliances for conducting business is perceptible in reduced expenses. Thus the introduction of a new piece of machinery, a copying press, a patent ink, a new blank or other contrivance intended for simplifying and cheapening, frequently renders a material reduction of the force possible, or prevents an otherwise inevitable increase. Innumerable illustrations of this might be cited.

The usefulness and perpetuity of a plant is indefinitely heightened and prolonged by maintenance at a high state of efficiency; this is particularly the case with machinery and equipment. Such property should be maintained at the maximum state of efficiency; the duration of a car, locomotive or stationary engine may be indefinitely prolonged by prompt and careful repair of the various parts as it is rendered necessary, while neglect will hasten the general breaking up of the whole structure. The necessity of protecting and maintaining a property at an adequate standard is well understood by railway managers; they are, however, very often overruled in the matter, not being allowed the funds necessary to carry out what they know to be for the best interests of the property, especially when it involves a reduction of dividend. There can be no doubt of the shortsightedness of such a policy. A company that does not continually adjust its dividends to its ability to pay is an unsafe enterprise to invest in. The fixedness of dividends is admirable, so long as warranted, so long as surrounded by an adequate surplus; no longer. No one who knows the needs of these properties but will feel safer and more willing to buy the stock of such a road. Dividends should be governed by current events, net income, and present and prospective needs of the property—never by a tradition or formula.

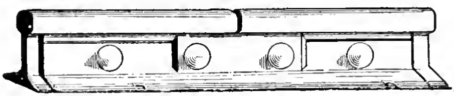


CHAPTER XX.

MAINTENANCE — TAXATION.

The questions attending the taxation of railway property are most perplexing. It is hard to conceive of a basis that will not, under conditions likely to occur, work hardship to either the state or the carrier. If the tax is based upon realty the difficulty of determining the value thereof is apparent; if based upon gross earnings its hardships and the temptations to abuse that it suggests are obvious. In fixing the tax it is apparent that different methods should be found from those in force in the case of private property, for the reason that railroads are surrounded by legislative and other restrictions (not known in other cases) that in many respects greatly retard their earnings capacity. These, it is manifest, under any just system of taxation, must be carefully considered. Many different methods of taxation for railroad property are in force. Differences seem to be almost as prevalent here as in other matters affecting the operation of railways. A brief description, however, of the systems of taxation pursued by a few representative governments and states will be found interesting. And first let us take the Belgian system. It seems to be, on the whole, the most satisfactory.

The Belgian fiscal system, as is well known, presents in many respects a most satisfactory solution of questions of this nature. Under its operation taxes are levied upon railroads on the basis of net earnings. If there are no net earnings no tax is paid. In other words, if the owners of a property do not receive anything for its use they are not asked to supplement their loss by further losses. Taxes upon real or personal property are unknown. A small tax on capital stock owned by Belgian citizens is exacted. But the law does not require holders to register their shares. The tax, therefore, can be, and is, evaded.



Rail Joint.

Indeed, the evasion is apparently designed, the purpose being to make net income the measure of assessment.

In Great Britain the general tax on railway property is based, like that in Belgium, on net earnings. Following the custom, however, enforced prior to the introduction of railroads, a tax of five per cent. is levied on gross passenger earnings; fares that do not exceed a penny per mile, maintained for the poorer classes, are, however, exempt. No direct tax is levied on freight, express, mail or miscellaneous earnings, as such. Taxes are based on net annual profits, which must be paid before dividing the surplus. Thus, except in the case of the tax on a portion of the passenger traffic, nothing is exacted in the event there is no surplus over and above operating expenses. It must be remembered, however, in connection with the English method of taxation, that the practice of mortgaging railroads, pursued in the United States, is hardly known there. The money raised to build railroads in that country is largely based on capital stock; the government tax takes precedence of any dividend on this stock. It is the same as levying a tax in the United States on earnings before deducting the amount paid as interest on bonds and dividends.

A committee of state commissioners appointed several years ago to examine the question of taxation, especially commended the English system, but, in the recommendations they make I am unable to find anything that conforms to its operation. The conclusions of the committee seem to be a tax on gross receipts without reference to net income.

The government of the United States does not levy any tax upon railroads. During the period of the civil war (1860-1864), however, a heavy tax was levied on gross earnings, but this was in every case added specifically to the tariff rate by the carrier so that he acted simply as the agent of the government in collecting the tax from the people. A tax of three per cent. (afterward increased to five) was levied on disbursements for interest and dividends.* A stamp tax on the bank checks of railroads was also levied. All these taxes were considered to be of an extraordinary nature consequent upon the expenses of the war and were one and all permitted to lapse with the occasion that gave them birth.

The taxes levied by the different states in the United States are not relatively the same. Frequently two or more methods are pursued in the same state; the basis will be different, the rate paid different and the method of assessment and levy different. Each state pursues a system, partly its own, partly borrowed. The annoyance these differences occasion are aggravated by the fact that the lines that separate the states have no commercial significance. Moreover, the differences in taxation are so marked in some cases, so discriminative in their nature, as to influence the cost of doing business upon roads owned by contiguous and rival companies, to the extent of two or three per cent. of their gross earnings.†

To those familiar with the subject it requires no difficult stretch of the imagination to picture,

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* The tax on capital was usually, in the case of mortgages, deducted by the companies from the amount of the interest the holders of the bonds would otherwise have been entitled to receive. In the case of dividends it frequently happened that the amount of the government tax was deducted from the amount that would otherwise have been paid by the company; in other cases, however, the amount of the tax was paid by the company in addition to the dividends declared.

† Thus in Michigan the tax is two per cent. on roads earning less than $4,000 per mile, while in Wisconsin, across the border, the tax is four per cent. on all roads earning over $3,000 per mile.

under such a state of affairs, a line so taxed as to afford a company pursuing a different route, and not so heavily handicapped, a margin on its business equivalent to a fair profit on its investment, sufficient, in fact, if divided among its patrons, to offer inducements to shippers that the first named company could not meet without ruining it or putting an undue strain upon its resources.

This is discrimination in its most malevolent form.

When a state discriminates, as is sometimes the case, between railways within its own borders, exactly the same results are produced; the difference in the amount of tax levied affording the favored line a margin which it may use to the ruin of its adversary's traffic.

A description of the different methods of taxation in the United States would in itself fill a volume. For the purpose of illustration the systems in force in a few representative states may be given.

In Wisconsin taxes are based on gross earnings. The tax is levied by the state and is payable yearly in two equal installments, six months apart, in the year following that for which the tax is levied. Towns and cities are permitted to levy a special tax for the improvement of streets within their borders occupied by railroads. The Wisconsin tax is based upon annual gross earnings per mile of road operated. When the earnings exceed $3,000 per mile of road a tax of four per cent. of such gross earnings is levied; when earnings are over $1,500 per mile and under $3,000 per mile, the tax is two per cent. of gross earnings; when gross earnings are under $1,500 per mile the tax is five dollars per mile of road.*

The advantages afforded the second and third class roads, while they may be just and proper in the main, are capable, it is apparent, of being used to the serious detriment of lines paying a higher rate of taxation. It is not difficult to picture a road of the second or third class that is earning more on its capital than those having a revenue of over $3,000 per mile. Of course the presumption is that the lower grade roads are only able to pay a small tax, but this presumption, while perhaps in the main true, is not tenable in every case, and when not true to the extent of the favor extended, the discrimination in its favor may be used to reduce rates to the serious detriment of roads of a higher class. It is apparent that a road that pays only $5 per mile annual tax is in a condition to do business at a much less rate than one paying $200 or more,

* According to the operation of the Wisconsin law the tax on a mile of road earning $5,000 is $200; on a mile of road earning $1,500 it is $5; and on a mile of road earning $500 it is also $5. The decrease of percentage in favor of the road earning $1,500 per mile as compared with a road earning $5,000 per mile is $3\frac{2}{3}$ or $91\frac{67}{100}$ per cent. of the tax levied on the latter. On the other hand, the road earning $1,500 per mile has an advantage over the road earning $500 per mile of two-thirds of one per cent., the tax being the same on both roads. On a road earning less than $500 per mile the discrepancy would be relatively greater.

and may use the advantage thus gained through the operation of the state to undermine and destroy other properties.

Michigan levies a tax of three per cent. on gross earnings when they exceed $4,000 per mile and a rate of two per cent. in other cases. Taxes are levied for the calendar year and must be paid in July succeeding. The operation of this tax, as in Wisconsin, is discriminative; this discrimination amounts to one per cent. of the gross earnings of second class companies. Michigan also levies a tax of three per cent. on receipts from passengers carried in any palace or sleeping cars, or any car for which an extra price is paid; also a tax of two per cent. on gross receipts derived from the leasing or hiring of cars by fast freight and other lines. Railroads incorporated before 1850 are subject to an annual tax of three-fourths of one per cent. on their capital stock and loans used in construction. Lands owned by a company in Michigan, but not required in connection with the operation or maintenance of its road, are treated in all respects as if owned by private individuals.

In Minnesota the tax is based on gross earnings; but the practice is not uniform; railroad companies organized under certain charters may pay, in lieu of all other taxes, one per cent. of their gross earnings for the first three years, two per cent. for the next seven years and three per cent. thereafter, or they may accept the provisions of the general law applicable to all property.

Iowa fixes the valuation of railroad property without the intervention of local assessors, by a state board, consisting of the governor, secretary of state, auditor and treasurer; the assessment is also made by this board. The tax is fixed arbitrarily at a certain amount per mile of road. The amount assessed is apportioned by the board to the various taxing districts through which the line runs, upon the basis of the relation that the mileage of the road in such districts bears to the total mileage. Under this method of taxation the relative value of the property in the various taxing districts, it will be seen, does not affect the amount allowed them by the state board, the basis being the number of miles of main track. The tax thus assessed and paid to the local authorities along the line includes real and personal property of every description, but does not prevent taxation for special improvements by cities and towns.*

Spike.

Illinois has a more complicated system of taxation than any we have noticed. Taxes are based directly on the value of the property. The assessment is made partly by a state board of equalization (elected by the people) and partly by the local authorities. Taxes are paid to the

* In Iowa the holder of the securities of a railroad company located within the state is taxed on such securities the same as on other personal property, although the railroad has already been taxed on its full value.

treasurers of the various counties. The value of the property in the various taxing districts, coming within the cognizance of the state board, is certified to such board by the local authorities. The state board then fixes the value upon which the assessment shall be made. A railroad in Illinois is understood to include the right of way, tracks and other improvements thereon. The value of the rolling stock is determined by the state board and apportioned to the local taxing districts on the basis that the mileage in such districts bears to the total mileage. Real and personal property not included in the assessment referred to above, such as wharves, shop grounds, supply depots, storage houses and the contents thereof, including furniture, tools, machinery and fuel, are assessed directly by the local authorities. Moreover, if the funded debt of a company and the market value of its shares exceed the value of the real and personal property ascertained in the manner described, the company may be taxed for such excess. This latter may be called a capital tax.

California taxes the credits, bonds, stocks, dues and franchises of railroads. A state board of equalization, also county boards, are provided for. The state board assesses the franchise, roadway, roadbed, rails and rolling stock of lines running through more than one county, at their actual value, and apportions the tax to each county and municipality in proportion to length of road therein. Other property is assessed in and apportioned to the place in which located.

Massachusetts taxes the railroads on the basis of the market value of the capital shares on the first of May preceding the assessment. The rate is determined on the basis of the whole amount to be raised by property taxes in the state during the year. Railroads are taxed locally on the assessed valuation of real estate and machinery, but the amount of this tax is deducted from the capital stock tax described above.

Such are the methods of taxation pursued by the states named. Further inquiry into the different systems would prove interesting, but the illustrations given are sufficient to explain the general methods in vogue. It is observable that the manner of applying the tax is never exactly the same in any two cases. The systems differ in detail, and many of them in principle. None affords a satisfactory solution of the question. It is possible that no such solution is attainable. To be entirely satisfactory the method must take cognizance of the local environment of each company, must be entirely equitable in its application, and honestly enforced. These are things hardly to be expected, because they presuppose a perfect enlightenment and unselfishness. We should not, however, cease to strive to attain this standard, because to do so would be to acquiesce in imperfection and wrong and lessen the zeal of those whose duty it is to devise more perfect methods. The more fair and enlightened among the officials of the various state governments appreciate heartily the inequalities and objections to the systems of taxation they enforce. This feeling found expression a few years ago in the appointment of a board of state railroad commissioners to examine fully into the subject. This committee recommended a tax on gross earnings as the best attainable basis, supplemented by a tax on realty. In its report it said:

"The conclusion at which your committee arrived was that all the requisites of a sound system were found in taxes on real property and on gross receipts, and in no others—in fact, that when these were properly imposed, no other taxes would or could be necessary, as nothing would escape untaxed. Under this system the real estate of the railroad corporations, held for corporate use outside of their right of way, would be locally assessed, exactly in the same way as the real estate of private persons or of other corporations adjoining it was assessed. There would be no distinction made in regard to it. It is the ordinary tax on real property. Beyond that a certain fixed percentage, established by law and of general application, should be assessed on the entire gross earnings of the corporations, and this should be in lieu of all forms of taxation on what is known as personal property. Under this system the rolling stock of the corporation would not be assessable; nor its securities, whether stock or bonds, either indirectly through the corporation or directly in the hands of those owning them. The entire burden, be the same more or less, would be imposed in one lump on the corporation and levied directly. It does not need to be pointed out that this system is perfectly simple; that under it taxation is fixed by a general law and not by local valuations; that it is thoroughly proportionate, inasmuch as the amount levied depends on the volume of gross receipts; finally, it can be ascertained by anyone, and can by no possibility be evaded."

Let us examine for a moment the method they suggest, and, as they have themselves pointed out its merits, we may, without unfairness, confine our examination to its objectionable features.

And first of all it is apparent that the property outside the right of way would be doubly taxed for the reason that earnings are based on total cost; a tax levied on property outside the right of way would therefore be supplemental to the tax on gross earnings. A tax levied on earnings covers every species of property so far as such property is necessary or contributes in any way to earnings. The fatal objection to this basis seems to be in supposing that property outside the right of way does not in any manner contribute to the earnings power of a road. Might we not with equal reason say that the brain is not a part of the man; that he is made up wholly of legs and arms?

A system, moreover, which permits a company to be taxed by the state authorities and also by the various districts through which it runs, independently of each other, invites in its operation measures of the most objectionable and oppressive character.

The rate of taxation under the proposed law is variable; if earnings exceeded a certain amount per mile, to be fixed by law, then a certain rate is to be enforced; if the earnings do not exceed this amount, then a different rate intervenes. The distinction contemplated in favor of companies whose gross earnings reach only the minimum sum is objectionable, as already pointed out.

The operation of a tax based on gross receipts without reference to the cost of a property or the expense of operating is objectionable, as its effect is to confiscate its net revenue in many cases. A tax on gross earnings does not recognize the equities of finances or the nice distinctions of business,—the difference between a profitable and an unprofitable business. If the amount of capital invested in different roads or different parts of the same road were the same, the cost of maintenance the same, the amount of business the same, the cost of operating the same, and if there was a uniformly sufficient margin of profit after deducting expenses of maintenance and operating, then a tax on gross earnings would not be objectionable. But unfortunately these conditions do not exist in a single instance.


Spike.

The cost is never the same for different roads, and for the same road one portion will cost more than another. The expensive part, however, is as necessary to the system as the other. But while gross earnings amounting to $1,500 per mile may afford a fair margin of profit on the cheaper line, earnings amounting to $10,000 per mile might be insufficient on a more expensive portion. A tax levied on gross earnings does not recognize the nice distinctions between these widely different classes of property, and in so far as it fails to do this is objectionable.

Discrimination between railroads through the levy of a different rate of taxes on their gross earnings respectively is in the nature of a subsidy granted to one enterprise and denied to its neighbor. The subsidy is allowed without reference to relative net receipts, and is, therefore, in many cases nothing more or less than a fund which the receiving company may retain at pleasure, or may use in the procurement of business to the ruin or serious detriment of its rivals. In Michigan this prospective rebate amounts, as we have shown, to one per cent. of gross receipts. In Wisconsin it exceeds three per cent. in some cases.

A tax based on gross earnings is objectionable under the most favorable circumstances, even if applied uniformly to all companies without reference to the amount they earn. The directness and simplicity of assessment and levy under such a system invites the constant interference of legislators and others. Its processes are too easy, too simple.

That is one of its chief defects.

If taxation were a blessing to be encouraged by the people, then the case would be different. Unfortunately, however, it is the reverse of this, and one of the chief concerns of mankind is to restrict by every means in its power the amount of the annual tax levy.

Under the system of assessing gross earnings legislators, ambitious of cheap renown, would see in the addition of a slight per cent. to the tax on railroads an easy way to relieve their immediate and more pressing constituents without risk or loss of local popularity; and thus difficulties brought about by the weaknesses of legislators would be forever fastened upon the railway interest. Or, in the absence of any inciting cause, the burdens of the community would be placed upon the railroads simply because they represented a small and unpopular minority, the process for fixing the tax upon them being simple and unmistakably certain in its results.* The community thus apparently re-

*"In certain states railroads are apparently looked upon as a species of windfall from which everything that can be exacted in the way of taxation is so much pure gain."—*Report of Committee of State Railroad Commissioners on Taxation; Proceedings of the National Convention of Railroad Commissioners, page 17, A.* This disposition would only be aggravated, we may believe, by simplifying, on the basis proposed, the processes whereby the railroad companies may be harassed by the states in question. In such localities our efforts should be directed to rendering it difficult, if not impossible, for the ignorant and vicious to make a football of the railway interest. Surely we would not be accomplishing this by the adoption of gross earnings, so easily ascertained, so generally known as a basis of taxation. That would be to invite the very evil we deprecate.

lieved of its burdens would cease to exercise that supervision over the acts of its servants which is so necessary to good government and without which good government is impossible. Only one termination to such a state of affairs could be possible. A tax on gross earnings is also objectionable on other accounts. If the business of a company were unprofitable the greater the amount of business the greater the burden. We can easily conceive of circumstances engendered by active competition, depression of trade or the restrictive laws under which railroads are operated, whereby the profitableness of a company's traffic might be destroyed; where it might have large gross earnings but no net revenue at all. The additional burden of a tax on gross receipts under such circumstances would greatly accelerate its road to bankruptcy. Whenever the business of a railroad is barely profitable, a tax based on gross earnings is in the nature of a prohibitory enactment, forbidding its further continuance. Taxation based on gross earnings is objectionable because it discriminates; because it takes no account of the cost of properties or their real earnings, namely, their surplus after paying expenses. There are other objectionable features that we can not stop here to notice. It seems apparent, therefore, that wherever taxes are based on gross earnings the amount of such taxes should be added specifically in each case to the tariff rate. In no other way can the baneful effects that are likely to follow such a system of taxation be obviated. On the other hand, a tax based on capital stock or bonded debt is even more objectionable than a tax on gross earnings. However, it has few advocates and we may dismiss it without further consideration. While apparently correct in its conclusions in many ways it is, like a tax on gross earnings, fallacious in application and unjust in operation.

Taxation based on real and personal property, the assessment, as in the case of individuals, being made by persons on the ground and familiar with local values, seems to be the least objectionable of all the methods that have been tried. Such a tax does not invite class legislation to the extent that a tax on gross earnings or capital shares does. Valuations are real, being based on the condition of the property situated in the various taxing districts. The tax on gross earnings and capital is based, in many instances, upon merely nominal values. The realty tax is more *bona fide* and permits, moreover, of the exercise of judgment and an equitable conscience. The objections to it are that assessments are not always made by persons competent to determine the true value of the property. The justness of such an objection can not be disputed or answered, but it may, with equally good reason, be made against our whole system of taxation, and is as marked in the case of individuals as of corporations.

A more serious objection to the realty tax is that it fails to take cognizance of the profitableness of the companies' earnings, the tax being the same whether the enterprise is productive or otherwise. This objection is fatal. So long as the state claims the right to fix the rates railroads shall charge or otherwise restrict their operations, it is bound to ascertain the effect of its action before determining the responsibility of the carrier as a tax payer. If the state exercises the right to circumscribe the earnings of a property it must circumscribe in like manner the taxes it imposes. The duties of sovereignty are not simply coercive in the case of corporations—they are protective as well, or should be. When a government, by direct or incidental action, reduces the income of a property, the amount of that reduction is in the nature of a tax and the effect must be fully considered before proceeding to impose an additional burden. The essence of railway property, as of all other productive property, is its net earnings. For this railroads are built; for this they are operated; this is the Mecca of owners; here we discover the true basis of taxation for this description of property. Railways are the slaves of the state, dependent upon it for their income; they require, therefore, special and exceptional consideration at its hands. If the state restricts their earnings it must not impose burdens inconsistent therewith.

Action of Spike on Tie.

And herein lies the unanswerable objection to any method of taxation of railway property not based on net earnings. So long as the state restricts railways in their operations the amount the property yields its owners must be the gauge of the latter's responsibility. The various systems of taxation that our states pursue do not make this just and necessary distinction. Whatever surplus remains, if any, after paying working expenses, is properly subject to taxation. In all matters relating to the worth of railroads, the estimates of investors are predicated upon net earnings, for the reason that railroad property, outside its uses for railroad purposes, has no value. This suggests the only true method of railway taxation. If a railway earns nothing, then the public which has enjoyed the benefits it confers without rewarding its owners should not make further claim upon it.* If the net earnings have been meagre, then the tax gatherer's portion should be correspondingly meagre. If the net receipts have been fair, then a fair proportion should be allotted the people for

* It may be said, perhaps, that this rule, if applied to railroads should also be applied to individual cases. Under exactly similar circumstances, yes; not otherwise. Many of the industries of our citizens are especially protected by a tariff designed largely for that purpose, and in those cases where protection is not extended the individual is left free to derive from his business, trade or calling such profit as his experience, foresight and capital render possible. The railroad companies, on the other hand, as already stated, are hampered by special laws and in many cases their income expressly limited by legislative enactment.

the support and protection awarded. If the earnings have been bountiful, then the tax may correspond in amount.* Herein I conceive to lie the true principles upon which the method of taxing railroad property should be based. Under so benificent a system the community of interest as between the state and its servant, the railroad company, would in this respect at least be complete. Under so benign a system the state would be concerned in fostering the interests centered in railroads rather than in harassing them. This direct and personal concern upon the part of our states is lacking; they levy taxes without reference to the ability of the company to pay, after having fixed, without reference to the subject of taxation, the rate of compensation it shall exact for its service. During the time railways are being constructed and before they are opened for business the method now generally in vogue for taxing private parties seems to be in every respect right and proper. But whatever the method of taxation, whether before or after completion, whether based on property, shares, bonds, gross receipts or net earnings, such tax, when levied, should be final and in lieu of all other assessments whatsoever.

Very little has been written or said in regard to railway taxation that has been printed.

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*Under a method of taxation such as is here suggested a company owning property not required by it in the operation or maintenance of its roads, would be taxed as in Michigan, the same as private individuals.

Sources of information in this direction are, therefore, very meagre. Mr. C. C. Harvey,* who has given the subject considerable thought, in an article on railway taxation, submitted to the Association of American Railway Accounting Officers, says as follows:

"In Ohio the county auditors constitute a board of appraisers and assessors and report annually to the Auditor of State for the use of the State Board of Equalization of Railroad Property, the amount assessed against each railroad, specifying the total sum and the amount distributed to each county, city, incorporated town, township and village. In addition to the tax paid thereon, there is a privilege tax of one dollar per mile charged by the state for each mile of main track and siding.

"In Kentucky the railroad commissioners (three in number) constitute the board of assessors and equalization, the valuations found by them being used for state purposes and also for each city, town, county and tax district.

"In Tennessee three railroad assessors appointed by the governor assess the distributable property, *i. e.*, the roadbed, rolling stock and personal property having no actual *situs*, every two years for state and municipal taxation, deducting from the valuation $1,000 before apportioning the amount per mile to each county, town and district. All other property, real, personal and mixed, including depot buildings, yards, etc., is assessed by county assessors and by the assessors of municipal corporations, who, however, submit the

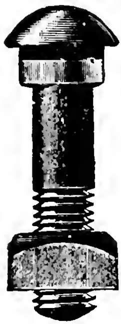
* Vice President and Comptroller of the Cincinnati, New Orleans & Texas Pacific Railway.

returns to the state railroad assessors. The governor, secretary of state and treasurer of state constitute a board of examiners upon the valuations found upon the distributable property, and their action thereon is final. It is provided that the assessors in making their valuations of distributable property shall have in view and look to the capital stock, property and franchises of each company as well as the gross receipts, the individual stock of each shareholder, and the schedules filed. The local property (depots, shops, yards, material, etc.) is assessed like other taxable property by county and municipal assessors upon the basis of the marketable value of the property. The assessment can be reviewed at the instance of either party before an equalization board and the assessments altered as the facts may warrant.

"In Georgia the comptroller general passes upon the returns made by the railroad companies, and, if dissatisfied with the same, reports to the governor, who shall then appoint three competent and disinterested persons to examine and assess the property. If the railroad company is dissatisfied, the state permits the question to be decided by arbitrators, one to be chosen by the state and one by the railroad company. The law provides that the property shall be valued, as far as may be practicable, to be taxed as other property of the people of the state.

"In Alabama the governor, secretary of state, treasurer and auditor of state constitute a board of assessment and the valuation found by them must be taken by the county assessors. Real estate, fixtures, etc., are, however, assessed as other property owned by private citizens.

The law provides that the valuation of railroad property shall be made upon the same principles as the valuation of other species of property, namely, what it would sell for under the conditions under which that character of property is most usually sold. In addition to the ordinary tax, a privilege tax of one-tenth of one per cent. is charged by the state.



Track Bolt.

"In Mississippi, the auditor of public accounts, treasurer and secretary of state form the board of assessors, the valuations found by them per mile being valuations to be used for state and county purposes and incorporate towns; but the local property of any railroad in any city or incorporated town may be taxed to the extent allowed by law upon a valuation made upon the same basis as the property of individuals. In lieu of this plan as to state and county taxes, a privilege tax ranging up to $125 per mile of main track is fixed, two-thirds of the amount being placed by the state to the credit of the counties, and in some cases cities and towns are allowed to impose a privilege tax equal to one-half that levied by the state in lieu of the *ad valorem* tax.

"In Louisiana the police jury of each parish is required to elect one of their number or some other property tax payer of the parish to act as a board of assessors on the assessment of railroads passing through the parish; the assessment, which shall be uniform, found by them, is reported to the assessors of the different parishes and is to be final unless changed by suit for reduction, said suit to be filed and conducted in the parish in which the president of the board may live. It will be observed that in Mississippi the railways may pay a privilege tax per mile of main track in lieu of the state and county taxes. This system of so-called 'privilege' tax is in vogue in other states.

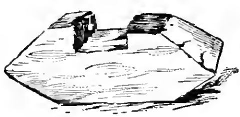
"In Wisconsin a tax on gross earnings is levied in lieu of other taxes, the rate being four per cent. on roads earning $3,000 per mile or over; $5 per mile and two and one-half per cent. of the gross earning in excess of $1,500 per mile upon roads earning less than $3,000 per mile and more than $1,500 per mile.

"Maryland, Minnesota, Dakota, Vermont and other states also tax gross earnings. The valuation per mile of road placed upon railroad property for taxation purposes also differs very materially in different states; for example, the assessed value per mile of road in Kentucky and Tennessee is about double the assessed value in Ohio, Indiana and Illinois. In like manner the percentage that taxes bear to gross earnings varies very much in different states and for different railways.

"As to the basis upon which railways should be taxed, there seems to be no good reason why the rules governing the assessment of other than railway property should not apply also to railways; the valuation of the distributable property per mile of road, however, should be uniform in each state, as the intrinsic value of the railway depends upon its integral feature, and it is impossible to correctly assess the road separately by tax districts; it should be valued as a whole and not as a collection of separate properties. The claim that because railways are monopolies, *quasi* public in character, they should in common with similar monopolies be subjected to greater burdens, is not founded upon justice. Unless there is an agreement as to special taxation, a railway company has the right to expect equal treatment with other property. Railways are subjected to governmental regulations of no ordinary nature; in addition to the control exercised by the interstate commerce commission, which affects their revenue and entails heavy expenses upon them, many states see proper to reduce railway rates, and, by various regulations, by demands for alleged improvements to rolling stock and for special station accommodations, greatly increase the operating expenses. They thus reduce the resources of the railway companies and certainly should not, in addition, demand special taxes from them.

"The question is frequently asked, How is the taxable value of a railroad to be ascertained? I am of the opinion that net revenue (the difference between gross earnings and operating expenses) should be the chief factor to determine the value; gross earnings may be large, but the value of the property will mainly depend upon the net earnings, which will be all that can be relied upon to compensate the owners for the money invested. Capital looks for a return upon its outlay and will not, under ordinary circumstances, invest in property that will not pay a dividend upon the investment, and, however large an amount a road may have cost, or however great its earnings, the property can not be expected to bring in the open market more than it can reasonably be expected to pay a dividend upon. The character also of the roadbed and the condition of the track will be reflected, in the course of a few years, in the net revenue of the company. Poor rails and unballasted track will entail heavy working expenses for maintenance of way and for repairs to rolling stock and probably in wrecks that might otherwise be avoided. Except as a going concern a railroad is worth very little; the cost of grading, bridging, tunneling, cross-ties, ballasting, etc., would be absolutely lost and but a small amount obtained from the right of way, station grounds, buildings, shops, machinery, rails and the other essentials of a railroad if the road should cease to be operated.

"It is worthy of remark that recently in England, the Southwark & Deptford Tramway Company successfully appealed against an assessment for taxation, and, by proving that from various circumstances and the low fares at which they were obliged to run, their expenses were greater than their receipts and that if the tramways were in the market to let, no tenent could be found to rent, the company practically obtained exemption from assessment. There are so many circumstances affecting the net earnings of a railroad—the actual competition of today, the possible competition of tomorrow, reductions of rates, poor harvests, dullness of business, labor strikes, increased demands necessitating heavy operating expenses or perhaps capital outlay, accidents that the most careful management can not guard against—that a liberal rate should be allowed by

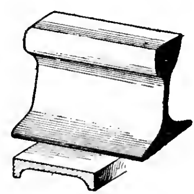


Action of Rail on Tie.

which to estimate the par value of the property. Probably ten per cent. would be necessary as a basis for par value, to place railroads upon an equality with other property. Upon this basis a road earning $1,000 per mile net would be valued at $10,000 per mile and a road earning $3,000 per mile net would be valued at $30,000 per mile, this valuation to be subject to such reductions as might be customary on other classes of property in the state. The annual accounts required by the interstate commerce commission are so complete that an accurate knowledge of the results of the yearly operations can be obtained therefrom. Assessors have more reliable means at their disposal by which to make a fair valuation of railway property than for any other species of property; they have the sworn statements of the railroad companies and can refer to the annual reports made to the stockholders, to the annual reports made to the interstate commerce commission, and in many cases to reports made to state commissioners.

"Unfortunately there is an increasing tendency to heavily tax corporations. The taxes paid by them are generally of large amounts and are easily collected with small cost, whereas the sums paid by individuals are comparatively small. The heavier the taxes on corporations, the lighter the burden on individuals, and the individuals are voters. A serious objection to taxing railroads by special laws, by a gross revenue tax or by a privilege tax per mile of road, is that the tendency induces legislators, perhaps unconsciously, to unduly increase the burdens on railroads; and, consequently, to decrease the burdens on individuals; in other words, to discriminate against one class of property. As an instance, the Mississippi code of 1880 fixed the privilege tax per mile on certain railroads at $80 per mile, $70 per mile and $60 per mile respectively. In 1884 these taxes were increased, the $80 and $70 per mile tax to $100 per mile and the $60 per mile tax to $80 per mile. Two years later (in 1886) there was a further addition, the taxes on all railroads being increased twenty-five per cent. over the amount fixed in 1884. In 1888 another increase was made by amendment to some local statute, which, however, was not signed by the proper authorities and did not, therefore, become a law. The increase actually made, however, between the years 1880 and 1886, amounted to over fifty-six per cent. on the $80 tax, to over seventy-eight per cent. on the $70 tax, and to nearly sixty-seven per cent. on the $60 tax, while reference to Poor's manual shows that very little improvement, if any, took place in the net or gross earnings of the companies in question during that time. For other classes of property the increase in taxation was comparatively light. The objections to a tax on gross earnings, beside that of principle, are that it operates against those roads which, for various causes beyond control, are worked at a higher cost per cent. of gross earnings than other roads (possibly their competitors) within the state; and also that it is unfair to those companies that do business at low rates, as the relative profit on low rates is less than on high rates."

Thus we have, in this and the preceding chapters, endeavored to present a summarization of differences in cost of building and operating railroads. They are too numerous and too complex to be described in detail. I have only mentioned those of the greatest consequence, namely, differences in the cost of supplies; in the price paid for labor; in the cost of transporting material and men; in the character of supplies available; in the effect of local environment, namely, climate, nature of country and natural facilities; the character, adequacy, condition and extent of the property; quality of its repairs and renewals; its facilities and terminal expenses; the direction, nature and volume of its business; season when moved; length of haul; the uninterrupted movement of its trains, their speed and dead weight; the amount of fixed expenses; and, finally, the amount of its taxes. The subject is a prolific one and may be pursued indefinitely. It would be well if it were more generally understood by railway owners and by those who make laws for railroads.



Rail on Tie Plate.

I have only attempted to point out the more salient features of the subject and the line of inquiry that must be pursued to comprehend its full scope and significance; to make clear to those who impose obligations upon railroads the necessity of their exercising discrimination; of tempering the wind to the shorn lamb, so to speak; of remembering that while uniformity may simplify the question to those who do not understand the subject, it will be fatal to the properties themselves; that the business of a railroad, like every other business, is a matter of detail and personal application and must be so conducted in order to be successful. It would be just as proper to make hats of a uniform size for all men as to prescribe uniform conditions for railroads; just as proper that the expenses of conducting the government should be collected by a uniform charge per head on men, women and children, without reference to their ability to pay, as to seek to make one railroad the measure of all or all roads the measure of one.

CHAPTER XXI.

MAINTENANCE—COST ARISING FROM NATURAL DECAY AND TRAFFIC—VARIOUS DETAILS OF MAINTENANCE.

(NOTE—The separation of the work of operating a railroad from the duty of maintaining it is entirely practicable, though that may not be the best way of carrying on such enterprises. It is as practicable as it is for a party to furnish power for manufacturing industries carried on by others; as practicable as it is to operate a great store the different departments of which are owned by different proprietors; as practicable as it is to maintain a canal used by a multitude of carriers. However, such joint use involves careful systemization, the supervision and directing care of those anxious to see it succeed rather than those anxious to see it fail, of those who believe in it rather than those who are sceptical, of those who would gain by its success rather than lose.)

Railway maintenance presents itself to us under various aspects. First, the maintenance of the economic conditions that appertain to common carriers; the due and full preservation of the rights of railways under their charters or acts of incorporation. Second, the maintenance of the *esprit de corps* of a railway force, a matter of vital importance to the public, the owner and the employe. Third, the dissemination among railway officers and employes of reliable knowledge of a general and specific nature in regard to the operation of railroads. These various phases of the subject, especially that relating to organization, claim more or less attention throughout these works; they are woven into the subject, no matter from what standpoint viewed, and find incidental, if not direct, reference, wherever the question of railway administration is spoken of.

The particular phases of railway maintenance, however, that I design to treat in this chapter relate mainly to the physical preservation of the property and the effect thereon of climatic influences and traffic respectively.

The possibility is suggested elsewhere that, through the unwise exactions of labor, it may be found necessary to close up a railway or group of railways for a longer or shorter period; that it may, in fact, be found impossible to procure men to operate them faithfully and intelligently.* To be sure such a contingency does not seem likely. Neither did it seem probable before the strike on a great southern railroad a few years ago that a great system, extending over several states, could be paralyzed for causes so trivial.† Yet such an event actually occurred. Moreover, the circumstances of the case were such as to suggest the likelihood of similar cessations of labor not only upon a particular railroad, but upon groups of railroads. In such an event, operations would


Track Level.

* In the volume "Organization and Forces."

† The Missouri Pacific Railway.

manifestly be impossible. No other course would be left but to temporarily close. Where labor has the disposition and facility to organize and act in concert over a great empire without reference to the rights of others, everything is possible. The nineteenth century is an age of centralization. It is especially so in business. We observe it in the growth of corporations and manufactories and other great enterprises. It is this vast concentration of capital, possibly, that suggested the centralization of labor; the delegation to agents of the right to arbitrarily control the many. The organization of labor, however, is much more extensive than that of capital. The latter is restricted and isolated in its efforts. Labor seeks to group great masses of men employed in widely diversified industries, and extending over enormous areas of country. If the effort is successful, and the vast association of men thus formed is not wisely governed, it will involve corresponding centralization of capital. Certainly it will render the continuance of business under present conditions impossible. Not only will the railway system as at present operated be broken up, but other industrial interests will, temporarily, collapse. Let us hope that these contingencies will not occur.

In the event railways were closed under the circumstances named, the duration of the suspension would depend on the disposition and power of the people to reassert the just and necessary condition of property, namely, its security and the protection of individuals in their right to work. The calamities that would grow out of such an upheaval and the distrust it would engender would require many years to heal. The possibility that a railway company may be compelled to stop business suggests the conditions that would attend such an act. Can the owners of railroads permit their property to lie idle? Passiveness is one of the greatest elements of strength capital has. Herein lies the secret of its power; its growth and beneficent influence; its ability to perpetuate itself. When it no longer possesses this it will cease to exist.

What would be the effect of idleness upon railroad property? Wherein would it deteriorate? What would be the amount of the deterioration? What expense does the maintenance of a railway engender? Would it be wiser for owners to suffer a known loss in an effort to maintain the rights of property (and incidentally of mankind), or should they effect a settlement with their employes, no matter what the sacrifice?

It is upon such a question that the contingency of a railway company closing its affairs for six months, or a year, or two years, may hinge. Upon the wisdom and courage that governs those making the decision the future of mankind may depend.

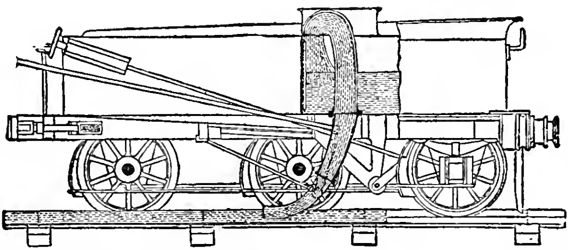
Let us suppose that a railway company decides, in view of the fact that it can no longer operate its property in harmony with honest usage or good government, that it will close its business until such time as just and necessary rights are accorded to it, what would be the expenses attending the maintenance of a property under such conditions?

The question is an interesting one abstractly considered, but especially so in the concrete. It invites investigation at the hands of experts, and demands the most careful and minute inquiry. Yet it has been little discussed.

In the event of the suspension of railway operations, what would be the effect upon the property? What would be the minimum amount that it would be necessary for a company to expend in order to preserve its property from deterioration? Having no income, the cost, it is manifest, would have to come from assessments levied upon the proprietors, or from reserves laid by against such a contingency. Of the wisdom of every company possessing a reserve fund proportionate to its operations, there can be no doubt. It need not be unproductive. If judiciously placed it would be a source of income as well as strength to its owners. Its effect would be evinced in the price of the company's securities. It would be a perpetual guarantee against the vicissitudes of business. It would enable its possessor to meet every expenditure, thus rendering him the master instead of the slave of circumstances. With such a fund, taxes could be paid, sinking funds met, interest on mortgages satisfied, and the expense of maintenance provided for.

It may be assumed, I think, that in the event a company found it necessary to suspend business, its bondholders would, if called upon, waive interest payments for awhile. The contingent fund would provide a reasonable sum to meet accretions of this character. The amount of the contingent fund should depend upon the annual burden for taxes, interest, tolls, sinking funds and expense of maintenance. Expenditures for the last named purpose are imperative. They must be met as they accrue, otherwise the owner will suffer enormous usury for neglect to preserve his property from decay. What sum would the cost of maintenance require? Would it be so great as to prevent the proprietor meeting it? I think not. The cost of maintenance may be determined with approximate accuracy.

Stripped of the glamour of public ignorance and comment, railway property does not differ from other property used in manufacturing, except that it is scattered over a wider territory. In the case of private manufacturers, their property lies within a narrow limit and when not in use the gates are shut and the public excluded, so that, no matter how great its value, its guardianship is compassed within the care of a few watchmen. These not only serve to protect the property, but prevent its deterioration, thus answering a double purpose. Unfortunately this simple disposition is impossible in the case of railroad property. Spread abroad, it is everywhere exposed. Its greatest security, however, under every condition, is in the difficulty of destroying or removing it. This renders it possible for the police force of a country to compass its protection (if it is so inclined), without material extra outlay. This would be of especial value to a company compelled to stop business. Only that portion of its property rendered insecure by fire would require especial guardianship, and even here the risk would be slight. Moreover, in considering the safety of railroad property under abnormal conditions, it is well to remember that



Tender Picking up Water from a Feed Trough. (English.)

the state must protect the proprietor, he being a tax payer, or, in the event it does not, must reimburse him for any damage he suffers. Losses, therefore, that arise from the acts of mobs or lawless combinations are public burdens, not to be thrown upon the proprietors of railroads, except in so far as they are taxed with others to meet the damage. The exercise of reasonable diligence in the preservation of one's property is, however, under all circumstances a duty. This duty railway companies least of all disregard. So that, in the event they closed their properties, they would still exercise a general and constant watchfulness. This would be chargeable to maintenance. Would it require special watchmen, or would the slight force required to keep up the organization be sufficient? I think the latter. In determining, therefore, the extent of the force necessary to keep up the organization of a property, we also cover its protecting force, except, perhaps, in isolated cases.

The question of maintaining the property of a railroad suggests many interesting enquiries, innumerable speculations. It involves many conditions manifestly not capable of demonstration in advance, contingencies that no one can predetermine. These contingencies depend largely upon the peculiar features of the property, largely upon its surroundings. In considering the cost of maintaining a road the cost of maintenance of organization must not be overlooked. This latter, however, in the case of a property temporarily closed, would depend upon whether the cessation was for a long or short period. If the former, the cost would be not nearly so great as if the stoppage were for a short period. If the cessation were likely to extend over a long period, it would only be necessary to look to the preservation of the physical part of the property. The traffic organization, or that portion of the force connected with or growing out of the conduct of business, would be wholly dispensed with, or so greatly reduced as to be no longer distinguishable as an organization. If, however, the stoppage were only for a short or indefinite period, it would be necessary to preserve the nucleus of an organization; such portion of the force as would render the resumption of business practicable without great delay or expense.*

If the stoppage were likely to continue over a long period, many expenses that, under other circumstances would be necessary, might be avoided. Thus, the cost of keeping up the road at a point that would permit the movement of trains would not be required. It would not be necessary to repair from day to day the ravages of storms or the damages caused by frost; expenses attending the use of bridges, culverts, buildings and machinery might be wholly avoided, as it would be necessary to give them only cursory attention. Effort would be directed wholly to preserving the property from permanent injury. Thus maintained, considerable time would be required to place it in shape for resuming active operations when the embargo ceased; buildings would have to be put in order, tracks repaired, bridges and culverts looked after, and a thousand things attended to before general resumption would be possible. This would require a month, perhaps six months. It would, however, be unavoidable, as the resources of the strongest company would not warrant it

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* Unless, indeed, it was assumed that the force might be brought together again at will, in which event the whole traffic force might be dispensed with. This is what would probably be done.

in attempting to keep up its property at the maximum point of efficiency throughout a long or indefinite strike.

In attempting, therefore, to determine the cost of maintaining a property under the circumstances named (without reference to traffic), all the conditions must be known. If resumption were likely to be immediate or within a reasonable time, the expense of maintenance would not be much less than during active operations. The disintegration of property from natural causes is very nearly the same, whether used or not. If cessation of business were likely to extend over an indefinite period, the advisability of reducing expenses would be so great that we may be sure every outlay would be cut down to the lowest possible figure.*

The maintenance of a property covers expenses arising from natural and artificial causes; from climate and traffic. Little has been done to determine the relative amount of these expenses. Few things are less understood. Every expense being primarily due to traffic, no attempt has been made to effect a separation. The conduct of business being the incentive to construct a railway, the whole cost of operating is properly chargeable thereto. Thus, the rates that are

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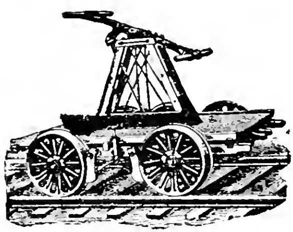
* It is possible, in the event a railroad company found it impossible to operate its property, that the wisest course to pursue would be to dismiss the whole force; that such a course would be the safer one to pursue and the one most likely to bring about a quick and satisfactory settlement of its troubles.

charged must conform as a whole to the cost of operating, including outlays incidental thereto. If they fall short of it, loss or bankruptcy intervenes; if they exceed it, natural causes intervene to correct the evil. The importance of a necessary expense does not depend upon whether it is due to traffic or other cause. In attempting, therefore, to separate the cost of maintenance arising out of natural causes from that due to traffic and organization, I do not wish to be understood as intimating that such expenditures are in any way distinct from traffic or that traffic has no obligation to bear the burden. It has. Any attempt to separate the fixed expenses of maintenance from those occasioned by traffic must in many things be largely speculative, must be largely hypothetical, must be based on collateral data and the estimates of experts. A separation, however imperfect, can not but possess great practical value to those who own and operate railways. It will enable them to view many questions from a higher standpoint than they otherwise would and will prove valuable in directing enquiry into other and collateral subjects of importance. Knowledge is not of so much value for the specific thing learned as for its contingent revelations and the other thoughts it suggests. And so it will prove here. Even the most imperfect conception of the expenses of maintenance of railways will afford suggestions in other directions to those who will not regard the information in itself of especial value.

Thus, while they may not care what relation fixed expenses of maintenance bears to the total outlay as a whole, yet the information may be exceedingly valuable to them in particular instances. Take the case of track rails for illustration. Experts in such matters with whom I have communicated as to the relative deterioration of rails from climate and traffic, have stated that a rail would remain fit for use forever, if trains did not run over it. Others put the deterioration from climatic causes at two per cent.; others again at five per cent., and so on. As a matter of fact, the deterioration of rails from climatic causes, while not great, is marked and cumulative. Deterioration of other material from a similar cause is much greater. However, I do not propose here to enter into a scientific estimate of the effect of climatic influences upon different classes of material. It belongs more properly to the scientist. I merely cite the case of rails to illustrate the lack of information on such subjects by those whose duties lie wholly in this particular department of railway operations.



Hand Car.

The natural decay of railway property is in many cases much greater than the damage occasioned by use. Where a business is so great as to produce immediate deterioration, the relation that the fixed expense of maintenance bears to traffic will, of course, be less. Whatever a property suffers from natural decay is a fixed expense. I will, therefore, speak of such outlay hereafter in connection with the maintenance of railway property as a fixed expense. Cost of organization is also, to a certain extent, a fixed charge. It is, however, never relatively the same. Thus, it is much less, relatively, for a company actively engaged than when the contrary is the case, for the reason that in the former instance a greater proportion of the cost is merged with current business. Thus, a superintendent will not only exercise direction over the maintenance of the property, but will also superintend the conduct of its business. In either case he is essential, and while he must possess greater diversity of knowledge in order to enable him to attend to both these duties than he would to attend to either singly, yet the increased expense occasioned by the multiplication of duty is not great.

The number of skilled laborers required in the operations of railroads is much greater than is commonly supposed. They form a part of the organization. They embrace innumerable men that are not usually classed under this head. Everyone understands that a locomotive engineer must be technically qualified. The value of skill and experience in the locomotive fireman is also well understood. The necessity of technical knowledge on the part of machinists is well known.

But the officials, agents, clerks and foremen of railroads must possess skill of a high order, and must, moreover, possess practical knowledge of the geography of the property and its business and wants. This is not so well known. It is probable that no class of labor possesses such great technical knowledge and skill as the clerical force of a railroad; and by clerical force I mean the whole body of employes concerned in the movement of traffic, including those connected with the accounts and finances. They are the fingers of the organization and afford much of its intellectual force. The affairs of a railroad are so great, and extend over so wide a range of country, that managers can do little more than avail themselves of the information the clerical force collects for their disposition. This force, in the event of the stoppage of business on a railroad, would have nothing to do and, therefore, might be dispensed with.

Only those who have watched the growth and maintenance of a railroad, and the patience and skill required to build up an efficient force, can estimate the loss its abandonment would entail. But it would be unavoidable in the event a disturbance of any kind necessitated a stoppage of business. Necessity does not recognize either values or utility. If through the upheavals of labor or other social disorders, railways were compelled to suspend business indefinitely, they would come out of the struggle without an organization. In attempting to determine the fixed expenses of organization, therefore, I shall not consider the case of such railroads. The fixed expenses of organization for properties, under normal conditions, are the officers and employes necessary to the conduct of the minimum traffic of a line. This force would embrace the general management, heads of departments and chiefs of bureaus and their immediate assistants; those, in fact, possessing a knowledge of the workings of the departments and versed in the requirements of the company's affairs, and necessary to its operation. Such a force can not be secured at will, and business can not be discharged without it. It is the staff, and grows with the growth of a corporation, and under right conditions should become more and more efficient every year. The necessary force of a road embraces, also, the agents at stations and, where business is great, their immediate assistants. Those, in fact, who possess high technical knowledge. They constitute a fixed charge. Common laborers, and those engaged in mechanical or simple employment about the general offices, warehouses and other buildings, do not. They may be replaced at will. The cost of watching a property is not a fixed expense, as this duty may be performed by employes possessing technical skill, who form a part of the fixed cost. The nucleus of a train force is a fixed expense of maintenance. In the case of conductors and baggagemen it embraces probably ten per cent. of the force. The skill of this body will constitute the nucleus of a complete organization. In the same way ten per cent. of the engineers and firemen of a company may be denominated as fixed. Such a train force would prove ample to guard the rolling stock and maintain it in a much higher state of efficiency than that which ordinarily characterizes it when employed. The engineers would be able to keep the equipment and machinery in repair, while the auxiliary force would look after its care and protection.

The technical force that is essential to a company may be utilized in the maintenance of the property, and thus serve a double purpose. Those occupied in advertising and in soliciting business do not constitute a fixed expense. Personal injuries, damages to property, contingent expenses, stationery, printing, supplies, advertising, oil, waste and tallow belong wholly to traffic, or if any portion is chargeable as a fixed expense it is nominal only.

As a rule the forces of a railroad that constitute a fixed charge would find active employment, even if the property were closed to business. However, it does not necessarily follow that there could be no reduction in the wages of this force. On the contrary, it is probable that a very large reduction might be made if it became necessary. The necessity of such a course and its justness in the event of a general strike would be apparent and would be cheerfully acquiesced in. The amount of this reduction would, I think, approximate fifty per cent. That it would involve hardship, goes without saying, but as this hardship would extend to the owners of the property as well, it would be borne cheerfully. If the suspension were likely to be of long continuance, the reduction might be even greater. However, fifty per cent. may, I think, be stated as the average sum. So that in determining the fixed expenses of organization we may deduct that amount of wages and salaries paid particular persons under normal conditions. In reference to the force that it would be necessary to discharge (in the event of suspension), it is probable that the majority of the men would quietly await re-employment. This would certainly be the case if the stoppage were not likely to be of long duration, or if the circumstances attending dismissal did not involve personal animosities. It could not but be apparent to men thus situated that their interests would be more likely to be conserved by quietly awaiting re-employment, than by seeking engagement elsewhere, accompanied as it would be by the necessity of commencing anew. It might be necessary in some cases (as it would indeed be both politic and wise wherever possible), to allow the force thus dismissed a small sum monthly. Such a course would be eminently humane, if the resources of a company permitted. I as-

Hand Car.

sume, of course, in suggesting this gratuity, that harmony of relationship exists between employer and employe.

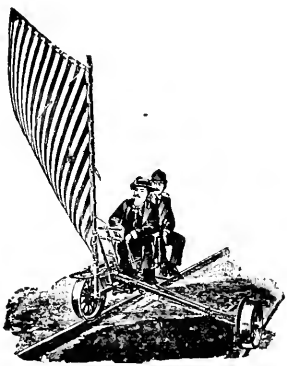
The best of feeling should ever exist between railroad companies and their employes. It is possible, indeed probable, that the latter may have grievances, but that these grievances are such as to engender lasting hatreds, indifference or disloyalty is impossible. Nor can they be so great as not to be more likely to be corrected by conciliatory measures than by strikes or other violent means. The interest of the proprietor in those who operate his property is too intimate, too vital, to permit him to disregard their welfare or to refuse to remedy just causes of complaint. And above all, employes should not, in enumerating their grievances, forget those of the employer. No intelligent person who has observed the operation of properties carried on by hired agents but must have noticed innumerable instances of gross neglect on the part of such agents, of manifest inefficiency, gross wastefulness, inattention to duty, idleness, and other evidences of a disregard of the interests of the owner. Every such instance is a legitimate and proper subject of complaint on the part of the proprietor, and while he may and does seek to rectify such acts whenever known to him, still his efforts in this direction, no matter how watchfully or intelligently directed, can never wholly, or even partially, correct the evil. Employes, therefore, while enumerating their grievances, should not be unmindful of those of their employer. To neglect to do so evinces thoughtlessness, lack of regard for the rights of others.

In the case of a railroad the interest of the proprietor is so impersonal, so covered up in the multiplicity of owners, in the rules and regulations of the service, in the acts of managers, and in the fulminations of legislatures, that we can not wonder the employe sometimes forgets there is an owner; fails to recognize the rights and prerogatives of the latter and forgets his own duties and responsibilities. If the owner possessed greater personality, were present on the ground, were a person to whom the employe could listen, could appeal, if necessary, he would appreciate his existence much more vividly. In considering, therefore, the relations that exist between capital and labor in connection with railroads, the first thing for the employe to do is to dismiss his prejudices, to remember that if he has grievances, so also has the owner, and that, in the generality of cases, the grievances of the latter are far more real than those of the employe. No railway employe, not blinded by passion or who does not deliberately shut his eyes to the fact, but knows that employes are fairly treated. If not fairly treated, the injury is not of the owner's making. The grievances that employes have are often more imaginary than real, and whenever real arise, not from the acts of the owner, but from those he is compelled to trust. The remedy does not, therefore, lie in strikes or indiscriminate attacks upon property, but in an appeal to owners. Too great care can not be exercised by employes of corporations not to confound the owner with his managers. The owner will never, it is safe to say, wilfully or persistently disregard the welfare of his employes; their interests are so inalienably connected with his, that to treat them unfairly would be suicidal. This truth is not always regarded by employes, and it is probable that the proprietor is frequently to blame. Wherever this is so it should be remedied. No one who is dependent upon the good will and fidelity of others for the maintenance of his interests can afford to permit them to remain in ignorance of his good intentions toward them. On the contrary, his duty and interest alike demand that he should cultivate such relations with them as may be necessary to assure them of his constant and friendly interest in their welfare.

When it is necessary that men should entrust the management of their property to others they must do so unqualifiedly and heartily, but such delegation of power should never extend so far as to relinquish the right and duty of enquiring into the welfare of subordinate employes. A proprietor will ever consult his welfare by such manifestation of interest in his servants, and any general or prolonged neglect to fulfill this cardinal duty of ownership will redound to his great and permanent injury. By many owners such manifestation of interest is thought to be subversive of discipline. It is sufficient to say that where the owner of a railroad can not come in contact with his employes without jeopardizing discipline it ought not to require an outbreak among his servants, or the destruction of his property, to convince him that there is a radical defect somewhere in the method of administration. The discipline of an organization that is dependent upon terrorism, upon ostracising or sequestrating the employe, upon separating him from the acquaintance or sympathy of the owner, is manifestly a gross perversion of responsible methods of government, and wherever practiced evinces mismanagement and may be accepted as evidence of an outrageous disregard of the rights of owners by those who represent them. If the history of corporations in the United States teaches one fact more clearly than another, it is that the owners of such property must personally interest themselves in the affairs of their employes, lest the personality of the owner be lost and his property confiscated. The possession of property presupposes the duty of guardianship, including a paternal interest in the operative, and its preservation to the owner will ever depend upon the general and wise exercise of this duty.

Continuing our consideration of the cost of maintaining a railroad, it is apparent that this cost is much increased by the delays and embarrassments attending the conduct of business. Thus, repairs of track are interfered with by the passing of trains and the thousand and one diverting influences that attend their movement, while necessary repairs to equipment and machinery are oftentimes delayed because of the pressing need of their use.

The insurance of property is under every circumstance normal, except so far as it covers the traffic of a line. Practices in regard to insurance are not uniform upon railroads. In some cases it is the policy to insure the property generally; other companies restrict their insurance to particular and ascertained instances of special importance; others, again, do not insure at all, preferring to assume the whole risk. I do not know that the circumstances likely to attend a cessation of business would be such as to require that a company's policy in this respect, whatever it might be, should be changed; the risk incurred from the movement of trains and the conduct of business generally would, it is apparent, be much less than under normal conditions, while all damages arising from the acts of mobs would be made good by the government. No two companies view the question of insurance from the same standpoint, and no fixed sum can, therefore, be stated as the extent of a company's expendi-



Sail Car.

tures in this connection. After considerable observation of the effects of insurance and non-insurance by great corporations, I should not think a company justified in expending any large amount in this direction unless its surplus were abundant and well assured. The variety and magnitude of its interests render it quite proper and feasible for it to assume risks of this nature, and while exceptions may be made in particular cases, it is manifest that general insurance of railway property will prove burdensome in the majority of cases.

The cost of insuring the property of a company may be safely reduced ninety per cent., in the event of stoppage of business from a strike or otherwise. The other ten per cent., therefore, constitutes a fixed charge.

Considered from the standpoint of organization and proprietorship, the taxes of a property constitute a fixed expense without reference to how they are applied. In this respect the widest differences exist. In some cases taxes are based on real and personal property; in others upon earnings; the amount and value of outstanding capital is sometimes a factor. When the tax is based on property the levy would be the same if the road were not operated. It is possible a reduction might be allowed under such circumstances. Certainly it should be, as it is manifest that property of this kind that is earning nothing is, constructively at least, worth nothing and ought not to be taxed except upon a merely nominal basis. Practically, however, only a small reduction would be made. When taxes are based on earnings it is manifest that cessation of earnings means cessation of taxes, unless the stoppage were so prolonged as to suggest some other basis. We can not measure the extent of a company's obligations for taxes in the case of an idle property, but whatever it is, it is a fixed charge.

What proportion of the cost of maintaining railway property arises from natural or climatic causes? Here only is there any similarity between railroads. The moment that the cost of wear and tear arising from traffic enters into the question, the volume, speed and character of the traffic intervenes. Two methods suggest themselves by which we may determine the extent of climatic influence upon railway property. The first is by a careful survey of the property, in which every feature is carefully ascertained and considered. This method is, undoubtedly, the best, if practicable. But, unfortunately, it is not practicable. The second method that suggests itself is through the relation that the cost of maintenance bears to the total cost of operating. This is the basis I have adopted, and while particular expenses vary greatly according to method of construction, extent of traffic and nature of climate, they are generally the same for railway property as a whole. Different climatic influences do not affect railway properties alike. Thus the railways of the north and the south have different conditions to contend with. Each in their way have peculiar outlays. Thus, the deterioration of wood in the south is much quicker than in the north, but, on the other hand, the northern roads suffer greatly by frost and snow and the abrupt climatic changes peculiar to the north. The conditions most favorable to the preservation of material are a mild, dry climate, but cost of renewals in such localities is usually greater than elsewhere. The advantages and disadvantages of localities are, therefore, about equal.

More than anything else, the fixed expense of maintenance of a railroad is dependent upon the quality of the material used, the measure of intelligence evinced in locating and constructing the line, and the skill and foresight exercised in protecting the property. The nature of the structure is especially important; a stone culvert is more durable than one of wood; a brick structure is more lasting than one of grout. But, in either case, the duration of the structure is largely dependent upon the care with which it is constructed. In the same way, the value of ballast is largely dependent upon its quality and the care exercised in placing it.

The extent of a business has much to do with the relation that fixed charges for maintenance bear to traffic expenses. If a traffic is such as to quickly wear out the equipment, machinery, rails, ties and kindred appliances, manifestly, the proportion that wear and tear from traffic bears to natural causes must be greater than when the business is less. The accompanying data are based upon the average conditions of properties located in a temperate climate, subject to such extremes of heat and cold as are to be found in the great lake region of the United States. Conditions here as regards wages and cost of material are those of American railways generally.

In the maintenance of railways the track is the source of the greatest single expense. This we may divide under its several natural heads.*

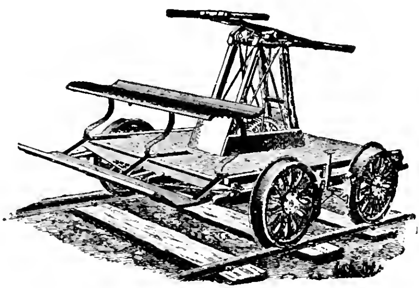
And, first, in regard to rails. Natural deterioration for this kind of material arises wholly from rust. Other classes of material suffer from fires and acute injuries. But in the case of iron, oxidation is the sole enemy it has to contend with. Deterioration from this cause is much greater in some localities than in others. The damage, for instance, is greater near salt water than elsewhere.† Ability of rails, therefore, to resist the effects of climatic influences depends some-

* These heads and the relation they severally bear to each other may be stated as follows:

	PER CENT.
New Rails (less value of old)	16.13
Handling Rails (*i. e.*, laying the new and taking up the old)	2.34
Ties	13.97
Handling Ties	5.18
Miscellaneous (general) Repairs, Roadway and Track	62.38
	100.00

† It is also great in tunnels. The durability of ties is also less in tunnels than elsewhere.

what upon location. We have, unfortunately, no accurate data as to the percentage of deterioration from climatic causes. It is a question about which metallurgists have collected little definite information. It is generally understood, however, that steel is less able to resist rust than iron. The deterioration of metal from oxidation is not uniform, but proceeds with increased momentum as the cause of decay deepens and spreads, each new inroad affording an additional



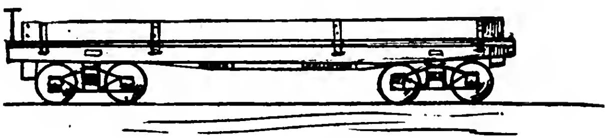
Track Inspection Car.

storehouse in which the destructive elements multiply and extend themselves. The increase in the destructive power of rust may be likened unto the cumulative malignancy of a cancer; as it grows wider and deeper it destroys the fibre and absorbs the tissues of the body, increasing in intensity with what it feeds upon, until the object attacked is no longer able to withstand the slightest strain. Oxidation is obviated by the exclusion of dampness. This would not be necessary if the article could be preserved free from abrasion or contact with surrounding objects; for while dampness is the propelling or primary cause of rust, it is not operative except in case of abrasion of the metal, or its contact with some particle of matter. Either of these precipitates vapor by rendering condensation of moisture possible, thus inducing oxidation. Wherever there is a scratch upon a piece of metal, or wherever a particle of dust (however invisible to the naked eye) adheres to it, there moisture collects, evaporation ensues and rust is engendered. An abrasion, or particle, affords a vantage ground for the retention of moisture. From this vapor arises, precipitating the conditions described. It is believed that rails in actual use suffer less from rust than those not in use. The friction of the wheel polishes the surface of the rail, while the vibration of passing trains prevents the retention of moisture. Professor Carhart of Ann Arbor, Michigan, in answering a question in regard to the destructive tendency of rust and the length of time that a rail will resist its effects, says:

"It is well known that a polished iron or steel surface does not rust so soon as a rough surface when exposed to the same conditions. Rough lines and sharp points appear to serve as nuclei, about which water condenses. Moist air when expanded suddenly precipitates its vapor as a cloud, if dust is present to furnish centers of condensation. Frost crystals form first along scratches on glass. So moisture appears to condense more quickly and freely on a rough surface of iron than on a clean polished one. Rusting takes place only in the presence of moisture. A clean plate in dry air never rusts. Mixture of explosive gases do not explode when the electric spark passes, unless vapor of water is present. When a metal surface is once covered with rust, the rusting proceeds much more rapidly than at first, because the rust is hydroscopic; moisture is taken up and conducted inward toward the metal; hydratic oxides of iron are thus formed, and fresh metal underneath is attacked because of the presence of moisture or of the hydratic oxides on the outside. A coat of iron rust hastens the rusting process except when the metal is coated with the black oxide of iron. It can then be exposed to any weather without rusting. But the black oxide is formed only at a high temperature. The scales that fall from the rails as they come from the rolls are largely black oxide of iron."

In a climate such as we are treating of, it is probable that fifty years of exposure would render a rail unsafe for use. If this is so, the deterioration from natural causes is two per cent. annually. With a moderate traffic the average period of usefulness of a Bessemer steel rail is fourteen and six-tenths years. It is probable (for the reasons we have already specified) that a rail will last longer under mild usage than if not used at all, provided its strength is commensurate with the load. Under ordinary usage, the rapid deterioration of rails is occasioned by the speed of trains. Speed not only intensifies the friction, but increases the weight through its centrifugal force.

Enquiries in regard to the percentage of decay of rails from natural causes elicit the most extraordinary differences of opinion, and ignorance as well. They serve to show how little attention the subject has received from practical men. In some cases deterioration is ascribed wholly to traffic. The highest rate ascribed by any one to climatic causes was fifty per cent. In considering the deterioration of rails from natural causes, the damage would not, as already stated, be the same relatively for railroads doing a great business that it would in the case of those doing a small business. When a rail is worn out quickly, relative deterioration from rust is not nearly so great, though it is undoubtedly weakened from this cause, especially where defects of any kind exist as receptacles for moisture. Herein, undoubtedly, lies the secret of the sudden and inexplicable collapse of rails that, according to the law of averages, should last many years. Just what the difference of deterioration from climatic causes between a rail in use and a rail not in use is. is not known. In answer to enquiries on this subject one writer says: "I do not know how long rails would be effective for fast running trains if laid down and not used, but will allow a hundred years; a track that is used would last about ten years." Another writer says: "The expense of maintaining rails is almost exclusively dependent on the traffic. If entirely idle, the loss by rust would be considerable in rails by weakening the fibre of the metal, and causing rapid wear and breakage when again brought in use. Under ordinary conditions ninety-five per cent. is due to traffic." Another writer says: "There would be a slow destruction of rails from rust, which might take off three or four per cent. of the expense chargeable to traffic." Another writer says: "If no trains were run there would be no wear of rails, except such as might be incident to the action of the elements. A rail laid in track twenty-four years would deteriorate from rust to such an extent as to necessitate renewal in order to put the track in first class condition." An authority upon the subject says: "The average life of sixty-four rails we are studying, on the supposition that they are worn out when they have lost eight pounds per yard, and that the yearly tonnage is eight million tons, is thirteen years. If we are able to obtain steel rails as good in quality as thirty-two slower wearing rails we have under test, the average life would be almost twenty years." The road masters in their meeting of 1884 state that "The average life of a steel rail may be taken at nine years." The source of information is not stated, but the duration of the rail, it will be noticed, is very much less than is generally given and is too small except for roads doing an unusually heavy business. From numerous enquiries extending over a large area of country, and addressed to practical men actively engaged in the care and maintenance of track, I find that they estimate the average deterioration of rails from natural causes in the lake region of the United States at about seven and a half per cent.; at interior points less, not exceeding two per cent. One piece of rail that has been in use thirty years was submitted to an expert in such matters.* He says: "The roughness of the surface indicates that some inroads have been made upon its integrity. The fracture recently made reveals a highly fibrous texture of the iron. I do not detect much evidence of granular or crystalline structure. The iron left, therefore, is in good physical, or perhaps molecular, condition to do



Flat Car.

service." The metals used by a railway outside of its track suffer from the same general causes as iron and steel rails.

Next in order, in connection with the fixed expenses of maintaining the track of a railroad, we may consider the question of ties. The cost of this item is great and exceptional. No class of material used by railroads suffers so greatly from the action of the elements. No matter how favorably placed, as regards quality of ballast, deterioration is noticeable and rapid. The kind of wood and how seasoned influence perceptibly

* Professor Carhart.

its duration and usefulness. Quality and arrangement of ballast have much to do with the preservation of the tie from decay. But ballast is intended to serve several other necessary purposes besides acting as a filter to protect the tie from dampness. It serves to increase the bearing surface of the tie, strengthen the roadbed, increase the elasticity of the latter, and render it more uniform. Broken stone and slag are the kinds of material most useful for preventing the decay of ties. Next in order are cinders, gravel and sand. The expense of handling ties (*i. e.*, replacing) is much greater where slag or broken stone is used, on account of the difficulty of removal, including labor of readjustment. This disadvantage is, however, more than compensated by the great advantages of such material. Where soil or clay is used, the interior of the tie oftentimes rots before it is injured by the weight of the traffic. Where the business of a line is heavy, ties receive material harm from respiking and resetting of rails, and if of inferior wood are frequently cut down and split by the rail. Ties, if properly ballasted, receive little detriment from the wear and tear of light traffic, except upon curves. The natural duration of a tie is dependent upon the kind of wood of which it is made, how it is seasoned, nature of climate, and quality of the ballast in which it is laid. All these must be considered in arriving at a result. The most serviceable tie that we have for all conditions of use is white oak. It is able to sustain a great load and affords very satisfactory resistance to the elements. Results of enquiries made of practical men in reference to the duration and value of ties, while exceedingly interesting, are not altogether satisfactory, for the reason that the premises upon which they base their conclusions are nowhere the same. This difficulty, however, besets the student at every turn in attempting to arrive at general conclusions from isolated instances. One writer says: "A tie will last about seven years. Without traffic, it would probably last ten years. Cedar ties would not last as long with traffic as oak, but without traffic would last longer. The life of a hemlock tie would not be as long with or without traffic." Another writer says: "Thirty per cent. should be charged to traffic account for damage by rails cutting into the tie and injury arising from driving and pulling of spikes, rendered necessary in changing rails and regauging the track." The greatest ignorance exists here as elsewhere among so-called experts. Thus, one writer says: "A tie will last just as long in a track that is operated as it will in a track that is not operated." Another writer of unusual intelligence says: "Natural decay of ties ballasted with the best material, such as broken stone, gravel or cinders, would be much less than where poor ballast was used. I should think twenty-five per cent. less, as a tie would lay perfectly undisturbed and dry, and would not be cut into by the rail. In poor ballast, such as soil and clay, the middle of the tie would decay before its surface was damaged." The relative deterioration of ties from natural causes and from wear and tear is dependent upon so many contingencies that estimates for particular properties would not apply generally. However, it is probable that the expense of maintenance for ties under the conditions of climate such as we are dealing with, can not be far from seventy per cent., leaving thirty per cent. as chargeable to wear and tear of traffic. The greatest difference of opinion exists among practical men as to the damage arising from decay and wear and tear, respectively, one writer insisting that no portion of cost of maintenance should be charged to traffic, while another not only insists that the tie is injured by the weight of passing trains and changing of spikes, but that the movement of passing train loosens the soil enveloping the tie, thus greatly hastening its decay.

I have not attempted in the foregoing to discuss the question of railway ties except in its simpler aspects. The various questions as to the best and most economical tie are discussed at length elsewhere herein. The subject grows each year more and more important to railways and to the public. The great cost of wood ties, the destruction of timber their use engenders, the ever increasing difficulty of procuring those of a suitable nature, render it more and more important each year that their durability should be increased or that a substitute should be found to take their place. To those who are interested in the subject—and all who are interested in economic subjects are thus interested—I beg to refer to what is said elsewhere in regard to the timber supply and its preservation, the qualities of wood best adapted for ties, how the duration of wood ties may be prolonged by preservative processes, and the experiments that have been made with metal ties.

The cost of repairs and renewals of roadway and track, outside of the cost of rails and ties, is made up largely of labor. In the appendix hereto will be found a table of expenses, classified under appropriate headings.* This classification is the result of many years of carefully collated statistics upon many hundred miles of railways and covering many millions of dollars. It is, so far as it goes, conclusive for the location it refers to, namely, that of the great lake region of the northwest.

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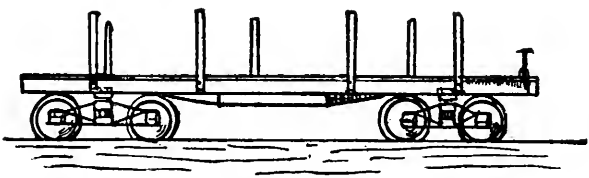
*Appendix B. While the matter is, perhaps, not strictly germane, it is proper to refer the reader here to the classification of track material and labor embraced in the volume on "Fiscal Affairs, Disbursements." The track accounts of railways are the most difficult of all to keep, because of the limited facilities possessed by those who have charge of such work. Detailed information in reference to track expenditures is, upon many roads, very meagre and, in some cases, wholly wanting. Yet an effective system of track accounts is necessary to the economical and effective management of railways. It plays a most important and necessary part in their physical maintenance. I do not pretend to say that the system of accounts referred to is the best; it is simple, economical, easily kept, and affords a graphic account of the divisions of track expenses. So far as I know it is the most complete system of track accounts in vogue.

The general repairs of roadway and track embrace all classes of material used in connection with the track, save rails and ties. It includes ballast and the tools and supplies of trackmen. The material embraced under this head is quite as quickly and vitally affected by wear and tear as rails or ties. Bolts, spikes, splicebars and nuts receive marked and rapid deterioration from both climate and traffic, while the tools used by trackmen (and they comprise a considerable list) are quickly consumed. General repairs of roadway and track embrace various



Flat Car With Stakes.

classes of material and include cost of surfacing the track, ditching, drainage, freshet repairs, track watchmen, clearing track of snow, and removing weeds, brush and grass. An examination of the different expenses of roadway and track elicits the fact that a large proportion of them is directly chargeable to traffic. The expense is increased, moreover, by the fact that the traffic of a line greatly interferes with repairs and renewals. The necessity of this work being carried on without reference to weather or the accommodation of business adds greatly to cost.

The added expense on this account is much greater than those not familiar with the work would suppose. Safety and the progress of business regard neither convenience nor economy. An occasion arises and it must be met, no matter how great the waste involved. The significance of this is startling even to railway men. Work is carried on in every instance at a disadvantage, and in many cases involves large expense over what would be necessary if it could be pursued with reference to the economical use of labor and the procurement and choice of material.

The most surprising diversity of opinion exists among trackmen as to the proportion that is chargeable to fixed expenses of maintenance of roadway and track. This is due in part to the peculiar circumstances that attend such expenditures. It arises also in part from differences in conditions and cost in different localities. The superintendent or roadmaster whose track is carefully and abundantly ballasted with broken stone or slag, if asked as to the cost of its maintenance, or the relative wear and tear of ties, or the duration of the ballast, will return an answer entirely different from that of the official whose road is ballasted with sand or common soil. The effect of this local coloring must be constantly guarded against in any attempt to arrive at general conclusions about railroads. People speak of things, not as they are commonly, but as they see them from day to day. No one is superior to influences of this nature, and but few, even among the most thoughtful, can rise wholly above them. As already stated, the relation of fixed expenses for maintenance to traffic expenses is governed largely by the amount of business. Wear and tear increase with increased use, but expenses arising from decay are not materially increased on this account, except in the case of rolling stock. I do not wish to be understood, however, as saying that while wear and tear increase with business the cost of repairing increases in a like ratio. On the contrary, it is relatively cheaper to maintain a track with the maximum amount of business than with the minimum amount, for the reason that it permits concentration of work within narrower limits. In the operation of properties deterioration is oftentimes due largely to traffic; in other cases almost wholly to natural causes. The intervening gradations are infinite in detail and complexity. In classifying expenses for ditching, freshet repairs, and removing snow, weeds, brush and grass, however, we are not beset by any difficulties. The movement of traffic has nothing to do with the filling up of ditches or the growth of vegetation. The movement of trains does not materially affect the cost of ditching or removing snow, weeds, brush and grass. In some cases it increases the cost, in other cases the work is assisted thereby. However, the cost of repairing damages by freshets is greatly increased because of the movement of trains, because of the urgency of the work and the inconvenience attending it. The expense of keeping a track free from snow and ice under normal conditions is lessened by the movement of trains. Except for such fortuitous help, cuts would in many cases soon fill up with snow, which, through the alternation of heat and cold, would quickly turn to ice, rendering removal both expensive and tedious. The movement of trains with the cursory assistance of trackmen keeps these cuts open. If a road were closed indefinitely, it would matter little whether it was imbedded in ice or snow. The movement of trains from day to day also lessens the expense of keeping a track free from weeds, brush and grass; except for the continual passage of trains and track forces these obstructions would quickly block the road.* Another important item of track expense is the cost of watchmen. This is, however, wholly chargeable to traffic, for, while they perform an important and necessary duty, they would not be

* I remember going over a piece of road in the eastern part of Dakota in 1874 that had been abandoned for several months. The train consisted of an engine and two cars and three days were required to travel eighty miles. The weeds and grass were from six inches to six feet in height. Everywhere the roadbed was tunneled with the burrows of jack rabbits and ground squirrels. The weeds and grass rendered the track so slippery that it was necessary for laborers to place sand and gravel on the rails as we proceeded. Water was procured with the aid of syphons from ponds along the road, and the trestles and bridges swayed under the weight of the train like trees in a tempest. When eventually this particular piece of track was opened for business it was found necessary to rebuild it entirely, although the abandonment had only extended over a period of five years.

necessary except for the constant passage of trains. In the enquiries I have had occasion to make in regard to the expenses connected with the maintenance of track, the marked intelligence of those in charge of work of this kind, and the purely speculative knowledge they have evinced in connection with it, has been apparent. Thus, in connection with the expenses connected with snow, one writer says: "To keep an idle road in condition so that business might be done at any time, would require that a snow plow should be used. The clearing off of snow also causes the track to heave, and makes shimming necessary." Another writer says: "A road would not be in first class shape (if temporarily closed to business), buried under six feet of snow, and yet the snow could not be kept off at ordinary expense unless there was a regular train service." Another roadmaster says: "Climatic cause is the largest source of expense, as we should have to keep the track free from snow by special means in the absence of regular trains."

While there is no great divergence of opinion in regard to the deterioration of roadway and track, there seems to be the greatest diversity of opinion among practical men as to the proportion chargeable to climatic causes and traffic, respectively. The question is a new one to many. With more reflection, it is probable they will be able to harmonize their differences. Men experience difficulty in forming an opinion as to

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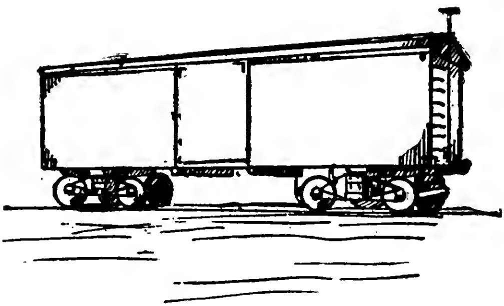
the relation natural expenses bear to traffic expenses, because of the fact that the whole is primarily due to traffic. This is true in the sense I have explained elsewhere. Every such outlay belongs to traffic. But, in an enquiry that seeks simply to determine what the local exigencies of a property are, what proportion of its expenses is due to wear and tear of business, and what expenses arise from natural causes, we may attempt a separation of cost without fear of being mis-



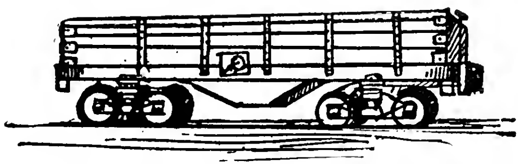
Box Car.

understood. Every expense must, of course, be borne by the revenue of a property, but that fact does not make the ascertainment of the source of the expense any less interesting or less valuable to its possessor. But the confounding of forms with principles always occasions more or less confusion in the minds of enquirers and renders them liable to decide every question according to preconceived notions. It is partly in consequence of this, no doubt, that in some instances those especially familiar with the operations of track ascribe an enormous preponderance of expense to traffic, while, on the other hand, men of corresponding intelligence ascribe it to natural decay. In attempting to arrive at the truth, the testimony of all extremists of this kind, it is apparent, must be eliminated. After throwing out evidence of this character, I find that the differences of opinion among practical men in reference to natural expenses are not great. According to their estimates fifty-seven per cent. of the expenses of roadway and track, excluding rails and ties, is considered to be due to climatic causes, and forty-three per cent. to traffic. In other words, if a railroad were to cease to do business, it would only reduce its expenses for miscellaneous track material and tools and track labor forty-three per cent., unless the suspension were permanent, or likely to extend over a period of a year or more. Fifty-seven per cent. would be required to maintain the track in a condition to resume business at any time. This is the careful and considerate judgment of practical men. The investigation would be more clear if we knew the expense for track tools separately from miscellaneous track material, but with this knowledge we would still be unable to determine what proportion of deterioration of tools was due to natural and traffic expenses, respectively. An obstacle in the way of a separation of natural and traffic expenses is the difficulty of determining the proportion of the expense of ballasting, surfacing, tamping, etc., due to the weight and vibration of moving trains apart from the damage occasioned by natural causes. These obstacles prevent an accurate account of relative expenses for decay and traffic, respectively, so far as the track is concerned. It is probable, however, that the estimate given above is approximately correct.

Next in order comes the cost of maintenance of bridges, culverts and cattle guards. In connection with these it is apparent at a glance that expenditure is dependent on the nature of the structure and the quality of material used. Manifestly a wooden bridge will decay much more rapidly than one of stone or iron or steel. The process of decay is constant and can not be prevented. A large percentage of the expense of renewing wooden bridges is due to climatic causes. Decay is also accelerated by the opening of the fissures in the material, the straining of the fibre of the wood caused by the weight of passing trains. To this extent the damage is chargeable to traffic. Repairs and renewals occasioned by the wear and tear of traffic are, as a rule, proportionate to the business done. This truth finds illustration in the experience of every bridge builder. He quickly discovers that expenses for repairs where traffic is great are much larger than where traffic is small. This is so marked as to be a constant subject of notice to him. Where business is small great circumspection is possible, permitting the use of bridges that would not answer at all where traffic was great.

The duration of an iron or steel bridge can not be determined in advance, as the extent to which the strain upon the metal will affect its fibre, impair its elasticity, or weaken its strength, can not be estimated. The frightful accidents arising from the breaking down of iron and steel bridges apparently stable make it apparent, however, that the material of which they are composed suffers constant, and in many cases rapid, deterioration from the start. The damage that arises from use, whatever it may be, is of course chargeable to traffic. The relation that the track and the bridges and culverts of a line bear to each other and the difference in degree to which they respond to the action of frost render their adjustment a source of constant expense and anxiety. Not only is the alignment different, but they do not settle or rise uniformly. The jar and weight of trains affect bridges and culverts so perceptibly as to continually require their readjustment. The expense of preventing the channel under or above these structures from becoming obstructed and damages from freshets constitute a fixed charge for maintenance. Experts place the duration of wooden bridges, under a light traffic, at eleven years. It is variable. The life of an iron or steel structure is much longer. The expense of protecting iron and steel structures is much greater than for wooden bridges. They require to be painted at frequent intervals; durability may be further prolonged by protective measures

In the case of a stone arched culvert, the material of which is of durable quality, properly laid, and of sufficient strength, expense from natural decay is merely nominal. The expense for repairs and renewals of bridges and culverts arising from natural causes depends upon the climate and the nature of the structure, the care expended upon it, and the volume of traffic. Taking the railway system in its entirety it is probable that the annual expense occasioned by natural causes is in the neighborhood of seventy-five per cent. My investigation in regard to these structures has extended over a considerable mileage of road and there appears to be little difference of opinion as to the relative expense for maintenance from natural causes and traffic. The percentage I have given is that of experts. Whatever the percentage of expense due to climatic influences is, it will grow less relatively in every instance with increase of traffic and improvement in the quality of the structure. Some of the communications I have received on this subject are exceedingly interesting. Thus, one writer says: "A bridge will lay still all summer, but as soon as winter sets in it is all out of shape. It heaves by frost up and down and sideways and out of line, causing it to be cut down, shimmed and respiked. Wooden bridges are very short lived, their life being ten or twelve years. Traffic affects them a little by shaking." Another writer says: "The relative expense depends upon whether the bridges are built of iron or wood; whether heavy or light structures, if of wood. If light they will deteriorate more rapidly under moving trains because the timber will spring, disturbing the fibre and opening the grain for the admission of water, thereby causing decay." Another writer says: "I notice that the cost is much greater upon some lines than upon others. It is partly attributable to the difference in traffic. The bridges that we use where the traffic is light and that we derive good service from would not answer at all where the business was great."



Gondola Car.

Of the multitudinous details incident to the construction and maintenance of railroads, no phase of the subject interests the enquirer more than those connected with bridges; the feat of carrying the track safely and economically across the streams, cañons and valleys that beset its course. The maintenance of bridges afterward does not involve special knowledge or art, but their construction and development have elicited the thought and life labor of many eminent men. Yet, it is probable that in this field, as in many others, the great advances made are only the precursors of others more great yet to come.

The technicalities of the subject do not properly find a place in a book of this kind. They are to be sought in the works of engineers. Countless volumes have been written on the subject. But while I can not take it up in detail, I may be pardoned if I quote here what an eminent engineer* has said in regard to the development of the art of bridge construction and the experiences of American railroads in this direction. It falls into line directly with our subject. He says:

"In the early history of railways in Europe, substantial viaducts of brick and stone masonry were generally built; and in this country there are notable instances of such constructions. . . . . In this country the wooden bridge has been an important, in fact an essential, element in the successful building of our railways. Timber is also used extensively in railroad construction in the form of trestles. . . . The fundamental idea of a bridge is a simple beam of wood. If metal is substituted it is still a beam with all superfluous parts cut away. The result is what is called an **I** beam. When greater loads have to be carried, the **I** beam is enlarged and built up of metal plates riveted together, and thus becomes a plate girder. These are used for all short railway spans. For greater spans the truss must be employed. . . . Except under special circumstances of location or length of span, the truss bridge is a more economical and suitable structure for railway traffic than a suspension bridge. The advance from the wood truss to the modern steel structure has been

*John Bogart.

through a number of stages. Excellent bridges were built in combinations of wood and iron, and are still advocated where wood is inexpensive. Then came the use of cast iron for those portions of the truss subject only to compressive strains, wrought iron being used for all members liable to tension. Many bridges of notable spans were built in this way and are still in use. The form of this combination truss varied with the designs of different engineers, and the spans extended to over three hundred feet. . . . The substitution of wrought for cast iron followed, and until quite recently trusses built entirely of wrought iron have been used for all structures of great span. The latest step has been made in the use of steel, at first for special members of a truss and latterly for the whole structure. The art of railway bridge building has thus, in a comparatively few years, passed through its ages of wood, and then of iron, and now rests in the application of steel in all its parts."

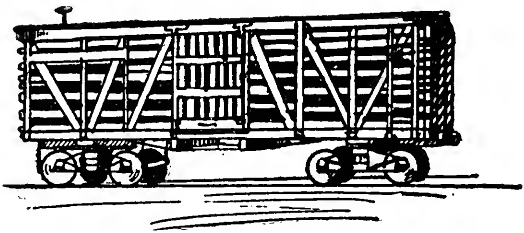
In connection with the maintenance of bridges and culverts, the necessity of preventing their injury or destruction by floods becomes an incident of our subject. The expense is a natural one. However, none the less real. It frequently happens in practical experience that because of lack of skill upon the part of the engineer, or on account of undue economy on the part of a company, sufficient space is not left underneath the bridge or culvert to carry off the water. In such cases the proper way would be to enlarge the channel; but as the necessity for this will not in every case be appreciated, or perhaps be practicable, the only common sense course left for those in charge to pursue is to see that the water course is kept free from obstruction underneath the structure, also above it, so as to prevent the accumulation of rubbish that by collecting might choke up the stream and thus undermine or carry away the structure.

Expenses attending the care and maintenance of buildings are analogous, in many respects, to those connected with bridges and culverts. However, these expenses are not uniform upon different railroads or even upon the same lines. They are like those of other structures. The wear and tear of machinery, furniture, implements and hardware used in and about buildings is almost wholly chargeable to traffic. The platforms, doors and windows of warehouses and depots are also greatly injured from this cause. The imperceptible wear and tear, the attendant accidents and mishaps of business, occasion more or less damage to every building, as may be readily supposed, but its extent is not uniform. The nature of the structure has much to do with its ability to resist deterioration from natural causes. But while brick and stone buildings require, relatively, little or no attention, the doors, windows, roofs, floors and other appurtenances of such structures require constant attention, and the cost of maintenance is not materially different from that of other buildings. In addition to the wear and tear from traffic are the losses from fires chargeable to the same cause. Cost rendered necessary by traffic will depend largely upon its nature and extent. The ability of a structure to resist deterioration will depend upon climate, material used in construction, and the care with which the structure is built, but differences in this regard are not so great that we can not determine with reasonable accuracy the proportion chargeable to natural causes for railroads as a whole. From careful enquiries of experts in such matters and from other sources, we find this expense is in the neighborhood of seventy per cent.

The cost of maintenance of fences, road crossings and signs is largely due to material causes. The damages arising from fires ignited by passing trains and slight injuries to crossings are about the only expenses connected with this account chargeable to traffic. It is apparent, however, that the damage occasioned by fires is extremely variable. Where wire is used the expense is merely nominal. In the case of timber fences it is fully twenty-five per cent. As, however, the use of lumber is giving place to other material, our estimate may be placed upon the general use of the latter. Taking this as the basis, the proportion of this account chargeable to natural causes may be placed at ninety-five per cent.

The cost of keeping rolling stock in repair is enormously increased by the outlay required to prevent deterioration from natural causes. This deterioration is much greater when the plant is actively employed and subject to the vicissitudes of weather than if carefully housed and protected, as would be the case if not in use. While, however, the facilities of railroads every day become more ample and better regulated, they do not yet generally contemplate the placing of passenger and freight cars under cover where they will be protected from rain and snow when not in use. A writer, speaking of the cost of preserving machinery, says: "A locomotive taken into the shop and covered with tallow would be ready for service with very slight repair to the stack and other parts. The atmosphere would have a greater effect upon freight cars, and it would be necessary to paint them at periods (probably of considerable length), even if not in use, as they would suffer from dry rot and other causes. With regard to passenger cars on the same basis, the percentage would not be so great as freight cars, as the material and finish are better, but they would require a coat of varnish, at long intervals, to preserve the outside paint." The upholstery of passenger cars suffers constant deterioration whether in use or not, no matter how careful the attention. The wear and tear of equipment from traffic is proportionate to its use. Cost depends largely upon the intelligence and promptness with which repairs are made. If locomotives are not properly painted, cleaned and housed; if passenger cars are not kept cleaned, painted and varnished; if freight cars are not kept painted and repaired as needed;

if machinery is not carefully looked after, deterioration will grow with neglect. In estimating the percentage of deterioration I assume that due diligence and skill are exercised in maintenance. For equipment in use expense arising from natural causes is, for locomotives, eight and a half per cent.; for passenger cars, nine per cent.; for freight cars, ten per cent. For equipment not in use, locomotives, five and two-thirds per cent.; passenger cars, six and four-fifths per cent.; freight cars, nine per cent. Expense



Stock Car.

arising from natural causes for the telegraphic apparatus of a company, including lines, furniture, tools, machinery, batteries, instruments, and other appurtenances, is about ten per cent.

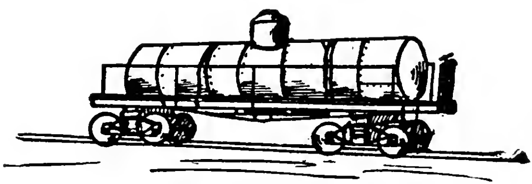
While it is apparent from the foregoing that differences exist among experts as to the amount of the expenses of railroads arising from natural causes and the relation they bear to traffic, there is no difference of opinion as to the fact that cost of maintenance is never exactly alike in any two cases. It is ever dependent upon the location of the road, the volume of business, the speed of trains, and the manner in which the property is constructed and maintained. The most accurate data, therefore, in regard to a particular road is not conclusive in regard to others. It will, however, afford an approximate estimate, for however greatly railways differ from each other in particular things, they are generally uniform. If, therefore, accurate data were obtainable for several railroads, this average would afford a glimpse, at least, of railway enterprises generally. We have this data, covering a period of twenty years, for railways embracing two thousand miles of road. The results are embodied in the appendix hereto.* They show the relation that particular items of maintenance bear to the total cost of maintenance; also the proportion that cost of maintenance bears to other expenses. They also show cost arising from climatic causes; also expense of maintaining the nucleus of an organization. I have not attempted to exhibit the aggregate cost in dollars and cents, but have sought to show the relation that this cost bears to the current cost of operating railroads, so that the reader has only to ascertain what the different classes of operating expenses amount to upon a road in order to ascertain approximately what its fixed expenses are. The accuracy of these figures will be questioned by many. The subject is so entirely new and the data so meagre, that any conclusion arrived at may very justly be criticised.

*Appendices C and D.

CHAPTER XXII.

MAINTENANCE—THINGS INVOLVED THEREIN; WITH SPECIAL REFERENCE TO TRACK DETAILS—SNOW AND ICE, RAILS, JOINTS, SPIKES, SPLICE BARS, PLATES, ALIGNMENT, PREMIUMS, AND OTHER MATTERS.

The maintenance of a railway involves many things beside keeping up the property. A proper organization must be maintained. Its supervision must be looked after; its legal rights maintained. The efforts of those who would destroy its usefulness or profitableness, whether knowingly or ignorantly, must be warded off. The property must be kept open for business. Nothing must be allowed to interfere with the regular routine of work, neither the march of contending armies, the difficulty of getting supplies, or the complications of labor. It is the duty of managers to look after the property as a whole. However, these phases of railway maintenance are discussed elsewhere. It is designed here to treat more particularly of the physical property of railways. Its maintenance involves a constant struggle with the elements; the frosts of winter, the floods of spring, the storms of summer. Each part of the property has its peculiar risks. In one case it is danger of breakage; in another, the risks from fire, from frost, from flood, from drought, from neglect, from lack of proper understanding. Each thing must be looked after, must be especially considered. It is impossible to describe the vicissitudes of railway property particularly. The most that can be done is to take up those of paramount importance, those that appeal to us as vital, as matters of such importance as to constitute conditions, as questions precedent. The keeping up of a property implies its being kept open. This



Tank Car.

is not the least of the difficulties that beset managers. Railways of different localities have different obstacles to contend with. In the tropics they arise from excessive growth of vegetation. In the north from frosts and snow, more especially the latter. Thus many northern companies have great difficulty in keeping their roads free from snow during many weeks and months of the year. At one time it was not an unusual thing for roads to be closed up for many weeks or months each year, because of the impossibility of keeping them free from snow and ice. The question has been much simplified of late years, however, owing to a better understanding of the subject, the use of more effective snow plows, and the construction of snow sheds and fences better adapted to their purpose. The protection of railroads from snow has received much attention from track men. I am indebted to them for the information I have on the subject.

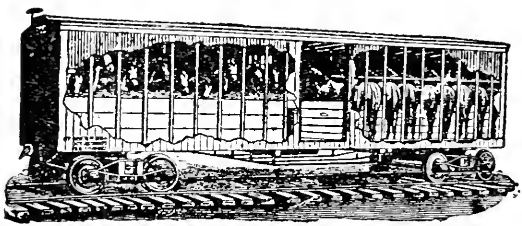
With a sharp and high wind snow accumulates with astonishing rapidity wherever obstruction is met with. Under other circumstances it does not drift much, if any. Protection of the track depends much upon the temperature and upon the direction and velocity of the wind. In locating snow fences they should be placed at right angles with prevailing winds. Trees afford the best protection where snow sheds are impossible. Of these willows and similar growths that may be planted compactly are the best. They must, however, be located at a distance from the track. Where it is necessary to depend upon fences, as many should be erected as necessary, the first one being placed one hundred feet from the track, the next two hundred, and so on. It would be well if each fence were supplemented by a portable fence; when the snow has drifted to the top of the permanent fence, the portable structure should be erected thereon; it may be raised higher and higher as the snow accumulates. In constructing a road in an open country it is, of course, desirable to avoid cuts as much as possible. When it is necessary to depress the track the ground on either side should be cut away at least seventy feet, sloping gradually to a foot below the rail. A fence should be so strongly constructed as to withstand the most violent storm. It should be eight feet high. However, the higher it is the better. Precautions such as these will enable a company, with the aid of snow plows, to keep its track open under the most trying of circumstances. In a mountainous country snow sheds alone will answer. Their nature will depend upon the country. On some roads they will have to be built so as to protect the track from avalanches. They must be strong and so placed as to carry the snow forward and over the track without impediment. In the majority of instances, however, simple snow sheds are all that is needed. The question of the protection of a railroad from snow is a great one. Its complete elucidation will be the work of time and experience.

In maintaining the property of railways, naturally the greatest importance attaches to the track. This is the artery of life, the vital thread. If not effectively maintained, risk and disaster follow as certainly as a weak truss or other defect in a bridge precipitates disaster. Not all railways are maintained at the same high standard, nor do different railways involve similar expenditures for maintenance. The routine, however, that is observed upon different roads is substantially the same. Here as well as elsewhere, wisdom and experience mark efficient from inefficient management.

The secret of the smoothness and stability of track and freedom from accident is not the result of chance, but of far seeing care and sagacity; of constant inspection and tests. It is not necessary to wait until a structure breaks down to demonstrate its weakness. The mishap may be averted by timely inspection and subjection to proper tests. Herein lies the secret of the luxury and security of railway travel. If equal care and intelligence were exercised in the maintenance of the highways of the world that railways observe, their cost would not be one-third what it is today, while they would be an ever increasing source of profit and pleasure to mankind.

"The province of labor is to make the track stable, and to securely fasten and unite its parts so as to prevent independent motion. Elasticity of bearing does not imply loose and shifting parts; flexibility of material must not be confounded with yielding and inadequate support. The impact due to low joints, bad surface, poor line and defective gauge greatly augments the destructive effects of increased wheel pressure, and the deterioration of track is much accelerated when deprived of proper care. This brings us to the quality of section labor and the attention paid to details. . . In nothing do our track men need to be so fully drilled as in the matter of thorough and conscientious track work, particularly in tamping, to stand the service to which our tracks are subjected. . . Thorough track work implies tight joints, the use of track level, true gauge, and conscientions tamping and attention to minor details. . . . As early in the year as settled weather will permit, the section gang should be increased to its maximum strength and the work of renewals should be substantially completed by the commencement of the hot season."*

Every detail connected with the maintenance of a property would be interesting if it could be so generalized as to come within our comprehension. This is not possible, however. The details connected with the maintenance of machin-



Stock Car.

ery and equipment are things that only machinists can explain or comprehend. To others the subject is a hidden book. They only know in regard to such matters that renewals must be made promptly and effectively as they are about a house, otherwise the damage is multiplied indefinitely. The same is true of buildings, fences and other paraphernalia of railways. It is true of the track. except that here the routine is more easily comprehended by the lay reader. An English writer thus describes the maintenance

*Benjamin Reece.

of the track on an English road.* It is not noticably different from our methods. He says:

"In England three men with a foreman form a gang. This gang has charge of the inspection and maintenance of about two miles of double line of railway. An average of one man to each mile of single line. The exact number depends upon the extent of traffic and consequent wear and tear; also the number of junctions and sidings which have to be maintained.† Every ten or twenty gangs are under the direct supervision of an officer known as an inspector. Every seven or eight inspectors are under the control of a chief inspector, who has also under him traveling gangs of ballasting men and relayers, who are employed in renewing the permanent way and carrying out alterations and additions. Each division of road has also a full complement of artificers, joiners, masons, bricklayers, painters and blacksmiths, with their foremen and inspectors, whose duty it is to repair the bridges, tunnels, stations and buildings of the company. All these men with their chiefs and inspectors are under the direction of a civil engineer of experience, who has a staff of suveyors, draughtsmen and clerks, located at the most important centre

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* Colonel Geo. Findlay. "The Working and Management of an English Railway," pages 59 to 61.

† The length of track allotted different gangs in the United States depends upon the character of the track and the amount of traffic passing over it; also somewhat upon the capacity of the foreman. Four miles is about the maximum, except in the case of single track. A section must not be so long that those in charge can not inspect it at frequent intervals, can not quickly reach any point in the event of disaster. Considerations such as these fix arbitrarily the limits of track sections. M. M. K.

of traffic on his division. The duties of the track force comprise the daily inspection of every portion of the section of line under its charge, and the repairs of the permanent way, fences, drains and roads. Track foremen are required to report anything they may observe to be amiss with telegraph wires, signals or passing trains. This duty is especially imperative during storms, fogs or heavy falls of snow. It is made their duty to furnish inspectors with a statement of materials needed, used and on hand. Each official throughout the corps is, in his order, responsible for the work of men under him. The stability of the permanent way and works of a railway is frequently threatened. Ceaseless vigilance has, consequently, to be exercised."

It is the duty of the force described by Colonel Findlay, with its graduated service, from an experienced civil engineer down to a common laborer, to exercise a surveillance not only over the track, but the property and buildings connected therewith.

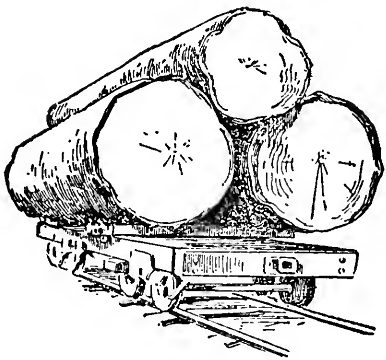
On some of the French railroads a novel system of maintenance is adopted which is claimed to lessen cost. Instead of making repairs as the necessity develops, the whole road is periodically gone over and repaired. At these times the ballast is re-adjusted, new ballast being applied if necessary, the ties are tamped, the track cleared of weeds, the rail fastenings cleaned and inspected, chairs examined, the gauge tested and corrected, rails adjusted, and defects of every kind remedied. The intervals between these periodic overhaulings vary according to the traffic; thus, main lines, over which more than forty trains pass daily, will be gone over once each year; track over which twenty and not more than forty trains run daily will be overhauled every two years, and so on. It is not asserted by those who practice this system that other repairs beside these periodical overhaulings are not required, but it is claimed that under this plan occasional repairs are reduced to the minimum.

In the maintenance of the track of a railway, the foremen in charge of the gangs of men that patrol the line from day to day are greatly trusted, because of their experience and reliability. They are not, however, as a rule, men of high education. They are practical men who have entered the service as common laborers. With the lapse of time, however, it is probable that superior officials, including civil engineers, will climb to preferment through positions of this kind. There is no doubt but that a civil engineer's efficiency would be greatly enhanced if he had the practical knowledge of track matters that is acquired by the use of the pick and shovel and by the actual management of a gang of men. Men may have experience in railway matters and not be so valuable as those without it, because of lack of general knowledge and comprehension. But experience adds to the value of every man's usefulness and understanding. A civil engineer in charge of roadway and track who has came to his position through the various grades of the service, has a much better grasp of affairs than one who has not. He is without prejudice and has an enlightened understanding of the possibilities and practices of every position under him. This knowledge can not be acquired in all its fullness except by such experience. Not only would the efficiency of the civil engineer be increased through his filling the various positions under him, but the efficiency of such officers, from the track foremen up, would be greatly heightened thereby. If there is any value in education, in knowledge, in connected and consecutive thought, it would in this way be secured for the lowest offices in the service as well as the highest.

In the things that go to make up the physical structure of railroads there has been a tendency from the start to conform to particular patterns. This tendency in the United States has been a healthy one because voluntary, based on enquiry, discussion and experiment. There has been no compulsion about it, nor suggestion of compulsion. The selection has been based on natural grounds; on the survival of the fittest. Inherent differences in properties have been recognized and attempts have not been made to harmonize elements naturally antagonistic. Unification so far as it has extended has been predicated upon similar conditions. The theories of doctrinaires nowhere find expression.

The standard articles used by railroads embrace things that are alike, such as the flange and form of wheel, the tread, the interposition of springs and equalizing bars to relieve the blow, the gauge of tires, driving wheel centers, couplers, gauge of wheels, journals, axles and many other items connected with the running gear of locomotives and cars.

But after patterns have been formally agreed upon, they continue to be the subject of animated discussion by railway officers and others.



Logging Truck.

So that the service does not remain stationary or deteriorate from lack of continual interest and attention, as it would if devices were introduced and enforced by arbitrary means. The work is only just begun. It is probable that a standard rail section for different kinds and weights of metal will sooner or later be adopted. Interest in the matter spreads continually. Manufacturers and those connected with the permanent way give the subject constant attention. It is of great importance in the maintenance of railroads. It forms a preponderating item in the permanent way. And in regard to this latter, it is the key of the railway situation. It dominates all other interests from the standpoint of construction and maintenance. The subject is most interesting and varied. It is practically inexhaustible.

The permanent way of a road consists of the rails, their supports and fastenings and attendant switches and frogs; the alignment of tangents and curves; the superstructure of stone, gravel and dirt; the bridges of stone, iron and wood. This combination, this mass, must be so constructed and blended that trains may pass over it safely and smoothly with the minimum wear and tear to both equipment and permanent way. An interesting writer* to whom I am indebted, speaking of American railways, says further in regard to permanent way matters:

"Rails should be curved before laying on any curve that exceeds two degrees; they should be curved with some form of machine which will not produce sudden concussion on the rail. Angle bar joints should not be over twenty-four inches long, of such weight and shape as not to break, and to give proper support. The ties should not be less than eight feet long, seven inches thick, with face at least seven inches, using at least twenty-eight hundred to the mile. The split switch with the automatic stand, with a flexible tie or switch rod, should be used not

*Wm. F. Ellis.

only on the main track but on inside track switches where there is any amount of switching done, and at side track switches where a derailment from an open non-safety automatic switch would stop the traffic on the main track. I would also recommend a guard rail to be used at the points of all split switches where same are not trailing switches. A spring rail frog should be used in all cases except where there is nearly the same wear on each wing of the frog and at yards where the rigid rail frog is used. The best form of guard rails at frogs is the following: Length, twelve to fifteen feet, curved a true curve, with a radius of one hundred and fifty or a hundred and seventy-five feet; center of guard rail set six inches ahead of point of the frog, securely spiked and fastened with three braces, one opposite the point of the frog, and one on either side. This would be a correct guard rail for rigid rail frogs, but for a spring rail frog the guard rail would have to be parallel to the main rail with a flangeway of one and three-quarter inches for at least nine feet of its length at center of same and well braced its entire length. Alignment of tangents once in ten years, and especially of the curves once in five years, should be corrected by transit. Elevation should be such as the speed of trains and traffic demand. Ballast should be of broken stone when circumstances permit, or good gravel with proper drainage to same, and at last once in five years in the surfacing of the track, slight raising of the same, where possible to be done. All highway crossings should be carefully cleaned out each year and renewed with fresh ballast. Culverts should be of stone and covered with ballast if possible. Where arches of stone, through cost or location, can not be used, iron bridges should be. They should be constructed with a view to carry with safety not only the weight of the present rolling stock, but a proportional increase in the same as the last ten years' progress has indicated what it may be, and with these bridges a floor and guard rail should be used, in which the ties should be ten feet long, eight by eight inches square, eight inches apart, secured in place by timber six by six inches square, gained on to each tie near the outer end and bolted firmly, an iron guard of railroad iron on the inside of the track rails and eight inches from them, and approaching the centre of the track at about thirty feet from the ends of the bridge and connected together by the old point of a frog; the long bridge ties for the distance of about thirty feet should be put in on the ground at each end of the bridge and the outside guard rail should be extended on same, spreading at the ends about three feet outside of the main track rail. To this I would add the use of a rerailing device. The metal used in a track should be such as the speed of trains and tonnage require. Material should be renewed at the proper time and when renewed maintained."

While cross ties are very generally used as a support for rails, the use of longitudinal bearings is more or less practiced. This is especially the case in Germany and Austria. They have, however, never been generally popular because of certain defects and greater cost. But the increase in weight of locomotives and cars, and the possibility that such increase will go on indefinitely, indicate a necessity for further strengthening the track. Exactly how this will be done has not yet been determined. It has been suggested that the use of longitudinal supports for the rails in connection with the cross tie would meet the situation. The requisites of such a longitudinal system are thus described by Thomas C. Clark, M. Am. Soc. C. E.:

"1. The longitudinal bearer under the rail shall be stiff enough to transmit the load to such a distance, on each side of the wheel, as will limit the pressure to not much over two tons per square foot of bearing surface, without requiring excessive width. Experience has shown that a greater pressure than two tons per square foot will sink ties too deep into the gravel or broken stone.

"2. The next thing is to attach the rails and bearers together by a form of fastening strong enough to resist all strains and shocks and yet allow of freedom of the rail to expand and contract independently of its bearer. It must also be held to its bearer so that creeping of the rail on the bearer may be prevented, and that without any notching or cutting of the rail that will impair its strength. The rails must break joints with the bearers. The fastenings must be so made that the rails can be quickly removed and replaced by new ones without disturbing the bearers. The fastenings must be able to hold for a time a broken rail so that it will safely pass the trains, and no system but the longitudinal can do this.

"3. The bearers and rails should be united firmly together by light metallic gauge ties, placed near enough to properly preserve the accuracy of the gauge.

"4. The bearers and gauge ties should be of such shapes as can easily be tamped with gravel or broken stone; as will stay in place vertically, laterally and longitudinally, and will allow of drainage to pass between them.

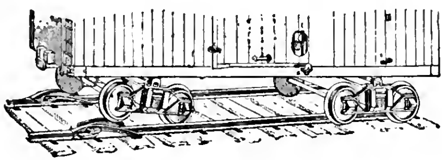
"5. The system should be so planned that no difficulty of construction can occur at curves, either in alignment or elevation of outer rail. Also it should be so made as to easily join to the ordinary form of T rail at turnouts and switches.

"6. Beside the obvious advantages which such a construction gives, there are two others: The upper rail can be made of a harder and better worked steel, while the bearer can be made of a softer and tougher quality of metal. Probably basic steel would do for this. Owing to the rails being supported under their entire length by continuous bearers they can be made of less depth and sectional area in their flanges than at present. The metal so saved can be put into the head of the rail, where it is most needed.

"It is believed that rails can be designed for a longitudinal system with heads three inches wide and instead of weighing one hundred and ten pounds to the yard, they need not weigh over seventy pounds to the yard. This saving of metal can be applied to reducing the cost of the whole system. The wear being confined to the upper rail, the amount of metal which goes into the scrap heap is the least possible."

The use of metals is becoming so general in railway practice that questions affecting their strength and wearing qualities grow each year in interest and importance. Many experiments, undertaken for the purpose of ascertaining the relation between the wear of metals and their chemical and physical properties, have been conducted, but never under entirely favorable circumstances. But few statistics have been collected by railroads on the subject. The matter still requires study. Conclusions now thought to be established will not stand the test of further light.

The wear of metals is understood to be the tearing off of minute particles of the substance



Car Replacing Device.

by friction. Conclusions arrived at have been drawn from practical experiments. Up to the present time chemists, so far as known, have formulated no theory in regard to wear. It is influenced by the particular conditions under which it takes place, such as lubrication, speed, temperature, pressure, rolling, friction, etc. Up to this time railways have, for various reasons, been handicapped in their experiments, and the partial conclusions drawn from the experiments that have been made, the future will quite likely upset. It is stated, however, by experts in such matters that metal having fine granular structure (provided its tensile strength and elongation are equal to those of a coarser description) will wear less, for the reason that the particle of metal torn off is smaller and, therefore, less destructive. This, however, is disputed. Actual tests, meagre as they are, show that metal which may be extended (elongated) most without breaking will wear best. Thus rails of mild steel, if properly made, are thought to be less liable to fracture, crushing and disintegration than harder rails. The fact has been disputed, but preponderance of evidence seems to be in favor of the conclusion up to this time. The same is claimed to be true of the wear of the tires of driving wheels. When tires taken from wheels of the same locomotive have come into the shops for returning it has been noticed that more metal had to be removed from the soft than from the hard tires, thus proving that the wear of the latter was greater. It is also claimed that experiments conducted in alloys used as bearings show that wear is greater with metals which are brittle, than with those which are more pliable. The reason for this is thought to lie in the fact that in metals of higher temper the rupture of small particles, because of their brittleness, occurs more easily than in more ductile metals. The more brittle a metal the larger its granular structure.

Conclusions arrived at up to this time in regard to metals appear to be that the greater the elongation of a metal while still retaining its tensile strength, the less the wear; that high tensile strength with great elongation and fine structure give the best results in actual service. Such are, briefly, the conclusions of experts. On the other hand, tests made on a state railroad of The Netherlands seem to disprove them in some respects; these tests, it is said, demonstrate that a soft rail wears much more rapidly than a hard one. In making the tests a number of experimental rails were placed in both single and double tracks. The point selected was on a level and straight track sufficiently distant from a station to avoid the use and effect of brakes. The rails were carefully selected, weighed and measured. Their tensile strength varied from sixty-seven thousand to one hundred thousand pounds per square inch. At first effort was made to ascertain wear by means of measurement with a micrometer. These measurements were not satisfactory inasmuch as the least inclination of the rail removed the point of wear to one side of the center. The instrument would not, because of this, record the actual wear. A number of the rails were then taken up and after being carefully cleaned of dirt and rust with a steel brush were weighed. The difference between the first and second weighing gave the wear due to the passage of trains and to rust. The conclusions drawn from the data thus obtained showed that the wear of the soft rails had been about twenty-seven per cent. more than that of the hard rails, or inversely to the tensile strength of the rails. From these practical tests it would seem that the harder the rail the better the wear. But as the wear of the rails in question was due somewhat to rust, it is claimed that definite conclusions can not be drawn until the rails are used up to the extreme limit, as it is yet to be determined whether the interior of the rail will wear as well as the surface or not.

Each year witnesses some improvement in the track of railways; the decrease in derailment of trains from an unstable roadbed, from the spreading of the track, from broken rails and defective switches, evinces this. These improvements are the result of greater experience and added ability on the part of carriers to supply their wants.

In the maintenance of the permanent structures of a company the payment of premiums for manifest excellence has been found advantageous. It has been found especially efficacious in securing a good roadbed, in maintaining and improving the tracks and yards. Awards are made under different systems by different companies. One company's schedule of premiums is given below.*

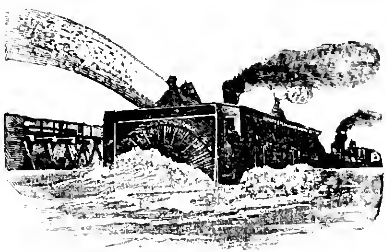
* $100 to the roadmaster having the best yard on his division. $100 each to the roadmasters having the best roadmaster's division on each superintendent's division of 100 miles. $75 to the section foreman having the best section of two and a half miles on his division. $60 to each section foreman having the best section on his superintendent's division, including yards. $50 to the section foreman having the best section on each roadmaster's division. $100 to the roadmaster having the best line and surface for the whole length of road. $50 to the second best *ditto.*

Its effect in securing greater interest and intelligence has been marked. In its practical operation the recipients of a premium are not allowed to compete for lower premiums. The inspections upon which the premiums are based are made yearly. The men for whom the rewards are instituted themselves make the inspections, each for the other. The premiums are awarded under the supervision of the employing company. The system has been in vogue ten years and has been found to stimulate the ambition of men and to increase and broaden their understanding. It intensifies their desire to learn, to increase their knowledge, to possess themselves of the wisdom and experience of others, instead of relying wholly upon themselves. The question of paying premiums for superior service is taken up more fully in another volume.* The subject is an interesting one and of great importance to railway companies. Wherever properly regulated the practice will be found beneficial. Men are differently constituted; some are more conscientious than others. But the interest of the best will be stimulated by prospective reward. If this is true of a conscientious man, how much more true it is of those differently constituted, who need the spur of incentive. There can be no doubt but that the zeal of everyone who labors for another will be heightened by the hope of special reward for faithful and intelligent service. Wherever the

* "Operation of Trains."

practice has been properly tried it has been found beneficial, especially in regard to the track and train service.

The maintenance of a railroad means many things and covers many practices. It means, among other things, freedom from risk, from accident, from delay, from unnecessary expense, the adoption of due safeguards. One of the greatest sources of anxiety to railroad managers is the care of bridges and culverts, their protec-



Clearing Track of Snow.

tion from fires, from the undermining effects of water and frost, from the floods of summer and the ice of winter. The struggle is a never ending one. Each month takes on some new phase. Each structure has its peculiar risks, its attending dangers. In addition to the dangers that menace bridges and culverts from the streams they cross, their immediate stability is threatened by the trains that pass over them. The risk here is a double one, that of destruction of both the bridge and the train with attendant loss of life.

The prevention of this double calamity, it is apparent at a glance, is one of supreme importance. Yet the risk is not so great or imminent as to have made the question a vital one. Accidents are only occasional and do not, therefore, greatly impress themselves upon either the managers or the public. Nevertheless, as railway practice grows older and men have more time to think and carriers have greater means and leisure to accomplish results, they interest themselves more and more in precautionary measures and, among other things, in preventing the mishaps that arise at bridges from the passage of trains. The devices adopted for this purpose are manifold. The great bulk of them, however, are manifestly inadequate and are recognized to be so even by those who gravely use them. In many cases they do not know of any better device; sometimes, possibly, they do not appreciate the gravity of the situation. The subject is not one that can be decided off-hand, nor can any particular device be recommended as being better than another or as answering the purpose. This can only be determined by careful investigation, by actual use, by the most thorough experiments. The device must answer certain conditions. A recent writer* on the subject says:

"The device must be so arranged that it can not in any way cause the derailment of a car. It should, therefore, leave abundant room for the passage of wheels, making allowances for the con-

*J. W. Post.

dition of wheels and tires that are badly worn, as well as those that are new. Account must also be taken of the use of cars from other roads. It must not touch the weak points of a derailed car, and must be so arranged as to come in contact with the running gear only. It must direct the wheels of a derailed car back upon the track without violent shocks, either in a horizontal or vertical direction, and must bring them back before they reach the bridge. It must keep on the track during the passage over the structure cars which may have been derailed from any defect. It must be constructed of durable materials, and in such a way that it will not fail when needed. It must have no very heavy pieces, so that its putting in place, repair, etc., can be easily done by an ordinary track gang. It must permit the tamping of ties. It must be cheap to make, to put in place, to keep in order and to renew. In other words, it must be easy to handle, and of small cost."

The track of a railway must be sufficient to support the weight and rush of a country's commerce and travel. That it should be well moored, should have a strong wall and a tenacious fiber goes without saying. The moorings of a track are its ballast, including the fastenings that hold the rail to the tie.* The devices used

* "Where there is not sufficient ballast to give elasticity to the track, the rail wears out twice as fast as on level ground or an embankment. A large stone or piece of rock under a tie will soon show itself by the rail wearing out over it. Clamp a pair of angle plates to the center of a rail where there is no joint and in six months the rail will be worn down in a rut directly over the plates, showing clearly that any extra resistance produces extra wear."—*James Churchward, C. E.*

for track fastenings have been improved in many respects, nevertheless no device has yet been found that will hold the rail securely to the tie. It may be too much to expect this. The strain is perhaps too great. However, if such a thing can be attained it will lessen greatly the wear and tear of the tie, add smoothness to the road-bed and lessen depreciation of track and equipment. The instrument that fastens the rail to the tie has two great purposes to serve, first, to prevent the rail from spreading, and, second, to resist the effort to lift it vertically from its socket. The lateral pressure of a train passing over a track would cause the rails to spread apart unless the fastenings prevented it. Again, the effect of the passing train is to depress the rail, and with it the tie. The reaction of the rail and the tie is not coincident. The rail springs back first. The result is to throw the weight of the tie and the surrounding ballast with the added strain on the head of the spike. This explains why, in examining a track, but few spikes are found to press firmly against the rail. Because of this the rail is allowed greater or less freedom of motion in every direction. Among other evils engendered by this is the accumulation of sand and dirt between the rail and the tie, precipitating the destruction of the latter. The difficulties of the situation are aggravated in winter. Thus, when the ground is frozen it is impossible for the spike to lift the mass in which the tie is imbedded. It consequently gives way.

It is possible that a fastening that will hold the rail and tie compactly together, making them one, will sometime be discovered. The value of such a device can not be overestimated. At present a common spike, driven perpendicularly into the tie, is the chief fastening used, as it has been from the first. This spike, while far from perfect from a theoretical point of view, nevertheless, under favorable conditions, gives fairly good satisfaction. A committee of experts having the matter under consideration condemned it as not the best possible design to resist the vertical pull of the rail, due to the theory of wave motion, or elasticity, under the moving train. How much this strain amounted to they were unable to tell, but believed the weight of the train able to resist the reaction. They thought the danger sufficiently great on bridges to recommend an interlocking bolt as a precautionary measure. What is needed is a spike larger than the one at present in use, made of steel, that shall be driven vertically on each side of the rail, thus securely interlocking the latter, that will resist lateral pressure or any sudden derangement of the machinery whereby extraordinary outward strain is thrown on the rail, that has a strong head, that can be used over and over again, that will cut and compress the fibre of the wood and not break or mash it, that holds tenaciously to the wood and is thus prevented from being loosened or withdrawn, a spike that will hold the tie and the rail securely together.

A steel pointed spike with corrugated sides has been invented that it is claimed substantially accomplishes all these things.

"A spike possesses adhesive resistance on account of the friction between the sides of the spike and the wood into which it is driven; this friction depends upon the amount of compressive stress exerted by the wood against the spike, and the friction will be greater or less according to the character of the surfaces in contact.

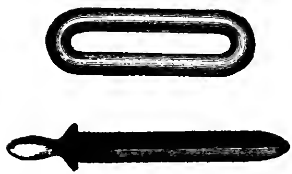
"In driving a spike the wood is compressed laterally. The resilience or tendency to spring back again gives the pressure against the sides of the spike. The greater the compression of the wood the greater will be the compressive stress until the wood splits; the limit of adhesive resistance is therefore that which is due to a compression of the fibres which splits the wood. Care must be taken, however, in driving the spike that the fibres are not too abruptly displaced.

"With spikes of large cross section dimensions there is a tendency to carry along some of the fibres in front of the blunt point, and leave cavities next the body of the spike instead of solid wood in close contact."*

It matters not how well a track is ballasted, it will not remain in good surface unless the rails are held securely to the ties. Moreover, a "rail being free allows sand and dirt to accumulate between itself and the tie, so that

*James E. Howard. Mr. Howard thinks that if it is required to materially increase the adhesive qualities of the spike experiments should be made in the direction of larger spikes with bored holes to receive them.

the movement of the rail from passing trains becomes a gigantic rasp to cut the tie. When it has once commenced to cut, the rate of disintegration is vastly increased. The wood underneath and around the edges of the rail is mashed so that it holds water; incipient rot is the immediate result. To make a tie last its natural life, the first cutting must be prevented."* It is a question whether so much shimming or blocking in winter would be required if rails were perfectly fastened, because the tie being securely fastened to the rail would bring it up to its own level and prevent its freezing down in the track. The friction of the tie meantime against the ballast, caused by its moving up and down as trains pass, would detach particles of ballast, thus tamping it to a fair surface. "Accidents frequently arise from the rail cutting away the tie underneath the outside flange, causing the rail to roll completely over. This trouble arises from the fact that the inside flange of the rail is not securely held down. Many European roads guard against this by canting their rails inward."*



Coupling Link and Pin.

Upon many roads the rail is laid directly on the tie and spiked thereto as described above. The placing of a plate or chair on the tie for the rail to rest on has many advocates. It is thought

*James Churchward, C. E.

by them to prevent the rail from cutting the tie, give it steadiness, and compensate for a narrow rail base. "Ties are made more durable by this plate and can be kept in service until rendered useless by decay. The cheapest kinds of wood will wear, except for decay, as long as the most expensive. Wearing away of the tie by the rail is the direct result of the creeping and oscillating movement of the rails caused by the impact of the weight passing over them. There are also indirect causes which contribute largely towards the wear, such as sand or grit between the rail and tie; also water under the base of the rail injected into the tie by the pressure of passing trains, making the wood soft and spongy where it should be hardest. The plate overcomes these difficulties. Being fastened to the tie, it receives the wear arising from any movement and friction of the rail and thus a combination is obtained which furnishes the wearing qualities of an iron or steel tie at a reasonable cost. These plates render possible the use of soft wood for ties,—cedar, for instance, which makes only a poor tie without the use of a plate or chair; it is very light and soft and is soon ground away under the attrition of the rails which imbed themselves in the timber weakening the tie, which quickly breaks under the line of the rail. Wear plates prevent this and thus a cheap tie is rendered as effective as a white oak tie costing much more. The value of the rail plate is becoming more marked daily from the increased weight that passes over the track. The portions of the tie where the strain comes, where the spike more or less injures the fibre and where the crushing by the wheels is most destructive, these plates perfectly protect from the weather. Under the plate there is no tendency to rot, even when the sun and rain have damaged other portions. Moreover, the weight is better distributed over the surface of the tie, and, as the area under pressure is thus considerably larger, the pressure per square inch on the timber is reduced."*

The durability of rails and ties is directly dependent upon a proper alignment of the track; upon the preservation of an even and firm surface to the rail, especially at the point of juncture. Track men believe that a proper maintenance of the joint (junction of the rails) is of supreme importance. It is ever an object of solicitude to them. If the joint is inadequately supported, the rail head will be quickly battered. The seriousness of this as regards the effect on equipment and roadway does not need elaboration. Track men are practically a unit in believing that the joint should be afforded such support as will prevent its sinking with the weight of passing trains. This requires, if the joint is not supported by a tie, constant readjustment of the support afforded by the angle bar to meet the ever increasing weight of trains. Upon many great and well managed roads the joint is not thus placed, but is supported only by a splicebar,—a bar fitting to the rail on each side, lapping at the point of junction and securely bolted to the rail. Each method has its advo-

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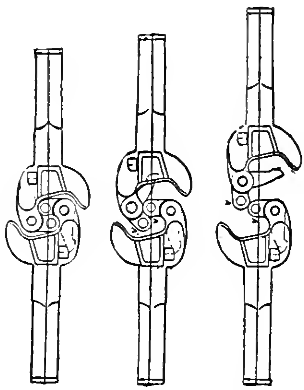
*James Churchward, C. E.

cates. The form of the rail and the pattern of the splicebar are factors that must be considered in discussing the merits of the support to be afforded the joint. Mr. Churchward, whom we have already quoted, thus passes judgment in the matter:

"Present joints are a failure. The principal way of fastening the ends of the rails is by means of splice bars in some form or other. This is the correct way; they form a bridge or support to uphold the ends of the rails, and, bearing against the head of the rail as well as the flange, keep the rails, where they join, in line and continuity. The objections to any fastening that does not bear against the heads of the rails as well as the base are: on curves, as the heads of the rails are in no wise held in continuity, it is a question whether with a heavy engine swerving against a light rail, the engine would not bend the loaded rail slightly over, presenting the face of the receiving rail for the flanges of the wheels to strike, thus causing derailment; and another question is whether the web or base of the rail would not break also, the leverage on it being greatly enhanced. The present angle or splice bars are of all shapes and sizes. They wear and crush down underneath the ends of the rails; a cavity thus forms in their center. The fault is not with the plates but with the rails. The bearing surface underneath the head of the rail for the splice bar (in the present shaped rails) is only about half an inch,—often less. This half inch bearing or face has to sustain the blow and weight of great engines ever increasing in weight. It is impossible for this face to withstand the blow it receives. Down it goes, forming first a loose, then a low, joint. It is impossible to make a suspended joint satisfactory with the present shaped rails and the ordinary shaped splice bars. The only thing that can be done is to make the joint on a tie with the plate underneath the ends of the rails to help the splice bars withstand the blow and weight of the load. If a suspended joint is used,—*i. e.*, where the ends of the rails connect between two ties,—it is absolutely necessary to have a base or auxiliary plate. Initial wear under the rail must be prevented, as tightening of bolts after they have once started can not make the joint solid again. Each succeeding blow from the wheels, from its lengthened drop, falls heavier than the previous one, making the cavity deeper between the end of the rail and upper bearing of the splice bar. The lower bearing of the angle plate on the flange of the rail never shows the same wear as the head, simply because the lower bearings are wide enough to withstand the blow. We therefore come to the conclusion that it is not practicable to form a perfect joint with angle or splice bars without the aid of an auxiliary base plate. It is yet to be demonstrated which is the best form of plate. It must not be too



Automatic Coupler.

heavy, otherwise it will present an extra resistance to the wheels, the effect of which will be as damaging as low joints.* If a four bolted angle plate is examined, it will be found that the wear commences about the second bolt and increases past the first, obtaining its maximum directly underneath the end of the rail. Many of our roads are increasing their angle plates to nearly double the old length to prevent the crushing over and in front of the first bolt. What is required is sufficient bearing and strength, not extra length. A splice should never be over twenty inches, and eighteen would be better; but it must have the necessary bearings to withstand crushing, and an elastic limit equal to the same length of rail. The objection to long joints is, they commence to strengthen what is not weak, and, stopping the elastic wave of the rail, they cause the wheels to jump and ricochet over the joint, thereby turning the even, gliding movement of the wheels into a direct hammering blow on the weakest part of the construction —the joint. A false mechanical function has been placed on the plates now in use. They are slotted or punched to receive the spikes to prevent the rail from creeping. Originally they were only intended to keep the ends of the rails

* "What is absolutely required for a perfect joint is a set of plates whose elastic limit shall be at least equal to the same length or span of the rail. These plates should have a bearing under the head or base of the rail sufficiently large to prevent crushing down under the weight of the maximum load; this bearing to be always kept solid by a sufficiently strong automatic power—a power that will force the plates to this solid bearing as the scale wears off and retain them there under the maximum load, so that the joint has never any movement independent of the rail."—*James Churchward, C. E.*

up and in line. This is enough. They are now clamped to the rail and spiked to the tie in such a position that with every passing wheel the rails and plates are antagonized and all repose destroyed. The spiked angle plate resists creeping; with every passing wheel the rails are pushed forward and again brought back with the plates. Every movement involves friction between the two surfaces. Metal is displaced by each operation. If the loss is infinitesimal, multiply the atoms by the wheels passing over the joint and it will be plainly seen why the joint is so quickly ruined. How is creeping to be stopped? By putting a separate fastening on the receiving tie, so that the rail is fastened to this tie. There are three or four forms of these fastenings,—simple, effective and cheap.

"One can not find on any road with heavy traffic a joint that is perfect at the end of two or three years' wear. They are all more or less worn and low. Every one of these joints is below the center of the rail, and goes lower every day.*

"No angle plate has yet been constructed that has an equal perpendicular strength as the same length of span in the rail; consequently when the weight of a passing load comes on the ends of the rails, it bends the plates down, and in a short time forms a permanent set in them. Many

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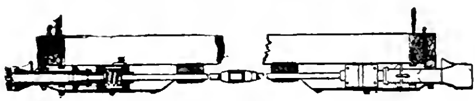
*He attributes this to the form of rail in use, first, in the preponderance of metal in the head over the base and the effect of the sun's rays on it, and second, because the elasticity and compactness of the fibres are less in a thick headed rail head than in its base, for the reason that the metal being so much thicker in the head does not get compressed by the rolls, as in the case of the web and base. M. M. K.

roads appreciating this fact, are placing the ends on a tie, to give additional support to the plates. It is but a short time before the ends of the rails, bending the plates, start to dent the wooden tie underneath, so that the evil of a low joint is only partially obviated by placing the joint on a tie. When the tie has been dented down, and the loaded rail can sink below the receiving rail, it strikes the latter with a leavy blow in taking it, which batters and burrs out the end, and finally ruins the joint. The tie plate referred to elsewhere prevents this, because the loaded rail can not crush the tie, consequently the loaded rail is always kept up on a level with the receiving rail. This does away with the blow before mentioned, and extends the life of a joint in a very marked degree."

The effect of a depression in a rail, in the joint or elsewhere, is felt outside of the increased wear and tear involved on roadway and machinery. It involves loss of power; a constant lifting of the vehicle from the declivities or sinkage in the track into which it falls. The power is proportionate to the number and depth of the depressions and the velocity of the moving vehicle. Moreover, a weak spot in a rail involves an undue strain on the rail opposite caused by the increased weight it must bear. Depressions in the track, as already noticed, are occasioned by defective joints, by lack of support for the tie and by the tie being cut into by the rail.

Track fastenings, whatever they may be, must adjust themselves to the form of rail in vogue. The patterns that answer with one form will not answer with another. Thus, the device used with the form of rail in the United States would be entirely out of place in India, where a different pattern is used.

Upon bridges and curves the spike we use is frequently supplemented by a bolt. The precaution is a natural and wise one. In early use, rail joints were supported by a piece of metal called a "chair." The device was far from satisfactory. It was replaced by the splice bar already described. The latter added greatly to the agreeableness of travel and measurably reduces the wear and tear of track and machinery.



Continuous Draw Bar.

It is, however, as has been shown, far from perfect. The form that will replace it will depend upon the form of rail and the speed and weight to be supported.

In considering what has been done by railways in connection with the track, it is impossible to resist the conclusion that advancement in this department of the service has not kept pace with that elsewhere. Greater familiarity with the subject upon the part of directing engineers and other officials will perhaps remedy the discrepancy.

The details connected with the care and maintenance of track are infinite. I can not hope to deal here with anything except its vital parts. These have been noticed. Perhaps amply. Yet I can not close what I have to say on the subject of track joints without quoting what a very interesting and intelligent writer* has to say on the subject. He says:

"First. The splice bar must hold the two ends of the rail at the same level; not allowing the slightest depression in one end without an equal depression in the other.

"Second. The strength to resist a vertical stress or shock downwards at the joint should be fully twenty-five per cent. greater than the strength of the rail to resist a similar stress or shock at any point in its length.

"Third. When the joint contrivance is tightened securely in all its parts, in a condition to meet the above requirements, the expansion and contraction of the rails should be absolutely unhindered; otherwise, the rails will be bent while expanding, and the track, in extreme cases, be buckled or spread.

"Fourth. At the same time the rails must be held so firmly that, with good ties and ballast, the creeping or running of the track will be effectually prevented.

"Fifth. The joint device should not require a form of rail which is uneconomical in the disposition of metal, or which for any reason is not as well suited as another form.

"In addition to this, there is also that very important consideration, the ease of manipulation, as governing the convenience and rapidity of laying track. Thus if a joint is cumbersome, in

*F. A. Delano.

many parts, and slow to lay track with, such disadvantages should be taken into account in figuring the first cost of the joints.

"Passing briefly over this list of requirements in order, let us consider the good points and the bad of the common types of joints now on the market.

"1. The fish plate and angle bar type meet the first requirement very well while they are new and the bolts are tight; but if for any cause the bolts get loose or broken the two rail ends are not held at the same height, or if the joint is neglected the bar is nicked or bent and loses at once its principal value, no matter how much attention it has afterward.

"2. All fish plates and most angle bars are sadly deficient in strength, making the strength at the joint only partly as strong as the body of the rail, whereas it should be twenty-five per cent. stronger than the body of the rail. With rail sections having wide, thin heads which are now being so widely adopted in this country, it is possible to make the angle bar far stronger than it has been possible to do with rails having deep and narrow heads; but after all the strength of the angle bar is only effective when the bolts hold it tight in its position.

"3. Every roadmaster knows that fish plates and angle bars when tightly bolted up do not meet the third requirement, and it is well known that if the track bolts are too tight in summer the angle bars clutch the rail with so much fierceness that the track is liable to be kinked or buckled sooner than let the rails take up the full space which has been left for expansion. Knowing that this is the case with angle bars twenty-six inches long with four bolts, it seems to me poor wisdom to make the bar forty-four to forty-eight inches long with six bolts. Indeed, it seems to me that this question of expansion and contraction in rails is too little regarded in the consideration of rail joints, and many of the patented devices which aim at curing the faults in the angle bar type of joint tumble into the fault of making no provision for the unhindered expansion and contraction.

"4. One much heard of and advertised device, while containing many good features, allowing free expansion and contraction, places no limit on the distance apart that the rails might be. In this respect the angle bar is good and prevents creeping, especially if anchored to three ties. Some of the patent devices attempt to hold the rail from creeping by notching it in the flange, which is, of course, a bad practice, as it makes the rail very liable to break through the notch.

"5. Angle bar and fish plate joints are at fault in respect to the fifth requirement in as much as such a type of joint requires flat finishing angles (the more nearly horizontal the better), small internal fillets, so as to reduce the area of support as little as possible, and small corner fillets, to increase this area of support as much as possible. To make a rail for the angle bar involves a sacrifice unquestionably, and while I am not prepared to say that the sacrifice is not worth making, I do think it is one which should be admitted and its value in money, as nearly as it can be estimated, added to the cost of the joint when considering it in comparison with other devices.

"6. Lastly, to take up the question of the ease of manipulation, etc., probably nothing will ever be made which surpasses the angle bar or fish-plate joint for convenience in rapid laying, and undoubtedly the extra time and labor incident to laying rail with other devices should be charged as part of the first cost of the joint."

Mr. Delano thinks that the perfect rail joint has yet to be devised. He concludes as follows:

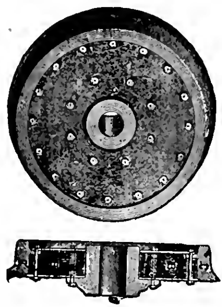
"A good track joint depends a great deal on the man who lays the steel and the man who takes care of it. Rails which are laid one-quarter of an inch apart in midsummer when they should be close together can not give the best results, no matter how good the subsequent maintenance may be. However, irrespective of the care which joints may get, they have a tendency to get low. Firstly, because there is a blow at the opening between the rails to cause this, and secondly, because the rolling of the wheels tends to lengthen the head, while the base remains the same, thus arching the rail to the detriment of the joint. The first difficulty can not be wholly avoided, but possibly the second might be partly overcome by making the rails a little low in the center. I do not mean by this that the rail should show this hollow when in the track, but simply that when on supports fifteen feet apart, and seven and one-half feet from each end, the rail should be hollowed enough to be one-quarter to one-half an inch lower at the center than at the ends."

It is possible that rails will be ultimately welded together in the track by electricity, so as to make a continuous rail. If necessary to repair any defect, the same power will be used to sever the rails and reattach them.

The maintenance of a railway involves, as we have already pointed out, innumerable things. Some of these I have referred to directly; others I have only hinted at. It involves the procurement and maintenance of the books, blanks, forms and stationery of a company; its furniture, fixtures and appliances; a proper system of accounts; the telegraph; responsible methods of handling money; the purchase, inspection, care and use of material; the proper employment of labor; the responsibilities of officers and employes; the government of the corporation; the handling of traffic and its appurtenances; the issuance of tariffs, rates and classifications; the movement of trains. Each one of these is involved in the maintenance of a railway. I have, however, given them more or less full exposition elsewhere. I desire here, as already explained, to treat more particularly of the physical operations of a railway, its track, equipment and attendant structures.

Much is said about the track. The theme is a great one. Questions connected with the maintenance of machinery and equipment are even more varied, more prolix; but less understood. Only those who have practical experience are capable of understanding such matters. Such persons acquire their knowledge, not from observation or the reading of books, but from actual experience. To attempt, therefore, to describe the construction or maintenance of equipment and machinery would be time thrown away. A brief reference, however, to the salient features of the subject may not be out of place. It will be merely descriptive. As those familiar with such matters know, railways repair and renew their equipment at shops conveniently located along the line for that purpose. Each company, however, has a central shop where important renewals are made. The object is to reduce plant, economize in the supervisory force and keep down the quantity of material on hand to the minimum. Lesser shops are expected to make only such current repairs as the equipment may need to keep it in continual use. When an engine or car requires general repairs or rebuilding it is sent to the central shop, where facilities are especially adapted to the work. In addition, however, to the various shops that a company maintains, it has scattered along its line at various places particular men or groups of men whose duty it is to look after the care and maintenance of the equipment. It is their place to inspect all cars that pass their stations; to see that the wheels and other running gear are in good order and lubricate them.* At particular points forces are kept to cleanse the interior and

*The effect of lubrication is to separate the surface of the bearing by a layer of lubricant. Thus the brass passes quite out of contact with the journal, so that if the lubricant were pure and sufficient in quantity, there would never be any wear whatever, friction between the parts being entirely overcome. Wear arises from the solids held in suspension in the lubricant exterior of cars, to look after the lights, to supply them with fuel and see that they are properly heated for use, and perform other duties incident to the care and maintenance of the rolling stock. These duties refer wholly to cars. The care and maintenance of engines passing over the line is looked after by those in charge. Machinery at shops is kept in repair by those immediately in charge, by purchase of the thing needed or otherwise. As a rule, an article may be bought in the market for less than it can be made or repaired at the shops of a company. The maintenance of the machinery and equipment of a road require the most painstaking and thorough organization and foresight to keep it at a point that is effective and safe. Inefficiency here can hardly be estimated in its disastrous results to a company.



Car Wheel (Paper).

In the maintenance of cars the draw bar and its fixtures succumb most frequently to the wear and tear of use; next to these the running gear, brakes and wheels. The process of repair and renewal commences immediately with the use

or injected afterward. This solid matter has a corroding effect on the bearing surfaces. It is less harmful if the particles are fine and the quantity of the lubricant ample so that the particles have opportunity to adjust themselves in the lubricant. If the lubricant is scant, wear is more quick and destructive.

of an engine or car and goes on with ever increased momentum until the object becomes so worn and strained that it must be relegated to the shops for general repairs or to be broken up.

The machinery required in the manufacture of the various parts of a locomotive or car is suggested by the thing itself and is forthcoming with the need. There is no limit to the skill and inventive genius of draftsmen and machinists. Perfection goes hand in hand with the requirement. Around each great principle or thought multitudes of collateral thoughts revolve. The machines that have been invented and are in use are in their number and integral parts more numerous than the stars of heaven.

In the maintenance of the equipment of a company, painting and varnishing are important factors. They constitute an ever recurring expense. Painting equipment does not serve alone an esthetic or ornamental purpose, for while incidentally it achieves this, its more important function is the preservation of the equipment and its protection from the elements. The material used requires to be of the best. Oils and varnish fresh from the manufactory are unfit for use. They must be allowed to settle. In the preparation of paints, the necessary ingredients must be carefully weighed and measured by a particular person. The material must be pure and finely ground. Colors should be harmonious and permanent. The work should at no stage be hurried. Varnish must be thoroughly dry and hard before being exposed, and in order to secure this plenty of covered space is required, well lighted, ventilated and heated. If the condition of the atmosphere requires it, artificial means of drying must be resorted to. In order to secure the best results, varnish, after it is applied, should be well rubbed in, so as to close the pores; in England, where much attention has been given to the subject, a coat of raw linseed oil, from which all the fatty material has been extracted, is applied to the varnish. In cleaning, care must be taken to avoid harmful or destructive methods, such as the use of very hot water or chemicals. The varnish on a car may be ruined within a month after it leaves the shops if improperly looked after. The question of color is not, as would seem at first glance, entirely a matter of taste. Advocates for light colors claim that the varnish holds better when a light colored paint is used; that it is easier to clean; that it wears better; that it does not absorb the heat as much as dark colored paint. On the other hand dark colors show the dirt less and require less material.

In concluding this chapter it may be proper to repeat what I have so frequently reiterated elsewhere, namely, that cost of maintenance is dependent upon the nature of the structure, the care with which it was built and the foresight and wisdom exercised in keeping it in order. Temporary and cheap structures, so characteristic of many new roads and a few old ones, cost much more to keep in order than more stable structures. Wooden fences, buildings, bridges and culverts require frequent renewals and constant watchfulness. Danger from fire is much greater than in other cases. Temporary and cheap structures, a poor equipment, an ill maintained track, greatly swell the loss and damage account of a railroad and what it must pay for loss of life and injury. Under the most favorable circumstances these items are large. They may be kept down by constant watchfulness and the exercise of prudent foresight in maintaining and renewing the various parts of a property as they become weakened or impaired.

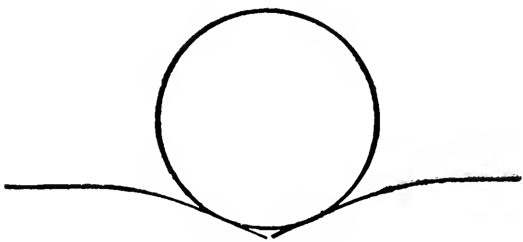
CHAPTER XXIII.

MAINTENANCE—THE USE OF WOOD BY RAILWAYS—HOW IT MAY BE PRESERVED—ITS SUBSTITUTES—METAL TIES—INVESTIGATIONS OF GOVERNMENTS AND EXPERIENCES OF RAILWAYS.

The kind of material used by railways depends on the facilities of a company. Where wood is plentiful and cheap it will be used. Where it is not, iron and steel will usurp its place in the construction of cars, buildings and other structures, including the track. The practices of one country will not be followed by other countries any further than economy dictates. These differences make comparisons difficult.

Heretofore railways have been constant and large consumers of timber; with improved processes, however, for making iron and steel, these latter more and more take its place. Coal for fuel has very generally become a substitute for wood. These changes are fortunate, as no country can long withstand so great a drain on its forestry. We have seen many illustrations of the effects of the destruction of the forestry of a country. Lands once possessing immense agricultural resources, the centres of a vast population, are today barren and desolate because of it. This is so of Palestine, many parts of Northern

Africa, Central Asia and vast regions in other countries. Uniformity of rain fall and an equable climate depend upon a moist atmosphere. This in turn depends upon the verdure of a country except in the immediate vicinity of large bodies of water. In North and South America and in Africa, where wood is plentiful and cheap, little or no effort has been made to preserve it or to economize in its use or increase its durability. This waste must, however, soon cease, from exhaustion if from no other reason. A solution of



Action of Wheel on Rail Joint.

the difficulty invites the attention and interest of every enlightened person. Economy in the use of wood is the first thing to be considered. This is to be obtained by the substitution of other material whenever possible, and by increasing the durability of such timber as we do use. Considerable thought has been given to the subject of preservation of wood against the common vicissitudes of the weather and also against the *teredo*. But the preservatives suggested will not be used, however much we may deplore the fact, except when it is clearly for the interests of the consumer to do so. But it is probable that effort is not made to preserve wood, because of supposed extra cost, in many cases when it would be economy to do so. Those interested in forestry have given the subject much attention. The measures of economy they suggest cover not only the preservatives, but the more careful use of wood.

The kinds of wood used vary, of course, with every country. I have only the statistics for the United States. It appears that the different kinds of wood used here for ties are in about the following proportions: Oak, sixty-two per cent.; chestnut, five per cent.; pine, seventeen per cent.; cedar (red, white and California), seven per cent.; hemlock and tamarack, three per cent.; cypress, two per cent.; redwood, three per cent.; various, one per cent.

The number of ties per mile of track is about two thousand seven hundred. The average duration of a tie when no preservative is used is about eight years. The reader may, therefore, estimate the number of ties required annually. The mass is enormous; the inroad it makes upon the forests alarming. Those, therefore, who have suggestions to make as to how the life of a tie may be prolonged, should be listened to gratefully. Mr. B. E. Fernow, Chief of the Forestry Division of the United States Department of Agriculture, suggests the following:

"1. Using only the most durable timbers.

"2. Giving proper attention to the cutting and piling of ties before they are used.

"3. Paying attention to the drainage and ballast material of the roadbed.

"4. Replacing ties in the roadbed which have rotted from the attack of a specific fungus by ties of a kind not liable to attack by the same fungus, so as to avoid its spread.

"5. Boring spike holes and filling the old ones when respiking, and the use of more permanent rail fastenings.

"6. The use of tie plates in order to reduce flange cutting.

"7. The use of preserving processes to lengthen the life of the timber.

"8. Cutting ties at the right season of the year.

"9. Increasing weight of rail.

"10. Careful drainage.

"11. Care in laying the tie."

Various methods are suggested for the preservation of wood. Creosote, chloride of zinc and sulphate of copper are the preservatives generally used. In Europe creosoting is practiced more than any other method. Ties thus treated are stated to have an average life of about twenty-five years. More or less preparation has been made in the United States for chemically preparing ties. But experience has proven that a tie prepared in a particular manner satisfactory in one locality oftentimes fails to give satisfaction in another locality. Different kinds of wood also require different kinds of treatment.*

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* Wood preservatives do not act alike in all countries. Thus in India, owing to sudden changes in temperature and other

Creosoting will never be as beneficial in the United States as in Europe, unless we make use of tie plates. Creosoting softens the fibre of the wood, and ties thus treated are quickly injured by the increased cutting of the rail flange when plates are not used; some other method, therefore, which will harden the wood while preventing disintegration would be better for our use. The use of metallic salts has been found to give good results in this direction.

The economy which railways may profitably use in the consumption of timber for ties may be supplemented by them in other directions with good results. This is particularly true in regard to buildings and fences. The wire fence, woven and otherwise, is now happily taking the place of all other kinds of fences in the United States. Hedges have been suggested. Unfortunately, our climate is not so favorable for this kind of fence as that of England.

In the use of wood for telegraph poles, little economy has heretofore been practiced. Underground lines are not popular and but little effort has been made to introduce tubular poles. The durability of the wooden pole might be greatly prolonged by painting or whitewashing, and by charring the base.

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climatic influences, creosoting does not preserve wood. The timber under the rail decays so that the duration of ties does not exceed ten years, except in the case of certain kinds of wood indigenous to that country. The difficulty of preserving wood in India has led to the extensive introduction of metal ties in that country.

Bridges of steel, iron and stone are rapidly replacing those of wood. However, wood will be used more or less, owing to its cheapness. In the construction of buildings, steel, brick and stone will be more and more generally used.

A large amount of wood is used in the construction of rolling stock. The tendency, however, is to substitute metal therefor. Cars constructed wholly of metal will ultimately be used.

Such are, briefly, the ways in which wood is used by railways, also some of the means suggested whereby its durability may be prolonged and its consumption reduced. The subject is one that invites the earnest attention of the owners and managers of railroads.

The following description by an English engineer of the creosoting process is interesting and instructive:

"Creosoting has both a chemical and a mechanical aspect. Chemically it may be looked upon as a process which renders wood fibre distasteful to fungoid growth or boring worms and insects, the material being fatal to such types of vitality. Mechanically, certain forms of creosote act like so much wax or paint, filling up the pores of the wood and thereby preventing the access of water or air. Clearly the mechanical effect can only endure while the creosote continues in the pores. When the mechanical process has been only half carried out the wood is protected upon its exterior surface and to a depth inward of half an inch and upward, according to the extent to which the process has been carried. The process of creosoting is one requiring care in the selection of a chemically proper creosote and in the mechanical process by which such creosote is put into the timber. . . . Timber can only be said to be properly treated when it is penetrated by the creosote to its very center. Where complete saturation has not been effected, it is only a matter of time for cracks to develop and fungi to grow upon the untreated portions thus exposed."*

Mr. H. W. Reed, in his interesting treatise on the maintenance of timber, thus discourses on wood preservatives:

"The destruction of timber by decay is ascribed by Liebig to 'eremacausis or a slow com-

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*In France "ties as delivered are piled and seasoned in the open air. They are then adzed and bored by a special machine, loaded on trucks and run into a drying oven, where they remain twenty-four hours or more. After drying at a temperature of about 176 degrees Fahr., they are run into a metal cylinder six feet three inches in diameter and thirty-six feet long, which is hermetically closed. The air is then exhausted and a partial vacuum is maintained for about half an hour. Communication is then opened with reservoirs of dead oil, which is allowed to flow in at a temperature of 176 degrees Fahr., under pressure. When the oil ceases to flow under moderate pressure it is forced in by a pump up to a pressure of eighty-three pounds per square inch, and this pressure is maintained for an hour or an hour and a quarter. Communication with the oil reservoirs is then opened again and the excess of oil not absorbed by the timber flows back into the reservoir. The cylinders hold one hundred and sixty-eight ties each. The quantity of oil absorbed is measured by determining the difference in volume of the oil before and after operation. The wood used is principally oak and beech. The oak ties absorb from 2.4 to 2.7 quarts per cubic foot; beech ties from 8.7 to 10 quarts per cubic foot. The whole operation takes about four hours."

bustion' by oxidation. Pasteur and Tyndall attribute it to the action of living germs in the atmosphere. The latter, in a series of experiments, found that on placing putrescible materials in a tube and excluding the air, which is laden with clouds of living germs or agents of decomposition, putrefaction ceased indefinitely or until the material was again exposed to the atmosphere. This is the generally accepted theory, and conforms very nearly to the results of modern observation. It has been determined by repeated experiments that a thorough preservative of timber must possess chemical antiseptics for the coagulation of albumen and power as an insecticide, and also the mechanical property of excluding the atmosphere by filling the pores and surrounding the fibres with a substance impenetrable by the atmosphere. The atmospheric germ theory seems to find additional support in the fact that timber constantly under water does not decay. Wood which is constantly dry decays slowly, due probably to the coagulation of the albumen. Timber thoroughly seasoned by heat decays less rapidly than if treated by any other mechanical means, because of the more thorough coagulation of the albumen. Timber subject to alternate dryness and moisture decays most rapidly, owing, doubtless, to the repeated softening of the albuminous substances of the timber, which renders it more certain of attacks by atmospheric germs.

Journal Bearing.

"There are four conditions under which timber is used which require different properties in the preservatives employed. They are:

"1. Submersion in water and subjection in sea water to attack of the *Teredo Navalis* and other sea worms.

"2. Exposure to alternate moisture and dryness.

"3. Exposure to the atmosphere only.

"4. Subjection to transverse strains.

"Of the many preservative agents employed, those of value may be resolved into two classes, viz.:

"1. Those derived from the distillation, at high temperature, of vegetable tars, albuminous and oily substances.

"2. Those having a mineral acid as a base.

"Under the first head we have creosote as the only known preservative capable of resisting for an indefinite time the attacks of the *Teredo*, destruction by atmospheric germs and leaving the structure of the timber in its normal condition. Creosoting is the only process known that meets all the requirements of a wood preservative, only one element, its expense, mitigating against it. The value of creosote is attributed by an eminent English authority, Samuel S. Boulton, to the presence of acridine ('an intensely acrid and pungent substance' and 'one of the alkaloids or bases' of creosote oil), and naphthaline, a substance less volatile than the tar acids; the latter is recognized in the thick yellow appearance given to the outside of creosoted timber, which afterward becomes darker by exposure to the atmosphere. These, Mr. Boulton, as well as other English scientists, agree are more powerful as permanent preservatives than the tar acids, which are more active at first in coagulating the albumen but exceedingly unstable, passing away in a comparatively short time. Acridine and naphthaline remain permanently, closing the approaches, both chemically and mechanically, against the attacks of atmospheric germs. These substances are among the residual products, after distillation, of coal tar at a temperature exceeding 450 degrees Fahr."

"Under the second head we have 'kyanizing,' 'burnettizing,' and the 'boucherie' process.

"The foregoing are the oldest methods and have shown the best results. Creosoting consists of the treatment of timber with dead oil or tar; kyanizing, with bichloride or mercury (corrosive sublimate); burnettizing, with chloride of zinc; and the boucherie process with sulphate of copper.

"Creosoting deals with the outer surface of the tie, charging the wood cells nearest the surface, varying from one-fourth to one-half inch in depth, according to the density of the wood, the bulk of the oil penetrating the ends of the ties, which prevents the further passage of water or air beyond the outer cells. It is also insoluble in water. The weak point of the creosote system for ties is, that this outer coating is broken by spiking, by rails cutting in, and by picks when drawing them into place in the track, so that the moisture has a free passage to the heart of the tie.

"Kyanizing, burnettizing and the boucherie processes consist in the use of mineral salts, which, being soluble in moisture or water, are practically useless for treating ties, unless the roadbed is ballasted with good clean material and properly drained. The track must also be in a favored location, where it will not be liable to be flooded.

"The boucherie process is also practically useless on account of the chemical action of the preservative on iron; because of this ties require to be coated with coal tar where the rails rest, and the spikes must be galvanized.

"Kyanizing, burnettizing and the boucherie processes harden the fibre of the wood, offering greater resistance to the cutting of the tie by the rail; for this reason better results are obtained from the treatment of soft wood than oak ties, the fibre of the oak being too dense to readily admit the antiseptic. These preservatives will, however, penetrate the wood more thoroughly than creosote.

In treating ties better results are obtained if, before creosoting, the ties are adzed and the spike holes bored, so as to allow those parts to be treated that are otherwise soonest liable to ferment and decay. Treated ties should be laid in the track with tie plates to prevent the rails cutting in and through the crust of the ties. A tie that costs 95 cents in the track and that will last without creosoting ten years will, when creosoted, last twenty years and cost $1.50 in the track. The saving effected will equal $17.60 per mile per year. A tie that costs 73 cents in the track and that will last without creosoting six years will, when creosoted, last eighteen years and cost $1.18 cents. The saving effected will equal $48.40 cents per mile per year. These figures will, of course, vary on different roads according to the cost of ties, labor and creosote, but they are sufficient to illustrate the substantial value of creosoting under the conditions named."

Processes for preserving wood are, under the most favorable circumstances, unsatisfactory. This is especially so in regard to ties. Because of this substitutes for the latter are sought. Attention is turned to steel and iron. Until recently their use has been merely experimental. Much misapprehension existed in regard to them. Greater familiarity will enlighten and clear away prejudices. In India and in several European countries metal ties are used almost entirely. Careful and painstaking experiments not only demonstrate their practicability, but their great superiority over wooden ties. Considering the relative durability of wooden and metal ties, and the expense attending the changing of ties in a track, metal is the cheaper of the two except in favored localities where suitable wood is plentiful and cheap. A metal tie, if properly laid, is more safe than one of wood because of its greater strength and durability; it affords an elastic and smooth track at once noiseless and durable.*

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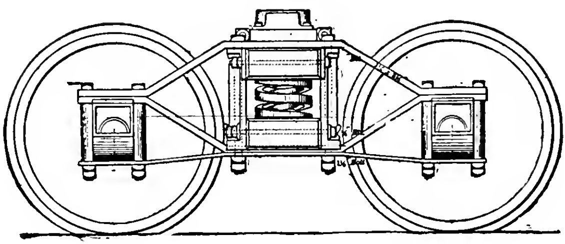
*The use of steel ties is now strongly advocated for tropical countries where the use of timber is open to many objections. In the official report on the projected Mombasa-Victoria Lake Railway, for opening up communication with the interior of Africa, it is recommended that general use be made of steel ties rather than creosoted fir or pingado wood for the following reasons: A permanent way of this construction is practically indestructible to natives with such few mechanical appliances as are to be met with in East Africa. The custom of firing the

The use of metal ties has advanced beyond the experimental stage. Among its advantages are reduction in cost of maintenance, less frequent renewals, and avoidance of the danger and expense thereof; also greater safety because of greater stability. The metal tie is the tie of the future. In order to be satisfactory it must be of sufficient weight to make a firm track, yet easy of manufacture and of reasonable cost. It must be convenient to handle and simple in construction; must be of a pattern adapted to the particular locality in which it is used; must be so made that it can be removed from or replaced in the track without interfering with traffic. It is desirable that it should be adopted for use in conjunction with wooden ties, so that a change from wood to iron may be made gradually. The fastenings must be simple and effective. Those patterns devised by experienced and practical men have hitherto been most successful. A trouble experienced in the use of metal ties arises from the wear of the holes for fastenings. Time will obviate this. The average duration of the metal tie depends upon several causes. It is, however, many times that of the wood tie. Moreover, at the expiration of its usefulness it has a value, the same as old rails. The wooden

grass at certain periods of the year, and the temptation to use the timber sleepers for fuel or hutting purposes, would expose a line laid with timber ties to many risks. White ants are numerous in the country and commit great ravages. The steel tie has also no tendency to float and be carried away by flood water, which is the case with timber.

tie when no longer fit for use is practically without value.

At first metal ties were made of iron; mild steel is, however, now generally used. The tensile strength depends upon the shape of the tie. No particular pattern has been universally recognized as the best. Ties made of mild steel have up to this time proven superior to all others. They are not easily broken, even when subjected to the shock of derailment. Danger of fracture, for a long time feared, has proven groundless.



Freight Truck.

In the construction of a metal tie it is usual to make it of uniform thickness throughout its length. A more economical distribution of the metal is, however, thought possible. In order to reduce the weight of the tie to the minimum the tendency is to decrease its dimensions. This must not, however, be carried too far, since it is evident that vibration and attendant noise will be less with a heavy than with a light tie. The weight of the tie must be such as to secure stability lest increased expense for maintenance and wear and tear of machinery be incurred. Moreover, if too light it can not withstand the concussions to which it is subjected, without breaking or distortion. The lightest metal tie found practicable under ordinary conditions of wear weighs about one hundred and fifteen pounds. When, however, a track is subjected to extraordinarily heavy traffic the weight must be increased. Experience shows that in ordinary gravel or dirt ballast there is very little corrosion. It occurs, however, with slag or cinder ballast, and in tunnels and damp places.* To prevent corrosion ties have been painted with a composition of oil and tar; generally, however, they are used as they come from the mill.

Much difficulty has been found in fastening the rail to the tie so as to hold the former securely, and prevent vibration, noise, wear and tear. The fewer the parts a track has, the more desirable, and the less the friction and expense for construction and maintenance. It is important, therefore, that whatever fastening is used it should not be complicated; it must be simple, easily understood and handled and such as to effectively hold the rail firm.

In order to deaden the noise, heavy paper soaked in tar, also asbestos sheets and tarred canvas, have been placed between the rail and the tie. Such devices are, however, unnecessary, if

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*This is owing to the effect upon the ties of the acids in the ballast and smoke.

the fastenings are properly secured. The fastenings should be made tight and kept so.

The first cost of the metal tie is estimated to be from one hundred and twenty-five to one hundred and fifty per cent. greater than wood. The cost will, however, exceed this until its use has become more general. The saving to be effected is in greater durability and saving in renewals. The cost of laying a metal tie is greater than laying one of wood, owing to difficulty of handling and the complications of the fastenings. This is more than offset, however, by the saving in renewels and maintenance and the value of the tie when no longer fit for use in the track. A metal track after it has become firmly settled is more stable than where wooden ties are used. Wherever metal is used it is the practice to use wooden ties at switches and frogs. There seems to be no good reason for this. The first cost of metal is greater, but if laid with proper fastenings and well surfaced, it is preferable here as elsewhere.

In connection with the use of metal ties wooden blocks have been placed under the rails to give increased elasticity to the track. It is unnecessary, however. If properly constructed the metal tie is elastic without extraneous aid.

Each year the discovery of a practicable substitute for wood in railway construction and maintenance grows more and more imperative; each year timber becomes more and more rare. It is found necessary to haul it greater distances. It is more and more costly. The danger to the country its use involves is more and more imminent. Anything, therefore, that promises relief, invites attention and interest, is worthy of the closest regard. In this connection the investigations of the United States government regarding the preservation of wood and the substitution of metal for it wherever possible, especially for railroad ties, are both interesting and valuable. I can not do better than close what I have to say on the subject here with a resumé of its labors.*

Mr. B. E. Fernow, chief of the department of forestry, places the present consumption of ties for construction and renewal in the United States at seventy-three millions a year. Railways are further consumers of wood for fences, telegraph poles, bridges, culverts, trestles, buildings, platforms, and for fuel. He points out that not only the different species of wood in practical use "show varying durability, that is, resistance to decay, but the same species exhibits variation according to the locality where it is grown, and the part of the tree from which the wood is taken, and even its age seems to influence durability." Young wood, it is observed, is more susceptible of decay than old wood; sap wood is less durable than the heart. "The idea that young wood is more durable because it is young, which seems to prevail among railway managers, must be considered erroneous. On the contrary, young wood, which contains a large amount of albuminates, the food of fungi, is more apt to decay, other things being equal, than the wood of older timber. Sound, mature, well grown trees yield more durable timber than either young or very old trees. Rapid growth, exhibited in broad annual rings and due to favorable soil and light conditions, yields the most durable timber in hard woods, and only as far as the growth in the virgin forest has

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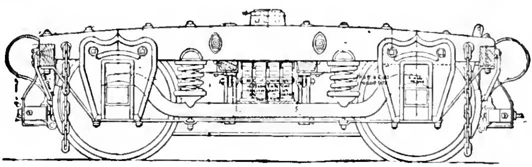
* "Practical economies in the use of wood for railway purposes and the substitution of metal for wood in railway ties."—*Report of the United States Department of Agriculture, 1890.*

been slow ought there be a difference in favor of second growth timber. In conifers, however, slow growth with narrow rings, which contain more of the dense summer wood in a given space, yields the better timber." In piling ties he recommends that they should be placed in squares, with not over fifty ties in a pile, "in such a manner that one tier shall contain six to nine ties, separated from each other by a space equal to about the width of the tie; the next tier to consist of one tie placed crosswise at each end of the first tier. The bottom tier should consist of two ties, or better, poles, to raise the pile from the ground. The piles should be five feet apart. The piling ground should be somewhere in the woods, or at least away from the sun, wind or rain, so as to secure a slow and uniform seasoning;

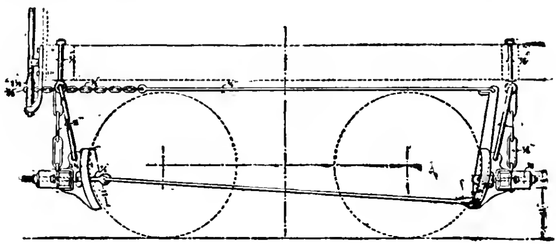


Passenger Truck.

if dried too rapidly, the wood warps and splits, the cracks collect water, and the timber is then easily attacked and destroyed by rot." He points out that "the best method of obtaining proper seasoning, in a shorter time, without costly apparatus, is to immerse the prepared timber in water from one to three weeks, in order to dissolve and leach out the fermentable matter nearest the surface. This is best done in running water—if such is not at hand, a tank may be substituted, the water of which needs, however, frequent change. Timber so treated, like raft timber, will season more quickly and is known to be more durable. The application of boiling water or steam is advantageous in leaching out the sap." Referring to the decay of railway ties, he ascribes the lack of durability to two causes, "namely, a mechanical one, the breaking of the wood fibre by the flange of the rail and by the spikes, and a chemical or physiological one, the rot or decay which is due to fungus growth. These causes work either in combination or, more rarely, independently."

The cutting of the wood may be prevented by the use of tie plates. The damage caused by the spikes may be lessened as pointed out elsewhere. In reference to drainage he suggests that "rock ballast is best drained, and hence the best record comes from such roadbeds: gravel is next best and clay or loam is about the worst. On the other hand, where soft wood ties, like chestnut, are used, the hard rock ballast, while unfavorable to decay, reduces their life by pounding and cutting. Sand ballast seems to vary considerably; a sharp, coarse silicious (not calcerous) sand with good under drainage should be next to gravel, while some reports give a heavy black soil and loam as better than sand. The reason why sand, although offering good drainage, is favorable to decay, may be sought in its great capacity for heat, which induces fermentation." Referring to wood preservatives, Mr. Fernow says in France wooden ties are universally subjected to preservatives; that similar practices are quite general in England and throughout Europe, caused by the scarcity of wood and its great cost. He ascribes lack of interest in the subject in the United States to ignorance, to unwise economy, to cheapness of wooden ties, and to the fact that the flange cutting of the rail is even more destructive than decay. He recommends the use of tie plates in order to prevent this. The cutting of the tie not only disturbs the poise of the track, but serves as a cup in which to collect dampness, thereby superinducing decay. There are many different patterns for these plates. A rail chair is used in England. A hard wood plate let into the tie is also in use. A plate of felt a quarter of an inch thick placed between the rail and the tie has been used satisfactorily in France. Lead sunk into the wood has also been used as a plate. Where plates are used there is practically no wear to the tie. Their effect is to secure a "more even distribution of rail pressure over a greater area of the tie; retardation of the mechanical destruction of the tie by cutting; avoidance of danger of tilting of rails; prevention of the lateral bending of spikes or screws thus loosening the rail; the increased resistance of screws and spikes against lateral motion or the spreading of the rails." The pattern of plate must be such as to secure these results most effectively.

The use of tie plates with preserving processes makes a wooden tie almost as satisfactory as a metal one as far as durability and safety are concerned. They also greatly extend the durability of ties of soft wood. Mr. Fernow does not endorse any particular preserving process. He thinks, however, that if what is known as vulcanizing (*i. e.*, subjecting unseasoned wood to a hot, dry air under great pressure) accomplishes what is claimed for it, it promises exceedingly favorable results. The cost of this process is said to not exceed three cents per tie. Its advantages are "that unseasoned timber is preferably used; that the fibre of the wood is not weakened by the process; that the timber may be worked after treatment without exposing any untreated parts, as the wood seems to be permeated through and through; that the timber is unaffected by atmospheric changes, being thoroughly seasoned by the process." Mr. Fernow, concurring with practical railway men in such matters, very wisely points out that the first cost of material is frequently not the most important factor; that it is oftentimes overshadowed by the question of maintenance and renewal; by perfection of roadway and appliances; the safety and comfort of travelers. He therefore



Brake.

recommends the use of preservatives where wood is employed and the adoption of such other devices as are calculated to lessen the consumption of timber.*

As a means of lessening the consumption of timber Mr. E. E. R. Tratman, an engineer of the United States government, has made most extended and careful enquiries in regard to the use of metal for ties. He obtained his information directly from official sources. It is, therefore, reliable. His enquiries covered two years' work, besides much preparatory labor. They are, consequently, exhaustive. He finds that the condition of a road, its traffic and rolling stock must be considered in using metal ties. His investigations cover twenty-five thousand miles of rail-

*He states that the consumption of lumber in the United States amounts annually to 681,000,000 feet.

road laid with such ties. He finds that the use of metal ties has long passed the merely experimental stage; that their practicability and value have been measurably well established. He observes a growing interest and knowledge of the subject in the United States. He believes their introduction and use here will cheapen maintenance and heighten efficiency. He finds from the result of his enquiries that mild steel is best adapted for manufacture of metal ties; that reduction in the depth of such ties saves materially in ballast over a wooden tie; that the pattern up to this time most generally satisfactory is that invented and improved by Mr. Post, the engineer of permanent way for The Netherlands state railways, — however, the developments of a day may change this; that in regard to the use of metal ties their efficiency is greatly enhanced, as in other departments of railway work, by intelligence and efficient handling.

Metal ties have not been generally introduced in England, though experiments have been made with them by all the principal roads. These experiments are generally satisfactory and promise to lead to important results.

The railways of France have not definitely adopted the metal tie, but are experimenting with a view to its adaptability and the discovery of a suitable pattern. M. Vautherin, a French engineer, has up to this time designed what is considered to be, all in all, the most desirable form. The use of preservatives in France has made substitutes for timber less necessary than they otherwise would be. They find that when a metal tie is used, tie plates are not necessary. French railways use the suspended joint, spliced by fish plates and four bolts. On the outside the ballast is brought up even with the rail head; on the inside, even with the bottom of the rail. No breakage has occurred in connection with the use of metal ties, nor have difficulties arisen with the fastenings. Their use is thought to lessen cost of maintenance and to increase the solidity, smoothness and safety of the track. Atmospheric agencies do not appear to affect the ties which are laid without any coating or other preparatory measures. When laid in tunnels or low places, however, or in ballast containing sulphurous material, it is noticed that they corrode more or less.

In Holland most of the railroads are using metal ties, and have been doing so for several years, notwithstanding the plentifulness and cheapness of suitable wood. Altogether the greatest intelligence and interest seem to have been observed in that country in connection with the use of metal ties. The results have been entirely satisfactory from every point of view. Of one hundred and twenty-four thousand metal ties laid since 1880, not one has had to be removed. Ties of this pattern, after being in use upon a particular road for twenty-five years with a service of sixteen trains per day, are found to be substantially as good as new. They find that the metal track is safe, elastic and agreeable for travelers. Its use is growing and promises to wholly supersede every other form.

In Belgium the metal tie was originally introduced through pressure brought to bear by labor agitators and unions, and was ill considered before its adoption and hastily and imperfectly tried. Because of this its use was not generally satisfactory. Later enquiry and observation, however, have induced the government to take up the subject again more deliberately.

The growing use of metal ties in Germany evinces their popularity. It is found there, as elsewhere, that great improvements can be made in the original device. The early forms introduced were too weak for present conditions of traffic. Longitudinal ties are quite extensively used in that country, but are being abandoned because of added cost of maintenance and the difficulty of properly draining the track.* The minimum of durability of metal ties is placed at forty years; it may be extended to seventy. Information on the subject there, as elsewhere, is exceedingly meagre. Mistaken economy and a desire to encourage forest industries have retarded the introduction of metal ties in Germany. Lumber used for the purpose is very generally subjected to preservative processes. Tie plates are also very generally used. The growing use of metal ties, and the fact that the government places them on its railways at switches and frogs, evince appreciation and value.

Austria and Hungary, the most favored of all countries as regards abundant, suitable and cheap timber, while making careful and protracted experiments upon metal ties, have not generally adopted them up to this time. They are, however, used upon one hundred and twenty-two miles of track. They are laid in both longitudinal and cross sections. Metal tie plates are

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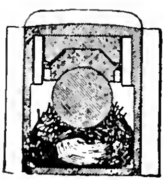
* The use of cross ties is not by any means universal. Longitudinal ties are also sometimes used. Upon many roads a cast iron or steel bowl or plate is used in lieu of a tie, being connected by cross rods or tie bars.

very generally employed when wooden ties are used. They are not, however, used on every tie, except at sharp curves. The spike passes through the plate and holds both the rail and the plate.

Metal ties are in very general use in Switzerland and are in high favor. "They have been given a thorough trial with eminently satisfactory results. Some of the railways have now definitely adopted them. At present they are used mainly on lines having the heaviest traffic; on these lines the metal ties give greater security than wooden ties, if of sufficient weight, have well proportioned dimensions, and the right means of attachment are employed."

The growing scarcity of wood in Spain, Portugal and Italy, and the probability of still greater scarcity in the future, have induced those interested in such matters to give attention to suggested substitutes therefor, and, while no general attempt has been made to introduce metal ties, careful experiment is being made with them. There is no prejudice against them, and the investigations, so far as they have been carried on, are satisfactory. But so long as wood ties are cheaper they find favor even where the ultimate cost, taking into account maintenance and renewals, is greater. However, this is probably the case to a greater or less extent in every other country.

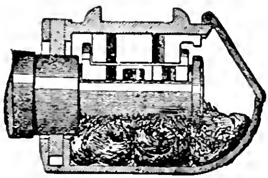


Lubricating Device.

In conclusion it may be said that in every country of Europe, indeed, in every country of the world, experiments more or less careful and full are being made with metal ties. Out of this will grow practical forms and efficient methods. Care should be taken by railways to collect and preserve the records of these experiments.

From his investigations Mr. Fernow concludes that the use of a metal tie under different conditions has conclusively demonstrated the fact of its practicability as a substitute for wood. Its advantages are economy, efficiency and safety. He thinks that the experimental stage has been passed as shown by the extent to which it is used and its steadily increasing introduction, and that it remains for us to profit by the experience already on record, making use of the improvements, modifications and warnings suggested by actual practice elsewhere. The main advantages presented by a good system of metal track he sums up as follows: "Reduced expenses for maintenance and renewals, owing to the solid construction and the greater durability of the parts; a better class of track, owing to improved fastenings, etc., and the fact that the roadbed is not torn up (as with wooden ties) for frequent renewals, so that it gives the best road with the least amount of work for maintenance; increased safety for traffic, owing to the superiority of the fastenings over those used with wooden ties."

The conclusion of men who have given this subject most study* is that if in comparing the cost of different systems of track account is taken of every expense, namely, first cost, transportation, handling, laying, maintaining, renewing, interest, and the value of the old material, there are few countries or railroads where the exclusive use of wood for ties is the cheapest. Mr. Fernow, who possesses great skill and experience as an



Lubricating Device.

engineer, sums up the results of his observations and enquiries in regard to the requirements of a successful metal tie as follows, namely: That it shall be "heavy enough to hold the rails down well and make a firm track; light enough to be of reasonable cost; metal enough to stand wear and tear and give ample strength; easy of manufacture, and requiring a minimum of shop work; not liable to lateral motion in the ballast; easy to be laid, removed, or ballasted; fastenings simple and efficient, with as few parts as possible, capable of adjustment for widening the gauge at curves, etc.; price such as to enable an actual ultimate economy to be shown; proper quality of metal to sustain shocks without injury; elasticity enough to give an easy riding track."

The value and character of the metal tie has been discussed frequently and exhaustively at the various congresses of rail-

*Notably Mr. Post of The Netherlands railways.

ways held in Europe during the last twenty years. The conclusions of the congress held in Paris in 1889 were that, while metal ties present many favorable and advantageous points, the experience with them has not been sufficient to justify any final decision in their favor against wooden ties. It recommends that each management should select two trial sections, laying one with metal ties and the other with wooden ties; both sections to have as nearly as possible the same conditions of grade, alignment, roadbed, ballast and traffic; that the trials should last long enough to enable definite conclusions to be arrived at; that the special points to be considered should be: first cost; cost of maintenance; cost of renewals; approximate life of ties; effect on the rails; best types or forms of ties, and general cost, taking renewals into account.*

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* In another chapter will be found illustrations of the various kinds of metal ties used in different countries.

Carriage in Western Africa.

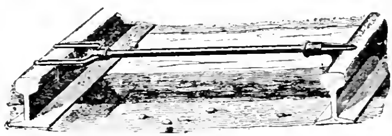
CHAPTER XXIV.

MAINTENANCE—THE CONSTRUCTION, MAINTENANCE AND CARE OF A ROADWAY AND TRACK.

(NOTE—An effective and thorough system of track accounts is necessary to a proper understanding of track maintenance and its due and economical enforcement. Such a system will be found in the volume "Fiscal Affairs, Disbursements.")

As this is the salient feature of a railway, it naturally excites greater interest and speculation among managers than any other part of the property. Upon it our lives depend and the safety of our property. Other structures connected with a railway are the work of architects, machinists, plumbers, carpenters and kindred accessories. We use the same agents in building and repairing our houses. We possess more or less practical knowledge of their methods. The track of a railway, on the other hand, it a thing apart, new, special, unknown.

A good track is commonly an indication of a solvent company, a wise manager, a skillful staff, careful and trustworthy employes. Much might be written about it of a theoretical nature. The subject is such as to excite the imagination and fancy. I prefer, however, to lay before my reader only that which will prove of practical use. I have given the subject considerable attention myself, but feel I can not say anything so good or so pertinent as those practically familiar with the subject. I beg the reader's indulgence, therefore, if, instead of attempting to write something original, I venture to avail myself of what has been well written by those wise in such matters. Under an invitation from an association interested in railway track matters, Mr. Andrew Morrison and Mr. H. W. Reed addressed themselves especially to the subject. Their work deserved the praise it received for fullness and versatile knowledge. There is no



Track Gauge.

danger of what they say growing old or becoming obsolete in railway use, except possibly in minor practices of a local nature. Their articles supplement each other, and together form a complete picture of track life—its wants, necessities and vicissitudes.

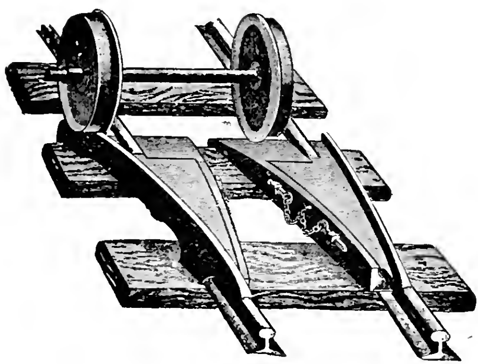
Mr. Reed, whose comprehensive knowledge and infinite grasp of detail evince his talent and wide experience, takes up the subject at the point where the roadbed is ready for laying the ties and rails. He assumes that the contractors have finished the work of grading; that the culverts and bridges have been constructed; that the ties have been bought and are piled at convenient places along the road, that their surfaces have so far as possible been prepared ready for the rail, and that they have been seasoned for at least one year; that the timber for switches is conveniently placed and similarly seasoned; that the rails and splices are ready for delivery as required. Here he takes up the subject, in substance, as follows:

There will, it is probable, be several places at which it may be possible to commence laying track. The first thing to be done is to organize one or more gangs of tracklayers; also a construction train for each gang, and surfacers for each gang. It will usually be necessary to prepare the roadbed for the track before putting these gangs to work. This preparatory work is commonly known as

TRIMMING.—This is work which contractors are very likely to do imperfectly or neglect entirely. Thus a most important part of their work is left for the track department to do, if a company is desirous of having good track so as to save expense in later years. The roadbed in cuts should be prepared with great care, especially in regard to drainage. The center of the bed should be eight inches higher than the ditches for single track, and eleven inches higher for double track. The roadbed for double track should have its summit of drainage at the center of each track. This provides efficient drainage between these points but not for the space between the track centres. This is why longitudinal drains with cross branches to the ditches are often necessary to drain the inner two halves of the track. The roadbed for double track should slope from the summit of drainage, at the rate of one-half inch to the foot, until it reaches the extreme outer ends of the ties, from which it should slope to form the ditch, six inches below this point; the bottom of the ditch should be six and a half or seven feet distant from the near rail of each track. Single track should be in proportion. All holes should be filled solid uniform with the surface of the bed. When this is completed gangs can be put to work.

CONSTRUCTION TRAIN.—The number of construction trainmen and foremen will depend upon circumstances. It is their duty to load and unload material. Work can be economized by using as few engines as possible. One engine can be made to do the work of two by placing the cars for loading and unloading material while it attends to other work. If, however, the haul is too great to admit of this, an extra engine is necessary.

TRACK LAYING.—A track laying gang should consist of as many men as can be worked conveniently. Small gangs can be worked more economically than large ones. The best men should be kept at the front. If one man in each sub-gang is paid five or ten cents a day more than the others (but known only to those who receive it) he will encourage his fellows to greater exertion than a foreman can. The foreman of a track laying gang should be smart and ingenious. The following is about the force required to lay the track of a new road under normal conditions: nine men to load construction material on the truck, eight men to unload the truck, one man with a horse to haul material, four men to lay out rope for lining and spacing ties, six men to put on splices, and a proper number of spikers. A track laying gang will lay on an average one mile in two days. Sometimes less, sometimes more. Portable turntables are used for the convenience of loaders and unloaders. When a truck is unloaded, and the horse has hauled back the empty truck, the driver will put the turntable on the track and haul the empty truck off on two cross ties; he will then hitch on to the loaded truck and haul ahead to be in turn unloaded; the loaders will then run the returned empty truck back to its position for reloading. Should the unloaders have their truck unloaded before the driver arrives with the next load, they will put the turntable on the track and run it off when the next loaded truck is hauled to position. Should the driver reach the unloaders before their truck is empty, it will be his duty to place the turntable. The object to be kept in view is the keeping of unloaders constantly supplied with material. An ordinary truck load is six rails and sufficient cross ties to lay that number of rails, with a supply of splices, bolts, nut locks and spikes. It is better and cheaper to lay ties complete than to lay them for joints and quarters only, allowing the intermediate ties to be unloaded afterward and pulled beneath the rails. It requires the track to be raised in order to accomplish this, and it is injurious to the rails and roadbed to run a train on such a track. As fast as the ties are laid sufficient for each half rail length, the rail is laid down, partly spliced and spiked, and the truck then moved ahead. The splicers and spikers do the principal part of their work behind the truck. The spacers will locate the places for the joint ties, using a pole of the proper length and laying the rails with broken joint. On curves the rope is first laid in position the same distance from engineers' stakes as on tangents; then put to curve by measuring off the middle and intermediate ordinates from the straight line first given by the rope. The rope is placed on the proper side for lining ties, namely, on tangents of double track, the right hand side in the direction the trains run: and on the inner side of curves. The splicers will space the rails by tightening up the rear bolt and then



Replacer.

inserting the round end of their wrench in the forward hole of the splice and rail, which will give sufficient leverage to move the rail. They should be provided with a suitable rail spacer. When they have adjusted the joint and bolted it up, the spiking may be done.

Gauging and Spiking.—Joints and centers should be gauged and spiked first, so as to bring the rails to their proper position on the ties. This facilitates intermediate spiking. Each tie should be gauged as it is spiked. Curves of three degrees and over should have their gauge widened, so that the longest rigid wheel based engine can pass around the curve without crowding or spreading the track; this will vary from one-eighth of an inch on a three degree curve to one and one-fourth inches on a twenty degree curve. The widening of the gauge should begin back on the tangent and be full gauge at the beginning of the curve and continue all the way round to the beginning of the tangent, being then run off on the tangent as before. Slot holes in flanges of splices should be spiked to prevent creeping of track. All spikes should be driven plumb and snug to the rail; they should not be struck laterally, as they are thereby bent and consequently fit improperly against the rail. Striking the rail should be prohibited; it is the result of carelessness and is injurious to the rail. A fracture on the base of a rail, caused by striking, is liable to result in a broken rail. This is due to the fact that in the manufacture of **T** rails the base cools faster than the head, and as the head contracts in cooling the base is forced to form the outer ring of a circle; to overcome this tendency it is curved in the opposite direction when red hot—hence the strain on the base when cooled.

LAYING TIES.—Those who unload the ties should select those for joints; the latter should be as near a ten inch face as possible, not over that width. No intermediate tie should have a face of less than seven inches. Ties should be spaced with a maximum distance of fourteen inches and a minimum distance of twelve inches between them. The butt end of the tie should be placed on she inside of curves.

SPECIFICATIONS FOR CROSS TIES.—Hewed ties require to be adzed level for the rails, and scribed for the outer side of rail bases. This facilitates track laying. The end which is to be placed on the lining side of the track should be indicated by adzing off a small corner, care being taken to select the butt end of the ties for the lining of curves and to pile them separately. Ties should be of young and thrifty timber (usually the second growth) which possesses the greatest toughness and elasticity. Trees should be felled during the winter months when the sap is down. Ties thus made are less liable to immediate attacks of fungi. The bark should be removed from all such trees to facilitate the seasoning of the wood and prevent the bad effect of bark upon ties when in the track.

TIES FOR TRACK.—Ties for main track curves should be of the highest grade. Those for tangents may be of the second order. No tie with a face less than seven inches, or more than ten, should be used in the main track. Ties should be of a uniform thickness of seven inches. They should approximate in length double the gauge, so that the rail may be equally distant from the end and center of the tie. This will greatly obviate the track becoming center bound and secure greater bearing surface on the roadbed. Ties should be spaced so that the maximum distance from face to face will be fourteen and the minimum twelve inches. The object sought is to distribute the weight of trains uniformly on the roadbed. Ties which are furthest apart have the greatest weight to sustain, and will be the first to show a weak point in the surface. Second-class or "cull" ties may be used in sidings and yard tracks. Hard wood should be used on curves. Soft wood may be used on tangents. Ties when received should be piled so as to allow free circulation of air around each tie and shed as much water as possible. Two old ties should be used as a foundation for each pile. The only ties that seem to meet the requirements of main track use are white or rock oak, chestnut and yellow pine. Oak ties should be used exclusively on curves and other kinds on tangents only. It is better, however, to use oak in tangents, instead of soft wood ties, as the spike has greater adhesion in an oak tie. Chestnut or yellow pine ties are altogether too soft to use on curves.

TIE PLATES.—By using tie plates on chestnut and yellow pine ties, they can be made to take the place of oak ties on curves. The plates must be of sufficient strength to overcome the turning up tendency they possess. They increase the lateral resistance of the spike. It is a question whether it will pay to use tie plates on tangents, as the tendency of the rails to cut into the ties is slight in comparison with that on curves. As soon as a low place is found on a curve, it should be tamped to surface; such places on tangents may usually remain till it is convenient to repair them. Tie plates used on tangents are liable to rattle and are in the way when blocking or shimming is to be done. Track on tangents is apt to heave more than on curves, because the latter are dug out and usually well drained and ballasted, whereas on tangents this work is not so necessary for safe and fast running.

DAMAGE TO CROSS TIES BY SPIKING.—Experiments show that driving the spike, without previously boring for the same, lessens the adhesion of the spike and injures the wood. When a spike is so driven in an oak tie, the woody fibres are driven downward with the spike, extending around the same for about half an inch, and inclining, on an average, at an angle of about forty-five degrees. By removing the spike and splitting the tie through the spike hole, it will be found that the fibres have sprung back until the hole is nearly half closed; they will also be found to be perfectly pliable, having lost almost all power of adhesion; they are thus in good condition to receive moisture, which engenders decay. To obviate this, a hole, one-sixteenth of an inch less in diameter than the thickness of the spike, should be bored the full depth that the spike will be driven in the wood. This prevents injury to the fibres and increases adhesion, which latter is the principal point gained by boring holes. A spike with a diamond point will give better satisfaction than the ordinary chisel pointed spike. The ordinary spike, on account of its sharp edges, has a tendency to drift from the direction of the hole. The diamond pointed spike will go straight home. The spike should have a short point commencing half an inch from the end and tapering uniformly on its four sides. The holes should be made in ties before they are put in track.

Track Jack.

INSPECTING RAILS.—Rails should be inspected with a view to their composition, length, flaws, line and surface. Each end of the rail should be filed underneath the head and top base to remove projecting sharp edges caused by sawing and allow the splices to fit snugly.

CURVING RAILS.—Rails for curves of over five degrees should be curved with a rail bender, but an allowance of curvature equal to that due to a curve of five degrees should be made to allow the lining of track to spring the rails that amount. This amount of spring in the rails is not injurious and will take out kinks made in curving. A kinked rail in a curve soon forces the track into the natural position of the rail resulting in a bad riding track and contional expense, as rails frequently require to be removed from this cause. The rail bender, while the best means of curving rails at present, is imperfect because the curving is a series of small bends, while it should be a perfect curve. The simplest manner of testing the curving of rails is to stretch a string from one end to the other of the rail and mark the rail off into quarters; from the string to the rail at the center mark will be the middle ordinate and at the quarter marks the intermediate ordinates, these ordinates being calculated according to the degree of curve.*

Splices.—Splices should be carefully inspected as to quality of material and make, care being taken to reject all that are bent or twisted in any manner. Only straight splices should be used. A splice bent laterally will prevent the track from lining, and bent vertically will prevent the joint from surfacing and be liable to break. Turned up corners on the ends of splice bearings should be filed level with the surface.

Supported and Suspended Joints.—This subject can not be given the consideration it deserves here. Suffice it to say that the mitre jointed rail, where used, has all but settled the controversy. The square jointed rail leaves more or less of an opening for wheels to fall into; in time this depression becomes greater by the rail ends flattening and the joints becoming low so that the break in the line of rail offers an opportunity for each wheel to strike a blow proportionate to the opening weight exerted and speed of travel. The mitre jointed rail practically overcomes this blow; with its use the splice acts as its name suggests and makes the joint as strong as the unbroken part of the rail while furnishing slot holes to enable the track to be spiked without injuring the base of the rail by punching slot holes. The splice should have sufficient bolts to overcome the tendency of rails to pass each other and form a lip. It is claimed by some that the supported splice joint has all these requirements and, in preference to the suspended joint, allows of an additional tie under the rail ends or center of splice, thereby securing the aid of this tie to act in resistance to the rail's running as well as furnishing greater bearing surface at this weak point of the rail. But there are objections to these points, namely, the punching of slot holes so near the center of the spice renders the splice liable to break at its weakest point, and, in the case of square cut rails, the placing of a tie underneath the rail ends prevents to a certain extent the free, elastic action

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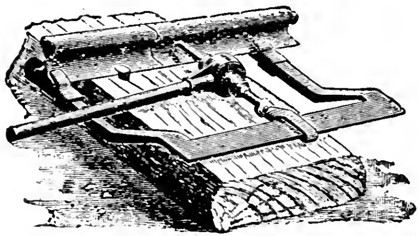
* One of the simplest methods of calculating the middle ordinate is to square half the length of the rail and divide the result by twice the radius of the curve, thus: Mid. ord. $\frac{(\frac{1}{2}\text{Ch.})^2}{2\text{ R}}$ The intermediate ordinate is three-fourths of the middle ordinate.

of the splice, thereby increasing the blow and weight to be sustained at that point. Further, this center tie can not remain at good surface, as it receives the blows exerted by the wheels directly and must necessarily soon get low. When the tie becomes below surface, it ceases to be a support and acts as a suspended joint. The same is true of the mitre jointed rail, though to a less extent.

RAISING TRACK.—The gang for surfacing will vary in number according to the kind of ballast used. Track should be raised to grade in two lifts, tamping with shovels only. In surfacing track, both rails should be raised and tamped at the same time to obviate unevenness.

TAMPING TRACK WITH BARS.—This work should be done several days after surfacing, so as to allow the track to be partially consolidated.



Track Drill.

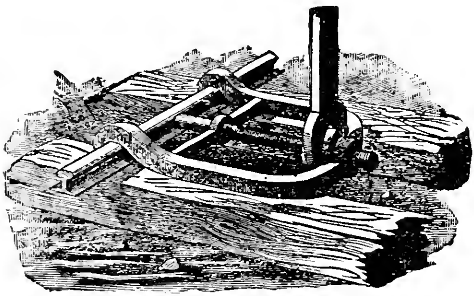
When square cut rails are used, the inside and outside of the joint ties should be well tamped and surfaced slightly high; the outside of the intermediate ties should be well tamped and the inside lightly a distance of twelve inches from the rail. Ballast should be simply packed around the center of ties so as to prevent the track becoming center bound.

CENTER BOUND TRACK.—This is due to settling of the ends of ties caused by their elasticity and the unevenly distributed weight passing over them; this weight is more on the ends of the ties than the centers. The track thus becomes more solid at the center than at the ends. Center bound track shows itself by the oozing of mud or water from the ends of the ties in wet weather and the rising of dust in dry weather. Sometimes a track becomes so center bound that the ends of the ties will depress from two to three inches. This is a drag on motive power, destructive to machinery and expensive in every way. Each depression forms a grade to be overcome. Time spent in repairing such a track is useless. It must be raised from its old bed.

LINING TRACK.—This is very important. All curves should have spiral ends to allow trains to enter and leave them gradually and also allow a proper elevation, since the elevation should increase with the spiral. Curves on new roads should be laid out with spiral ends because it entails enormous expense to relieve old track in this manner, requiring the purchase of additional right of way, cuts and fills, and the building of new bridges, etc. The great defect of the trackman in correcting engineer's stakes by throwing in the points of curves is, that while he lightens the curve points he increases the curvature further in on the curve, thereby transferring the swing of the cars towards the center of the curve; but as the greatest centrifugal force to overcome is at the point of curve, he has removed the objectionable lining to a point requiring less lateral resistance, which is, however, a move in the right direction. A good practice in correcting engineer's stakes when dealing with old track, or even new track, is to examine the nearer obstructions along the inside of the curve and determine how far it can be thrown towards its center without interference with such obstructions; then set stakes—or measure the required distance from the engineer's stakes (if such have been given)—the distance it can be moved; throw the track to these stakes all around the curve, except the last hundred feet or so (according to the distance thrown), and line with the eye the ends of the curve so as to run out on the tangent about the same distance from the point of curve as the point first started to line from is ahead of the original point of curve. This is simply throwing the curve points out instead of in, thereby lightening instead of increasing them. The lining up of a curve should be done by sighting on the outer rail; better work can be done by bending down to bring the eye near to the rail than by standing. This is more necessary on curves than on tangents, because it is necessary to be nearer the bars on the former than on the latter. Curves on old tracks should be lined with a sixty-two feet line, first obtaining the average ordinate by trying each joint around the curve, then going around again and taking out all its irregularities; this is the only true and easy manner of testing curves, as the eye is deceiving in lining as well as in leveling. A sixty-two feet line should be used because with a curve of that length each inch of the middle ordinate represents that number of degrees of the curve. Stakes should be set for all tangents as it is impossible to get them correct otherwise.

Elevation of Curves.—The outer rail of curves should be elevated according to the degree of curve and the speed of traffic, taking the slow trains, however, also into consideration, as well as the grade of track, as grade and curvature usually determine speed. The outer rail at point of curves should have the full elevation carried back on the tangents at about the rate of fifty feet per degree of curve (if the tangent is sufficiently long for the purpose), and should decrease at this rate for curves beyond six degrees. It often occurs that the engineer has left tangents of one hundred or one hundred and fifty feet between the points of curves as a matter of economy in construction, and as for a length of a passenger car at least the track should be level between the two elevations of outer rails, the trackman discovers that he will require to make the elevation very suddenly, and can only give half the required elevation at the point of curve instead of full—shortening the run off on the tangent in consequence. Should such a case occur on double track, the elevation on the run off end should be reduced considerably further back on the curve, thereby terminating its elevation nearer to its point; this will allow more room for the elevation to enter the next curve on the run on end, which is vastly more important. Should the two curves be in the same direction, it is good practice to carry a certain amount of the elevation throughout the entire tangent intervening, as in such case it will not be necessary to leave any level space on the same for the cars to partially gain their equilibrium. No fixed proportion for the elevation of curves can be given, as the lighter curves require much more elevation per degree of curvature than the heavier curves without detriment to slow trains. The elevation for light curves can be calculated so that the fast trains will have their centrifugal force equalized, but nothing more. The elevation on heavy curves should be such that the outer rail will not require bracing to prevent its spreading; the inner rail, in lieu thereof, should be braced to prevent its spreading and turning. There should, however, be a brace put on the outer rail opposite the inside braces to prevent the tie pulling through, as the spike will be insufficient to prevent it from doing so. A good manner of determining the proper elevation for fast trains, and what will be safe for slow trains, is when the passenger car will ride perfectly level; should the outer side ride above this level, the elevation is too great; if below this level, it is too small.

BROKEN *vs.* EVEN JOINTS.—Broken joints are the custom upon some of our best roads having tracks ballasted with broken stone, gravel, slag and anthracite engine cinder. Even joints are the custom on some roads where the different kinds of material the road passes through govern the kind and quantity of ballast. Hence roads having poor ballast are laid with the joints even, and those having good ballast are laid with the joints broken. It is self evident that the softer the ballast the quicker the joints will become depressed, and the opposite is



Track Drill.

true the harder the material. We might, therefore, assume that low joints are in proportion to the quality of the ballast, other things being equal. When a wagon crosses a ditch at right angles so that each pair of wheels will descend at the same time, the jar is lighter than if the wagon crosses so that one wheel descends before the other. As a wagon goes along an ordinary road with slight depressions, the jars are so slight that they are, practically, of no consequence. This is true of rolling stock on the track. Broken joints are less likely to depress, since the ballast is superior, the depressions not being of such consequence as to require special adjustment, whereas the opposite is true of even joints. Even joints would answer the same purpose on good ballast, if it were possible to lay them perfectly even, which it is not. Again, on curves it is out of the question to have even joints, as the outer rail is continually falling behind the inner rail. Therefore, since even jointed rails are practically impossible, it is preferable to have the joints in one rail come as nearly opposite the center of the other as possible.

BALLAST.—Ballast usually consists of broken stone, slag, gravel or anthracite engine cinder. Each has its peculiar qualities. The extremes are broken stone and cinder; the mean, slag and gravel.

Broken stone is superior to any other ballast for cleanness, durability and absence from dust; for drainage and distributing the weight over the entire roadbed; also for use on grades to prevent the track from creeping. It should be placed twelve inches deep below the bottom of the ties and well filled in between them. It is, however, the most expensive ballast to prepare and also to deal with in the track. Section men will perform twice as much work in cinder ballast as in stone. With stone ballast it is difficult to obtain a good surface. It is not the best preventive of track heaving from frost. Where the roadbed is of a muddy nature the soil will ooze up through the stone, unless the ballast is deepened to prevent it. It is also destructive to soft wood ties, their lower corners being rounded by the sharp edges of the stone when tamping, and the tie greatly damaged by the stones cutting into the wood.

Slag is a good ballast. When the rougher slag is selected for ballasting underneath the ties, and the finer from that point up to the surface, it may be said to possess all the good qualities of broken stone and cinder, excepting the lasting qualities of the former.

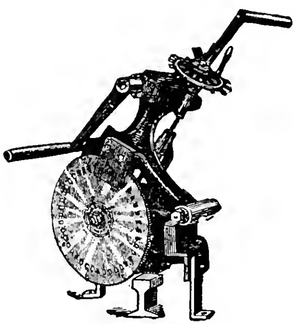
Gravel is a good ballast. It should be carefully selected and the larger stones removed. It should be clean and clear of loam. It may be classed as a fourth class ballast. It has good drainage qualities and prevents the heaving of the track from frost, though to a less extent than slag or cinder. An objection to gravel ballast is the roundness of the stones composing it, which is the opposite of what stone for ballast should be. It is, therefore, of little value for holding track on grades. It also shakes from the ties from vibration caused by traffic and is, therefore, of little value for distributing weight.

Anthracite cinder is the best ballast to prevent heaving. It can be worked more cheaply than any other and the finest surface and line can be obtained with it: it, consequently, makes the easiest and smoothest riding track. It is more elastic than any other ballast, and, when new, adheres well to the ties. It must, however, be renewed from time to time as it works fine and makes dust. This feature obliterates its fine qualities. However, it may be remedied by having it watered when first laid, after which it will give little trouble.

STREET CROSSINGS.—One of the best methods of preparing a street crossing is to place a guard rail on the inside of each rail, so that their two bases will butt against each other. The guard rail should be one-fourth of an inch lower than the main rail. The ends of the guard rails on each side of the crossing should have a sharp curve towards the center of the track, so that the end of the guard rail will be about four inches from the main track rail, having the outer corner of head chamfered at each end. Previous to placing the guard rails, a piece of oak that will fit underneath the railheads and base should be so placed between their webs. This strip of wood filling overcomes the objectionable feature to such guards, namely, the catching of horses' toe calks under the rail heads. The space between the two guard rails should be filled with three and one-half inch white oak plank spiked to the ties. If the track rails are four and three-fourths inches high, the plank should have one inch oak undershoring extending the full width and length of the tie so planked, a twelve inch plank being used on the outside of each main rail, up to which it is paved between tracks. On crossings of little traffic, guard rails may be omitted, having in place of them a plank beveled so as to lap over the rail base and up to the web, to prevent dust, dirt and snow from working underneath and heaving it up. The plank should be beveled on the upper surface sufficient to clear the wheel flanges, the upper edge of the bevel being distant from the gauge line of the rail two and one-half inches.

GUARD RAILS FOR BRIDGES.—Bridges should be provided with guard rails. Old rails as near the height of the main rails as possible should be used; these rails should be placed as near the main rails as the splices and spikes will allow, and on the approach end of the bridge should be carried parallel for at least thirty feet, where they should converge to the center of the track so as to line into the old point of a frog; at the point where they diverge from the running rail rerailing castings should be placed. Three or four braces should be placed on the inside of each guard rail between the castings and the frog point; these guard rails should be spiked on each tie, and as a foot guard for the frog point, a piece of twelve inch plank (oak) three and one-half inches thick, cut to fit the frog point from where the rails are twelve inches wide up snugly into the sharp point, should be placed and spiked to the ties, finishing the twelve inch end by leveling. The run off end of the bridge for double track need not have a rerailing apparatus, but the guard rails should be continued about thirty feet beyond the bridge, where they may terminate in a slight curve distant from the main rail about six inches.

CATTLE GUARDS.—Such guards should be placed at all farm and public road crossings where there is no protection by gates or otherwise; to prevent cattle running along the track, a fence should be built from the right of way fence on both sides of the opening to as near the rail as practicable. There are various forms of cattle guards. One plan in particular commends itself, being effective and cheap. It is a space of not less than six feet stretching the entire width of the track parallel to the road, laid with two and one-half by four inch oak pieces laid across the ties parallel to the rails, cut to a sharp edge on the upper face, spaced with two inch spacing blocks, and spiked down to the ties. The most effective plan, however, is to build a pit the entire width of the road about six feet wide and of sufficient depth to enable a cow to drop entirely clear of the trains. This, however, is too expensive, requiring the building of retaining walls and bridged for the rails only. This style of a cattle guard is perfectly effective.



Track Saw.

SLOPES AND DRAINAGE.—Cuts should be sloped to an inclination arrived at after careful examination of the material composing them. In ordinary earth cuts a slope of one and one-half to one will be sufficient, while it may be necessary to give some cuts a slope that an engineer would not approve. In all cases they should have slopes that will obviate land slides.

FILLS.—Fills made of rock and good sharp material will give little or no trouble, but those made in a careless manner will be a source of continual expense. Engineers should prohibit the use of material that will slide at a slope of more than one and one-half to one, unless it be along the tail of fills where the weight is comparatively slight. To prevent fills and cuts from sliding, in slight cases, willow cuttings or shrubbery of a rooty and spreading nature may be planted. In severe cases, broken stone or slag dumped down the face, so that it will be about one foot deep at the top and two or three feet at the bottom (or of a greater thickness if necessary) will prevent sliding.

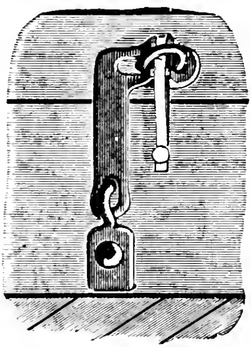
ROCK CUTS.—Rock cuts should be examined and all loose material removed. Trees that might fall on the track should be cut down.

SLOPE DRAINAGE.—Earth cuts should have a berme ditch on both sides (except side hill cuts, where one on the upper side is sufficient) to intercept surface water. The ditches should be of sufficient width and depth to accommodate the maximum drainage. At the tail of the cut they should diverge sufficiently from the track so that the water will flow off. Ditches should be run parallel to the track in all cuts, and wherever the adjoining ground is higher than the roadbed, the bottom of the ditch should be for single track eight inches, and for double track eleven inches, lower than the center of the roadbed, and seven feet from the near rail.

SPRINGS ON SLOPES.—Cuts showing springs of water should be provided with a system of surface drainage. A good plan is to dig ditches straight or diagonally down the slope, intercepting all such places; the nature of the material will determine the depth and distance apart. These ditches should be filled with stone of a size sufficiently large to allow the water to pass through their interstices. Should the flow of water be too copious for such a drain, a pipe or ordinary square built drain will answer the purpose.

SODDING AND SOWING GRASS SEED ON EMBANKMENTS AND CUTS.—Earth cuts and enbankments should either be sodded from the sod saved by stripping the surface or by sowing grass seed and white clover. Should they not slide before a sod has been formed, this will be sufficient to prevent slipping.

TUNNEL DRAINAGE.—Good drainage in a tunnel is necessary to secure safety to traffic and enable the trackman to do his duty. Tunnels have proportionately more water to be drained off than other parts of the track owing to the surface water permeating to them: moreover, the strata being interfered with in the building of a tunnel, it receives the drainage for a greater or less extent of country. The roadbed of a tunnel for double track should have a uniform grade from the sides to the center, with a fall of six inches emptying into a drain at its center running the length of the tunnel and emptying into the ditches at each end: this drain should be eighteen inches wide and twelve inches deep with a covering stone to allow the tracks to be filled up between. Where the bed is other than rock, this ditch should be made by laying a bed stone wide enough for a stone on each side to rest upon it, these forming the sides of the drain; the covering stone should rest upon the side stones. Where the bed is rock, the drain should be excavated as near the required form as possible, and where it is too wide side stones should be used to support the covering stone. All large holes should be filled and carefully packed to a uniform surface, so as to assist the flow of water to the drain and prevent its accumulation in pools. The grade of the track in long tunnels usually has its summit in the center, so as to drain toward both ends. Broken stone is the best ballast for use in tunnels, the larger sized stone being put below the ties and the finer from thence up to the surface. If the bed is poor, an inverted arch should be built as a bed, both for advantage of drainage and to support the side walls and arch.



Car Seal.

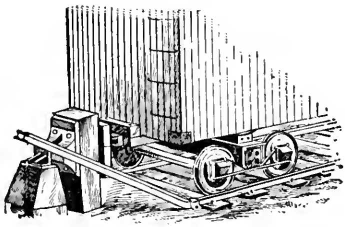
SWITCHES.—The split switch has long been in use and is the favorite for all purposes. It is the cheapest (in the long run) yet invented. The split switch should be planed to the lightest possible angle, without having the rail too long; the best length and angle being twenty-one feet long with a spread of six inches at the heel, which is just enough to clear the base of the splice from lapping on to the base of the stock or main rail. The split or point rails should be planed straight on both sides (except for special use) and chamfered three feet back from the point. All split switches should be fitted with adjustable rods. The best form of side plates are made of one inch cast steel.

The objection to wrought iron plates is their bending and the imperfect manner in which the projections for the point rails to slide on keep the main rails in position. The point rails should crown one-fourth of an inch above the main rails, which gives a good shoulder in securing the main rails and especially when lining up the track at the time the switch is being put in.

SWITCH SILLS.—Sills for switches should be of good, sound white oak, seven by ten inches, well seasoned. They should be prepared in sets by cutting the line side square and the turnout side to the required bevel. The most convenient manner to cut sets of switch timber is to prepare a board one inch by ten inches, planed and sufficiently long to mark the longest sill thereon. The length and bevel of each sill should be marked by a scribe line on this board laid off from the square or line end, having a line indicating the outer base of rail on the line end, for guidance when putting them in the track; on the turnout end of the board the number of each sill should be marked for its corresponding line. These numbers should be marked on the end of each sill and lettered, thus, R–10 or L–10, indicating the number of the frog the set is for and whether it is a right or left turnout.

FROGS.—As the stub switch is to the split switch, so is the cast iron frog to the rigid rail frog, and the rigid rail frog to the spring rail frog. Spring rail frogs have been long tested, and have stood the test, except at places where trains run at great speed. The damage to the spring rail frog by fast running is either in the breaking of the spring or spring rail, or damage to the wheels of rolling stock. But this has been overcome by the use of heavier rails. While the cost of a spring rail frog is but slightly more than of a rigid frog, it lasts three times as long. Rigid frogs should not be longer than will allow of splices being put on without cutting the base; in no case should they be shorter than six feet, as a short frog has a tendency to tilt whenever the wheels strike either end, thus depressing the sills. The distance from the toe to the point and point to the heel should be even feet. This will enable trackmen to remember the different parts of the frogs more readily and prevent mistakes. The distance from the toe to point of spring rail frogs should not be less than seven feet, and the distance from the point to the heel the same as that of rigid frogs; this will save cutting when there is occasion to replace one by the other. It has been found satisfactory to rivet (not bolt) rigid and spring rail frogs to a plate; it increases their bearing surface on the sills and more securely fastens their parts together. The plate is somewhat expensive at the beginning, but it can be used over and over again.

TURNOUT.—The simplest form of a switch on straight line or curves is a turnout. To locate a turnout on a straight line, the heel of the frog should be placed at a joint if possible, so as to save a cut and allow the guard rail to be placed clear of a joint on the opposite rail; this obviates the use of a fish plate. The distance from point to heel of frog should next be laid off, marking the point on the outside of the head of the rail, and the lead should be laid off to the point of switch from the last named point, marking it in like manner. When splices are two feet long and the switch twenty-one feet, and bend in turnout rail two feet ahead of switch point, then the joint of the bent rail can be seven feet ahead of the last named point, while the joint on main line side can be three feet ahead of same point, thus allowing them to break joints by four feet at point and six feet at heel of switch on main track; this clears all joints so that there will be no two butting against each other, and no necessity of cutting the splice base or using fish plates. If, however, thirty inch splices are used, the only way to clear joints will be to put joint of bent rail five instead of seven feet from point of switch, the main rail joint remaining the same. After the rails are cut for the main track side opposite to which the frog is located, they should be put in first, the switch timber being next put in and spiked to the side already put in, spacing them properly for all joints as they should appear when the switch is completed. When putting in the sills, however, it is necessary to place the switch plate on each as far as these plates extend underneath the switch, spiking them on the above named side, but only as much on the opposite side (as well as for the remainder of the sills) as will be necessary to hold the rails safely in position. When all the rails to complete the main track are ready, the frog should be put in place, then the switch laid and rails bent to place. Next the track should be spiked throughout, spiking the turnout rail not any further ahead than its bend, which should be done to gauge. Next the main track should be lined up; that done, the bent rail should be spread at heel of switch the calculated distance and lined perfectly straight between the end and bend already spiked. The switch plates should be tapped up snugly against the rail and spiked. This will allow the split rail to fit properly to the bent rail, and line nicely for the main track. Since the split rail, while being made and after the base is planed, will curve more or less in consequence and will require to be straightened, the back of the split rail should be planed perfectly straight, so that when put in place in track and thrown over against the straight part of the spiked bent rail, it will straighten up in its proper position. The bend in the turnout rail should be according to the angle of the split rail. In order to secure a true bend that will guard the point to its fullest extent, the rail, after being marked where the bend is to be put, should be heated enough to boil a spittle; then, with a rail bender, it should be given the calculated bend. A line should then be stretched between these two points on the gauge line and the calculated distance measured to this line from the line so stretched. If this rail is bent properly, there will be no

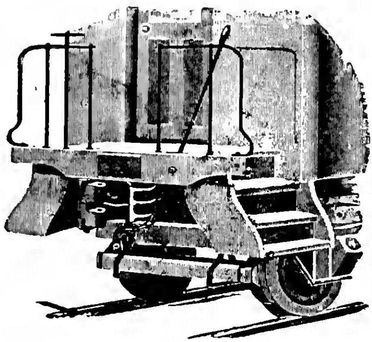


Bumping Post.

trouble in securing a good and easy working switch. The turnout lead is next to be put in. If the difference in length of curve lead over that of the straight lead is not known, the switch should be squared and rails measured and cut accordingly. These rails are next to be curved to calculated ordinates, allowing for the equivalent of five degrees of curvature to be put in by lining; the splices must also be slightly bent as the degree of curve requires. The lead should be calculated so as to enable the frog and switch to be placed naturally, *i. e.*, straight as they are built, except for special cases, and should not be distorted in the track to a curve. A frog distorted will not remain in any such forced condition and will thus spoil the lead. Should the turnout side be curved to suit the turnout lead, it necessitates the use of right and left hand frogs. This is objectionable. They should only be used for special cases when it is desirable to lighten curves to the minimum. Engines can not pass through curved frogs unless the throat is made wider to prevent the rigid wheels binding; and the wider the throat the less the point is protected and the quicker it will wear down. In lining up the turnout curve, a line should be stretched from the heel of the switch (the latter being thrown over to position) to the end of curve at frog tangent; this distance should be divided into quarters and the curve tacked at these points according to calculated ordinates. It is necessary in spiking the frog to see that the frog as well as heel of switch is spiked at proper spread, otherwise these ordinates will be of no consequence. The curve should then be lined between these points and spiked down.

Frog Guard Rails.—Guard rails may be made of slightly lower rails than those of the track (never higher), and should be of steel in preference to iron, as the latter wears more rapidly, consequently widening the opening of flangeway. Guard rails should be made of old rails removed from curves where the rails have never been changed to the lower side or turned, their original height being nearly retained. Each guard rail should be cut in two and bent to a uniform curve throughout, so that the maximum opening at the ends will be three and one-half inches and the minimum opening at the center one and seven-eighths inches, thus allowing the wheels to be drawn to the guard point with the least possible jar. When curving these rails the unworn side should be kept to the outer side; the base of the outer side should be planed so as to clear the spikes, the ends having the rail heads chamfered on each side. In making guard rails, care must be taken to have them perfectly level. They should be placed in the track so as to extend over one more sill ahead of the frog point than behind it, letting each end lie uniform relative to the sills; this will bring their centers opposite a point between the throat and point of frog. Each guard rail on a curved track should be supported by not less than four braces and on straight track by not less than two. As the gauge of the track is widened, the guard rail must be set correspondingly wide from the track rail.

Three-Way Split Switch.—A three-way switch is simply two turnouts beginning at the same point, or with the point of one switch far enough behind the other to allow it sufficient room to work between the main turnout rail of the first switch. These turnouts can be arranged one on each side of the main track, or both on the same side, according to the frog used, so that the curve of the second turnout may not be too heavy. When one switch is behind the other, it is necessary to make oblong holes in the web of the turnout rail of the first switch, through which the rods of the the second switch work. Usually the first or second rods are all that require to be dealt with in this manner, the remainder being bent down at right angles close to the split rail, low enough to pass under the turnout rail of the first switch. All crotch frogs should be "specials," built to the proper angle and curved to the same curve as that of the turnouts. A three-way switch consisting of one turnout to the left and the other to the right will require two bent rails opposite



Miller Platform.

each other; if both turn out to the same side, one bent rail is all that is required, but it must be bent to a much greater angle. The main line frogs can be either opposite each other or one ahead of the other. The crotch frog, if not built on a plate, should be supported by not less than four braces so as to secure its position. So should all such heavy angled frogs.

Cross-Overs on Straight Lines.—A cross-over is a turnout in two adjoining tracks, located so that one will connect with the other by a straight line between frogs, or curved, as the case may be; the latter, however, is only done where room is deficient. The explanation given to the turnout is applicable to this, but care must be exercised in setting the frogs; they must be carefully spread to the calculated angles or distance apart, and the tracks lined to their true centers, before spiking down, otherwise it will be impossible to secure a line between them.

TURNOUTS AND CROSS-OVERS ON CURVES.—The same leads as are required for straight lines will practically suit on curves, the only difference in their construction being more or less angle in the bent rail, and making the turnout curve longer or shorter than the main line curve, according as the turnout is on the inside or outside of a curve,—being less when on the outside and greater when on the inside. Leads with a heavy curve should have their gauge widened, as provided for curves on ordinary track, and when so widened the guard rails must be placed correspondingly wide. Guard rails on turnout side should have six braces to the rail, and on main track four.

DOUBLE CROSS-OVERS.—A double cross-over is a cross-over passing directly through another. It is a convenient system of switching, and greatly economizes space. It is more expensive than two single cross-overs, though it requires less timber. It requires a set of crossing frogs; the two center frogs being double, and the extreme frogs either double or single. If the parallel tracks are less than eleven feet on centers, the two frogs in the main track on one side and the nearest center crossing frog on same side require to be built in one, and should be on one plate; the two remaining corner or extreme frogs should be built single. No special rules can be given for putting in this system beyond those heretofore described.

CROSSINGS.—A crossing is where one track passes directly through another without switches. All the frogs may be double or the center frogs double and the extreme single. Should the crossing be on straight lines, it is more economical to make all frogs double and reversible so that they may be changed, as the wear is greater on one side than on the other. If, however, the crossing is curved, this is impossible; but the center frogs may be made double, though not reversible, and the extreme frogs single. It it not absolutely safe to use double crossing frogs on a less angle than fifteen degrees, as they then cease to be self guarding, especially so on curves. Instead of using double frogs for center frogs, it is much better to use a system of movable points admitting of any angle being used. The frogs for a crossing should be built very carefully, and it is impossible to secure a good line and gauge unless they are strictly true.

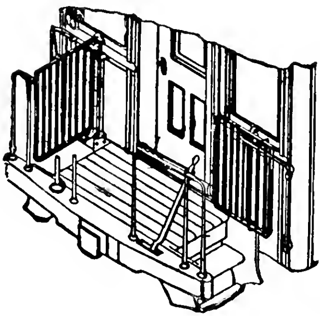
Slip Switches.—Slip or diamond switches have become much admired in this country for their compactness, and because they embrace nearly all other kinds of switches in the space required for one of them. What is known as the number seven frog is the angle usually adopted, so that the center double crossing frogs may be as near an angle that will be self guarding as the degrees of curvature on the turnout sides will permit. A single slip switch is a crossing with a turnout on one side only; a double slip is a crossing with a turnout on both sides. The rods of the switches are depressed near the split rail so as to pass under the other switch and crossing rails. If the points are opposite each other, the distance between the diamond or crossing rails at the point of switches should not be less than twelve inches, so as to allow sufficient working room for the points; if not opposite each other, one point may be placed nearer to the frog and the other further from it. It is important with crossing frogs of all kinds that they be built true, otherwise it is utterly impossible to put them in correctly, and they invite disaster. The construction of this system is similar to the turnout, so far as the bent rails and side plates are concerned, only the joints should be brought nearer to the switch points (in using number seven frog), so as to save a cut on the outer or turnout rails. It is customary, however, to build these split switches for a number seven frog, especially, so that they can be built on a curve; when such is the case, there should be no bend in the rails referred to, but they should be curved to correspond with the switch rail, the curve starting sufficiently far ahead of the point to allow the turnout and crossing track to gauge.

Movable Points in Lieu of Crossing Frogs.—To enable slip switches to be used on curves and to light angled frogs, it is necessary to use a system of movable points, or split switches, in lieu of the center double crossing frogs. The outer rails at the crossing points should be bent to the crossing angle at that point, and the points of the movable switches placed so that they will come six inches or more from each other at the crossing point, their heels being connected with the diamond or crossing rails. These points work on plates extending under the turnout rails and offset for the movable points, as is customary in ordinary switches, so as to raise the split rail above the main rail. This system of movable points is more economical than the double crossing frogs, as they will last as long as the main rails, whereas the frogs would require to be removed every two years or more, according to the traffic. In addition to this matter of economy, they are absolutely safe when properly attended to. It is quite common on examining number seven crossing frogs to find marks squarely on their points made by the flange of wheels on imperfect axles; as the angle decreases in crossing frogs, the danger is proportionately increased. The above system is very desirable for yard purposes, where space must be economized. It gives access to tracks in four different ways. When put in correctly, so that all its parts fit snugly, it will stay in better line than any other system of switches. This is due to its numerous combinations of rails and frogs so constructed that each part braces another. The plates for these switches, except for the movable points, can be made the same as the cast iron plates used in the ordinary switches or turnouts.

Switches on Outside of Curves.—All facing point split switches on outside of curves in main track should be "special," having the point rail on that side at least two feet longer than the inside point rail, so as to admit of a guard rail being placed opposite to prevent the wear of this rail. There is more or less of an angle at the point of all split switches, due to the fact that it is wholly impracticable to plane them to the theoretical point of curve—the consequence being the dropping of wheels into this angle, creating a great lateral strain and consequent wear on the split rail point; but by placing the guard rail as above, it will be sufficiently long to guide the wheels clear of this angle.

Derailing Switch.—Each side track leading to or from the main track, on which cars are allowed to stand, should be provided with a safety throw off or derailing switch (except where grades make this unnecessary). It should be placed not nearer to the main track switch than the point at which the siding becomes parallel, and arranged so as to throw the cars off the side track and prevent them from entering upon the main track. This switch may be either a point rail of an old split switch, or one especially constructed for the purpose. It should be put in similarly to a turnout rail of an ordinary split switch, having side plates and bent rail; the bent rail should be carried straight along the point rail as far as the rail head planing extends, whence it should diverge from the track so that its end will spread at least five inches from the gauge line of the near track rail, so as to clear the wheel treads. This switch can either be operated by a stand connected therewith for that purpose, or connected with the main track switch. In either case it should be provided with a lock and kept locked when cars are on the track.

CLEARANCE POSTS.—All tracks leading to or from the main track should have a distance, clearance or tail post set in the ground between these tracks immediately beyond the safety switch, and not nearer to the main track switch than eleven feet on centers. These posts are usually made of chestnut, four by four inches by four feet, planed square and rounded on top, the lower half being placed in the ground; they are painted white, and tops black.



Safety Gates on Passenger Coach.

MAINTENANCE OF TRACK.—A railroad is by no means a permanent piece of work; as soon as traffic commences repairs are necessary. To provide for this necessity section gangs are organized, and a certain amount of track, termed a "section," allotted to each. A section of double track should be four miles long, and of single track six miles long. On roads having a large traffic, each section gang should consist of a foreman and one and one-half men per mile of double track, with an additional allowance of one man for every two miles of sidings. On single track each gang should consist of a foreman and one man per mile of track, with an additional allowance of one man for every two miles of sidings. Taking these proportions as a basis, sections may be varied in length as locality and circumstances make necessary; no section should be so reduced in length that its proportionate allowance of force would be less than six men and a foreman; watchmen should be counted extra. All extra work should be calculated to be done by a special gang and gravel train, or extra men should be allowed section foremen. Each section should have a tool house large enough to accommodate a hand car and a full complement of tools.

SPRING REPAIRS.—When the snow has disappeared and the frost is going out of the ground, the track should be cleared of rubbish and dirt accumulated during the winter; then should begin the work of reducing and removing the blocking as the track settles. As soon as this work is done, spring work will have fairly begun. Ditches should then be opened, low joints raised, and the track lined.

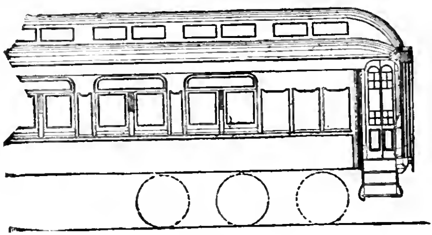
RENEWING TIES—OLD TRACK.—The foreman should test and mark each tie that needs to be removed. He will thus know the number of ties required, and where they should be unloaded. The foreman, when ready to renew faulty ties, will divide his gang into sub-gangs of three men. Before taking out a tie, the spikes should be started far enough to allow a spike to be placed between the rail and tie, when, by raising the rail with a bar, the old tie can be readily removed, and the new one put in without raising the adjoining ties from their beds. This avoids the likelihood of ballast getting under adjoining ties. Previous to removing the old tie, the ballast should be dug out on either side, making it lower on one side than the tie bed; the tie should then be pulled on one side into the ditch thus made, where it can readily be pulled out. The new tie is next pulled into the same ditch, lifted up to the rail and drawn to its place. If it is too thick to go in on the old bed without raising track too high, the bed should be lowered accordingly. The old bed should be disturbed as little as possible. It is customary with most section foremen to allow their men to lower the old bed, and as this can not be done with exactness, the result is that the new tie will be from one to three inches too low; this necessitates tamping from time to time in order to make its bed as solid as that of the old tie. Every ten years at least a track should be raised from one to three inches above the old bed, to prevent its becoming center-bound; all low spots should be raised, however, when ties are renewed. Old ties taken from track should be piled on the last day of each week, so as to give the track a neat and tidy appearance; this allows them to dry either for use as cribbing, fire wood, or burning on the ground, Ties should be adzed level to secure the better fitting of the rails and wheels. Rails will not turn on tangents, nor on the outside of curves, if properly elevated. To overcome the turning of rails on the inside of curves, rail braces should be used; they will also prevent the spreading of the track. In order to perform the latter office properly, a brace should be placed on the outer rail opposite each brace on the inner, otherwise the spike will bend over and the tie pull through. Ties should be renewed for the season by the end of September; from that time till winter the track should be surfaced and trimmed, and the ditches put in good condition for the winter.

GRASS AND WEEDS.—Grass, weeds and brush on the right of way should be cut sufficiently often to prevent the weeds running to seed. Generally, one cut in the first week in August will be sufficient. Brush cut at this time is not likely to sprout again. Brush and weeds should be gathered into piles and burned.

CHANGING RAILS.—On roads having heavy traffic, it is customary to change rails on Sundays, preparing the track on week days. On roads with light traffic rails can be changed at any time. One side of the track should be changed at a time.

PREPARING TRACK MATERIAL FOR SUNDAY WORK.—Rails and splices generally require to be filed on the ends to a uniform surface, so as to remove projections; this work is therefore included in preparing the track, though properly speaking it should be done at the mill. The following is the organization of men for such work, namely: The first thing to be done is to put four men on the car of splices, two on each end, to file and inspect the splices, each man having a small bench to lay the splice on to facilitate the filing; after they are filed they should be thrown on a car, laying them at right angles to each other the full length of the splice; this will facilitate their being counted. When the men have sufficient room on the car they are filing on, they should pile the splices behind them in like manner. Rails, splices, bolts, nut locks and plugs should be distributed at the same time as the rails. It is necessary, however, to have half of the cars which are loaded with rails turned on a turntable or Y block to admit of their being unloaded, with the brand on the outside of the rails as they will be put in the track.

UNLOADING RAILS.—Care should be exercised in unloading rails. Rails, on gondola cars especially, should be let down to the ground on skids. and each skid should be provided with a pulley on the upper end, placed below its surface: a rope with a hook sufficiently large to receive a rail should be used through this pulley for lowering the rails to the ground; each skid should be provided at its lower end with a round iron projection. around which the rope is turned for the purpose of controlling the rails while being lowered. Two men on the ground, operating the ropes, raise the hooks to the upper end of the skids, when one foreman and twelve men (handling seventy-six pound rails) will place the rail in the hooks and lower the same to the ground. The first named two men, in addition to lowering these rails, will lift the skids as the car is moved ahead. On another car are the rails for the other side of the track, the men being similarly organized. Unloading a rail on each side prevents moving the train so often and



Vestibuled Car.

obviates the men passing from one car to another. Time may be saved by unloading two rails from each car before moving the train ahead, unloading the next two rails one rail length ahead of the last two. Two men on the splice car will distribute the splices, bolts and nut locks, and two men with a basket will distribute the plugs from the supply car.

Filing Rails, Etc.—As soon as the rails are unloaded, men should be set at work to file the ends of the rails underneath the heads and upper side of the base. After the rails are unloaded, the men should be organized as follows, namely: One foreman and eight men with tongs should string the rails along the outer edge of the ties; one man with an adze should level any projecting ends of same, and one man should tack spike all unspliced ends of each four rails. For six bolted splices, six men should bolt the rails and lay the splices, bolts and nut locks at each unspliced end. Four men should remove all the bolts that can be removed with safety from the rails in the track; these men should also put the nut locks, or washers and nuts, on each bolt as it is removed. Four men should pull the spikes that can be pulled with safety, those remaining being left slightly started. On tangents four spikes to each rail are sufficient to leave unpulled, leaving one of these spikes at each joint; on curves six spikes to the rail should be left, and one in the slot hole as above. These spikes should be pulled on the inside when the same sized rails are to be used, and when of different base the inside of one rail and outside of the other should be pulled, which will admit of their being laid retaining the same gauge. When pulling spikes on curves, they should be pulled on the side having the ties cut down the least, which will more readily admit of ties being adzed. Four men should be at work score adzing each tie on the side from which the spikes are removed, keeping well on the outside of the spikes. As each sub-gang finishes its work, it should clear the ballast between the ties and underneath the rails; the other foreman should look after the sub-gangs except rail stringers. Two boys should be engaged in carrying water for the men. In all, forty men will prepare in the above manner one mile of track per day. On double track one track should be used to distribute from, allowing schedule trains to pass on the other, flagging all other trains and allowing them to pass as they arrive.*

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*Gang for Changing Rails on Sunday.—The same gang of men that prepared the track at the rate of one mile per day will change the rails at the same rate, organized as follows, namely:

Men removing bolts	4
Men throwing out rails	2
Men adzing ties	13
Men spiking rails, joint slot holes, quarters and centers	4
Foremen	2
Men pulling spikes	4
Men plugging spike holes	2
Man guiding and testing adzing with single headed spotting boards with face one-half inch broad	1
Water boys	2

As adzing is more or less on account of ties being cut into, these men will require to be increased or diminished accordingly. The remainder of the spiking can be done by this gang the next day, as well as tamping up all ties that are loose or low, especially the joint ties. They should also go over all bolts with wrenches and tighten them up.

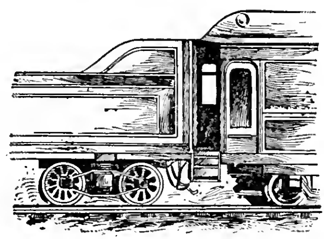
JOINTING RAILS.—As it is impossible to change rails and have them joint on the old ties, it is necessary that these ties be changed to admit of the slot holes being spiked, and thus prevent the rails from running.

MOVING OLD TRACK.—Improvements of line, especially double tracking, when the old line is being improved at the same time, render it necessary to either take up and relay the old track or move it over to the new line. When the change of line is within twenty feet throw, it is cheaper to move the track than to take it up and relay. This work, like changing rails, is usually done on Sundays. It is, however, possible to be done in the week, if there is an occasional half hour or so between trains. It requires skill and scientific ability.

PROPER CARE OF ENGINEERS' STAKES.—Grade stakes set by engineers for top of rail for new line should be set so as to be clear of the track when it is being moved to place. If, however, the same grade is to be retained, the foreman in charge should put two intelligent men to transfering the level of the lower rail, using a long straight edge and track level for this purpose. The engineers' center line stakes are liable to be in different positions relative to the old track to be moved, necessitating the latter passing over these stakes in many cases. In order to obviate as much as possible the liability of their being moved, they should be driven sufficiently low to clear the bottom of the rail. Another manner of dealing with these stakes is to pull the spikes out of each tie surrounding the same, so as to allow of the track being moved and leave those ties untouched. This, however, entails considerable expense. Another manner of dealing with these stakes is to transfer them so as to be entirely clear of the track when moving. Too great care can not be taken with these stakes, in order to facilitate the lining and surfacing of the track so changed.

PREPARING TRACK FOR SUNDAY WORK.—The bed for the track on a new line should be ballasted and leveled off on tangents, and elevated on curves so that the bed will be within two inches of the bottom of the ties. It is necessary to prepare this bed with more than ordinary care, so that when the track is moved over to its new position trains can be allowed to pass without the necessity of holding them until the track is tamped. All trains, however, should run slowly over this track. When old track is to be thrown entirely clear of the old bed, it is not necessary to dig it out between the ties, but only to loosen it up with a pick, so as to make it easier to throw. This loosening might be omitted, but in that case it would take half as many more men to pull the track out of the old bed. If old track is to be thrown less than the length of a tie, the part occupying the old bed should be dug out slightly below the bed of the ties, and the remainder loosened with a pick. This being done, the track is ready to be thrown.

MOVING THE TRACK ON SUNDAY.—It is necessary that good judgment be used in determining what amount of track can be moved to allow necessary trains to pass without being held, and also to determine the proper place to cut the track so as to prevent the necessity of pulling it longitudinally more than one foot each way. The men may be divided into sub-gangs of not more than thirty men with two foremen each, and a certain piece of track allotted to them. This number of men will admit of being divided, using one gang behind the other in throwing the track, or have one surfacing while the other is finishing the lining and surfacing later. When throwing the track it should not be moved more than twelve inches at any time; this saves the rails and splices and prevents twisting the ties. Rail cuts, to allow for expansion or contraction, should be at the center of curves, or at as many more places as the degree of the curve and distance to be thrown render necessary. Not less than six men should be placed at each cut, so as to employ three in cutting rails and three drilling; they should first remove the splices from two joints, one on each rail, and pull the spikes on the sides opposite to which the track is thrown, so that the ties will be taken along as the track is moved.



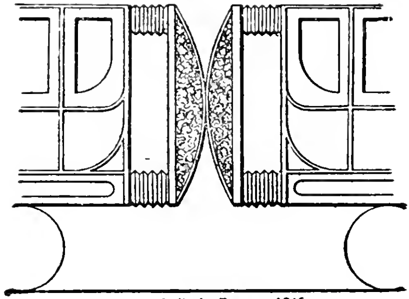
Vestibuled Tender.

In order to pass trains after curves have been moved the line should be changed on the tangents by reversed curve. When the track is in place, two men in each gang with sledge hammers should be put at work tapping the ties to proper space and square to the rail. Track in cinder may be tamped only with shovels and tamped with bars later after it has consolidated.

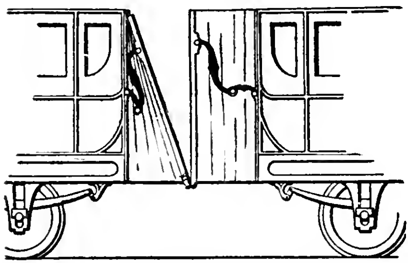
To Move Track During the Week.—After the track is prepared, it is necessary to know how much shorter or longer it will be when moved. This can be ascertained by setting temporary stakes. They should be placed on the line of rail where its position will be when changed, measuring along this new line to the similar rail of the old track, after which this latter rail should be measured between the same points; thus the difference between them is obtained. This can only be done correctly by using a steel tape. When moving track during warm weather, the track to be changed should be first examined and for every tight or close joint one-eighth inch allowed for expansion; the sum of these allowances must be taken into consideration in ascertaining the difference between the two rails. The rails should then be cut and drilled ready for use. When the time selected to make the change arrives, and the last schedule train has passed, gangs should begin to throw the track, always throwing towards the point or points cut loose. As soon as the throwing of the track is started, the rails at these points are replaced by those already cut. When the track is finally thrown to position, the ends can be spliced and bolted.

Winter Repairs, General Routine.—The principal work during winter is blocking track, clearing snow and ice, and keeping ditches open. Where track heaves badly, the rails should be marked on the web, and in the spring such places should be dug out and ballasted with clean, sharp material. No digging out of such places should be done during winter, other than lowering ties to overcome too high blocking, as it is too expensive.

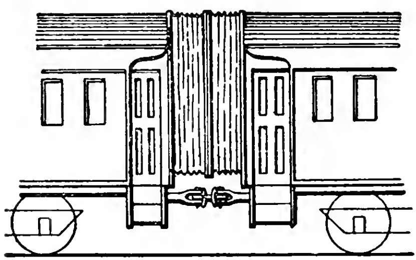
Blocking or Shimming.—Generally, the maximum blocking should not exceed two inches. On curves, the blocking should be spiked to the tie, and holes bored for spikes. Good and cheap blocking can be had from car shops, where oak offals can be had of any thickness. These offals should be from four to six inches in width. Extreme blocking on tangents may be four inches thick; the rail block should be braced by fitting one end into a notch in the tie and the other underneath the head of the rail; the block should be spiked to the tie at the notched end and should incline at an angle of forty-five degrees. Another manner of dealing with extreme blocking of from four to six inches high, is to have the blocking in two pieces, the first being two feet long the width of the tie and securely spiked thereto, while a second block of the same size is laid on top of



-Fuller's Patent, 1845.

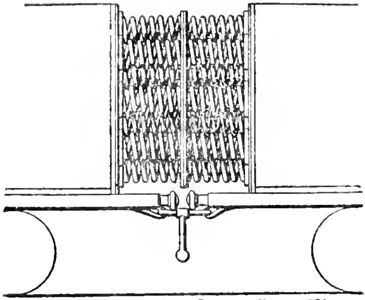


Bessemer's Canopy, 1847.

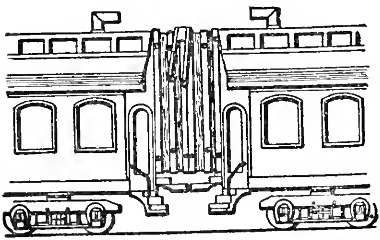


Atwood's Covered Passageway, 1855.

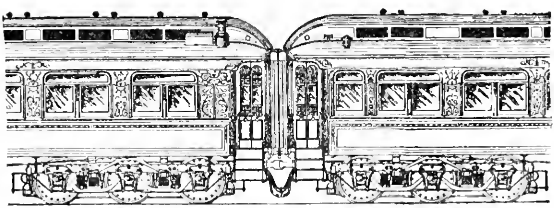
The Evolution of the Vestibule.



—Waller's Face-Plate Buffers, 1871



Smith's Car-Platform Hood. 1882



PULLMAN VESTIBULE 1894

The Evolution of the Vestibule.

the first and spiked through holes bored for the purpose. The rails should be track-spiked through half inch holes bored in the blocking. When blocking more than one inch thick is used on curves, the safest and cheapest method (and the least injurious to ties, especially when the track is braced) is to spring the ties from their bed and drive a wedge shaped block of wood underneath until the rail rises to surface. During snow storms sufficient force must be kept on hand to keep switches, crossings, station platforms and flangeway of track open for traffic.

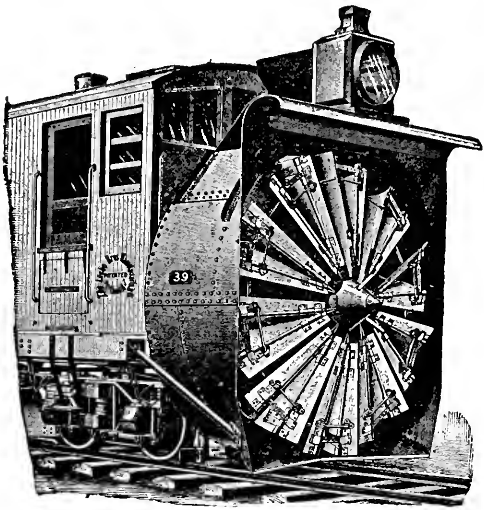
TRACKWALKERS OR WATCHMEN.—The number required depends on location. The least should be one by day and one by night. It is the duty of these watchmen to clean, light, put up and take down switch lamps; to tighten bolts and remove obstructions from drainage. When more than one track walker is employed, each should be allotted a certain distance, commonly called a "beat;" this beat he should patrol ahead of schedule trains as nearly as possible. A shanty, with a stove, should be provided for each beat, in which watchmen can take shelter.

INSPECTION OF ROAD.—The roadmaster should ride over the track and examine it from the rear end of trains as often as possible. He should do this at least twice a week. He should note all irregularities in the track, marking off on previous notes what has already been attended to and making any additional notes concerning the work. He should keep informed of the work each gang is doing and as to the number of men at work. His orders to foremen should be given verbally; by so doing the work will be executed with less trouble and at less expense. He should make frequent visits to the foremen and walk over their sections with them; these opportunities should be improved to draw section foremen's attention to the items of work requiring to be done—explaining, advising and encouraging them. Section foremen should walk their track as often as possible,—at least once a week. Trackwalkers should report all defects or obstructions of the track to the foreman; should any such be found likely to interfere with traffic, approaching trains must be flagged until the trackwalker has an opportunity of being relieved or of sending word to the foreman; the foreman should, in turn, notify the roadmaster and ask for such assistance as may be necessary if it requires more force than his own to remedy the defect or remove the obstruction.

PREMIUM SYSTEM.—Nothing is more encouraging or stimulating to men engaged in any work than the fact of having an object in view. The payment of premiums is a recompense in acknowledgment of superior ability: it creates a stimulus to thrift and energy that can not be aroused in any other manner, and, at the same time, it does not injure the feelings or lessen the ambition of those less successful. The mere intrinsic value of the premium offered is not the sole encouragement given, the contest for pre-eminence is a valuable aid in the attainment of what is desired.

Mr. Andrew Morrison, who has had great practical experience in connection with the construction and maintenance of railroads, especially that part relating to track, is recognized everywhere as an authority on such matters. The paper he submitted, and to which I have already referred, is at once able and exhaustive. His grasp of the subject is that of a manager as well as an expert. He believes that the contemplation of the vast expenses incurred in the maintenance of way and the necessity for rigid economies in the face of an equal necessity for perfect conditions illustrate the importance of a wise and progressive management. This can only result from careful training and judicious selection of the men who manage these expenses, either as a whole or in part; therefore, to obtain competent men is the first requisite of any well conducted railroad. How to obtain such men is governed largely by local considerations, but some system of training and examination must be instituted for the men who are to fill the responsible positions on our railways.

In the roadway department there is especial need for a thorough system of accountability, which can only be exacted by superior governing intelligence, and must be executed by well drilled subordinate talent. Railroading has advanced from the experimental theoretical stage to the plane of practical business. The roadmaster, or engineer of maintenance of way, should know just how much labor and material are required



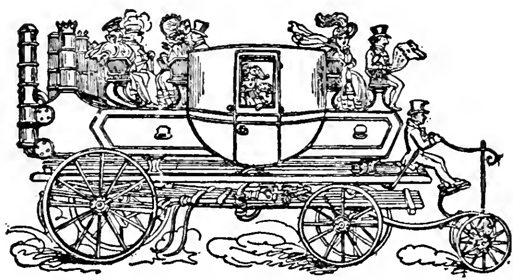
Steam Snow Plow.

under certain conditions to maintain and equip every element of his roadway, and, knowing this, he should draw standards of efficiency and economy, and every man who fails to work to these standards should be dismissed as incompetent.

ROADBED.—The roadbed is the foundation upon which is built the superstructure or track. If the foundation is defective, its imperfections will develop a rough riding and dangerous track. The material of the roadbed is of first consideration. It should be the best soil or earth obtainable in the locality—soil that will hold its position, become compact, resist the action of storms, and possess elasticity. Rolling logs into a roadbed is pernicious, as they decay and allow of sudden and dangerous pitfalls; large rocks or boulders are also objectionable, as they allow an uneven and rigid bearing, and permit the too free percolation of water, that, in time of heavy rains, may develop a washout; clay and sand, in about equal quantities, generally give about the most satisfactory results. The size and shape of the roadbed will be determined by the importance of the road and the character of the material; as a rule, it should never be narrower at the top than six feet added to the gauge of track, and generally eight feet should be added to the gauge of track, for single track roads. The slope of embankments should be at an angle of one and one-half feet horizontally to one foot vertically, and a space of at least three feet of the natural earth should be left between the base of embankment and the inside edge of side ditches. This space is called the berme, which should be kept intact.

Drainage of the roadbed is the process of preventing its saturation and erosion by water. Thorough drainage is necessary. Ordinary drainage is provided by a system of side ditches, surface ditches, ballast, and the improvement of natural waterways. Extraordinary drainage, by special methods to suit particular obstacles to be overcome. Side ditches should be straight, with a uniform gradient toward their outlet. It is not customary nor expedient to make side ditches of sufficient capacity to provide for the largest recorded rainfall, as, in such cases, ordinary prudence would dictate the suspension of traffic, and the the construction of such ditches would entail useless expense upon the road; but it is essential that side ditches should be so made as to provide for carrying off, with greatest directness and rapidity, all the water falling within forty feet of the rail; beyond that limit surface ditches should be provided. In alignment, side ditches should conform generally to the alignment of the road, and should not be deviated around stumps, boulders, etc., as such obstructions decrease the efficiency of the ditches and detract from the good appearance of the road: therefore such obstacles should be removed, and ditches made straight, except where they emerge from a cut and join the ditches along the embankment, when they should be connected by a ditch of gentle curvature, and, at such connecting ditches, the earth removed in their construction should form a dam on the side toward the roadbed, to prevent the water from the cut overflowing the ditch and damaging the embankment. Side ditches along embankments should be made of a cross section; the bottom of ditch should be made to slope away from the road, as any wash will then occur on the side of the ditch where the water is deepest, and away from the road.

Ditches should be maintained to a depth of at least two feet below the level of the bottom of cross ties, as an earth roadbed will absorb water to the height of two feet by capillary attraction; they should gradually increase in size toward their outlet. Surface ditches should be constructed on all slopes that tend toward the roadbed in cuts; they should be made of the same general cross section as the side ditches along embankments, except that the earth should be thrown on the side of the ditch toward the roadbed. This affords ready access for the water coming from the slope, and prevents overflowing on the side of the road. The size of surface ditches should be sufficient to carry off the rainfall from the slope on which they are dug; they should be straight, free from obstructions, and increase in size toward their outlet, which should be directed into the nearest natural waterway. On new roads the track forces should watch the drainage system with special vigilance during storms, as some weakness is almost sure to exist, which will develop at such times. If the quick construction of a ditch is necessary, it should be started at the lower end, as it will thus drain itself as it is made. Where a roadbed is in a saturated condition, the constant passage of trains will cause the track to sink in the wet earth, and "churn," resulting in a rough riding track. To prevent this and also the "heaving" of track by frost in winter, a layer of porous material called "ballast" is introduced between the ties and roadbed proper; thus the weight of passing trains is distributed uniformly over the entire surface of the yielding roadbed, producing a uniform surface under all circumstances. Stone broken uniformly into cubes of about one and one-half inches on the side, clean gravel, furnace slag, clay burned with coal into hard lumps from one inch to two inches in diameter, and coarse sand, are valuable for ballast in the order named. The last, however, is exceedingly dusty, and is of too unstable a character to make good ballast. Broken stone has the advantage of freedom from dust, dirt, weeds and grass. Broken stone and gravel also wear much better than furnace slag or burnt clay. To ensure a good track, ballast should be uniformly placed for a depth of at least one foot below the ties. Probably the ideal ballast is a layer of broken stone from eight inches to one foot thick on the roadbed, and a layer of from four to six inches of gravel above the broken stone, and immediately under the ties. This ensures perfect drainage, and renders the track easy to keep in surface. The top of the roadbed, under the ballast, should slope both ways from the center, so that water filtering through the ballast may pass off immediately into the side ditches. Where ballast can not be obtained except at such an expense as to be prohibitory, it is important to secure perfect drainage in other ways. In such cases the top of the roadbed should slope both ways from the center of track



Steam Road Carriage, A. D. 1827.

to the bottom of the ends of cross ties, to afford an opportunity for rain water to run off rapidly into the side ditches. This is, however, only a partial remedy, as the roadbed will ultimately become saturated with continuous rains. The surface of such track should never be broken during rainy weather, as the looser the earth the more rapidly it absorbs the water. After continuous rains, the earth of a roadbed frequently becomes so thoroughly saturated with water as to render it unfit for tamping under the churned ties; in such cases it is necessary in the absence of ballast and dry earth, to use some other coarse material as a temporary substitute until dry weather; ordinary grass sods, long coarse grass, or even brush, particularly pine, may be tamped under the ties; this will sustain the track at soft spots in a passable condition for a considerable length of time.

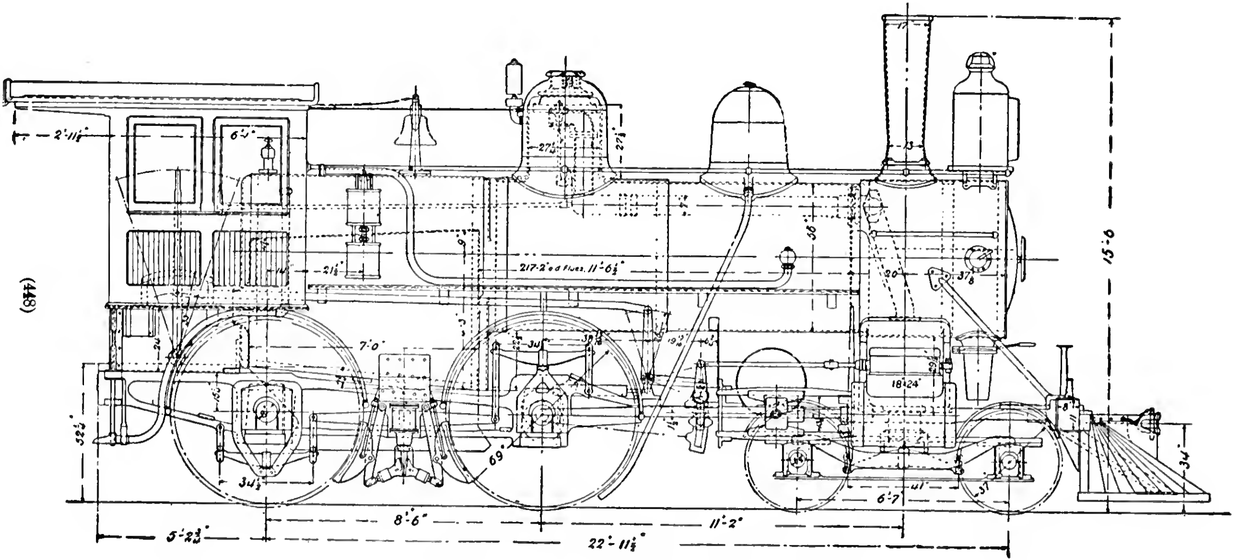
The next element of ordinary drainage is the improvement of natural waterways; they constitute the main arteries of a drainage system. The small natural streams should be examined for a considerable distance above and below a road, and all obstructions that tend to affect the natural flow of water should, if practicable, be removed; old timber from bridges, logs and other debris should never be allowed to obstruct them.

In reference to extraordinary drainage, the protection of slopes and banks is an important feature. Generally some short, creeping, long rooted variety of grass will be ample protection for slopes and banks, both from the effects of rainfall and of flowing water. It frequently becomes necessary, however, to furnish additional protection at abuttments and along embankments where there is a swift running stream. Rock revetments or "riprap" can be employed to good advantage in such places, or a wooden revetment or walling made of old bridge timber is a good substitute.

This walling should project into the trestle opening at least six feet, so that the current passing around the corner of the revetment walling will form an eddy sufficiently far from the abuttment not to undermine it. In severe storms, where revetments have not been built, or have been washed out from any cause, a good temporary substitute for the protection of the bank is found in tree tops or large bushes, placed so that the bushy ends of limbs will spread over the side of bank as deep in the water as possible, the butt ends being laid in a direction up stream against the top of bank, and held in that position by timbers or earth piled on them. Springs occurring in cuts can generally be sufficiently drained by means of porous drain tile run at right angles to the line of track, about two feet below the ties, the ends opening into the side ditches. Sometimes, however, it is necessary to excavate an opening in the roadbed for several feet below the ties out to the side ditches, filling the bottom with coarse rock and the top with sand or gravel.

Track.—The prevailing material for cross ties is timber. The qualities required of timber for cross ties are durability, to resist decay; hardness, to resist wear; toughness, to resist breaking; and elasticity, to save the rail and rolling stock and to hold spikes in position.

The size of cross ties will be regulated largely by the timber supply on different roads. Where suitable timber can be



Eight-Wheel Passenger Locomotive, A. D. 1894.

obtained in abundance, a cross tie seven inches thick, ten inches wide, and nine feet long is probably the best, though on many roads it becomes necessary as a measure of economy to use ties from six to eight inches wide and eight to eight and a half feet long. But whatever the size, the total bearing in a given distance is the important feature; the thickness of the tie should be fixed at not less than seven inches; the length not less than eight feet, and from that to nine and a half feet, bearing in mind that with the increased length should come increased thickness, and the width from seven to ten inches. The distance apart of ties in the track should be regulated according to their width, so as to maintain a uniform bearing surface. The usual limits of this bearing surface require that ties shall not be placed farther apart than one and one-half times their width, nor nearer than a space equal their width, for if they are closer there will not be sufficient room between the ties for proper tamping. Above all things, the size of ties and the distance between them must be uniform to ensure good track.

Fences.—The best material for a cheap fence is wire, and barbed wire is the most effective. Wire is practically indestructible, is cheap in first cost, requires the minimum number of posts, and is more rapidly put up than any other kind of fence. A top rail or board should be added as a brace for the posts and as a protection to stock that can not see the wires. A flat wire ribbon with projecting points is used, as stock can see it better.

Cattle Guards are the means of continuing fences across railroad tracks without interfering with the passage of trains. They form a very considerable portion of the expenses of a road, and therefore it is desirable to obtain a device as simple as possible, and yet it must effectually exclude all stock from the enclosure. A framed pit sufficiently wide for the connecting fences to afford proper clearance for the cars, and with stringers for the rails to rest on, was, until recent years, the form in most general use. The danger of stringers spreading and the disastrous effect of a derailment at these pits led to the addition of ties and guard timbers; these additions permitted a much shallower pit. As cattle, sheep and goats learned to walk these ties or guard timbers, it became necessary to have them chamfered.

Many other forms of stock guards, principally surface guards intended to do away with the pit entirely, have been suggested and patented.

ROAD CROSSINGS.—The intersection of a highway with a railroad at an elevation common to both is called a road crossing. At such points it is essential to provide an easy and safe means of passage for vehicles over the track. Grade road crossings in cuts and on or near curves should be avoided whenever possible. At road crossings the grade of highways immediately approaching the track should not exceed one foot in ten. Public road crossings should be sufficiently wide for two teams to pass easily abreast, and in cities the width should be regulated to suit local requirements. Eight feet is sufficiently wide for private crossings, and twelve to eighteen feet for public roads; this width should be carried out to the limits of the right of way, if on banks, by a "ramp" of the same width as crossing; culvert pipe should be used under the "ramp" to prevent obstruction of drainage.

TOOLS.—The character of a workman may be determined by his tools. If found in proper order and ready for any emergency, he may be classed as a first class foreman. Good tools are necessary for good work. Formerly most roads made their own tools; but, as a rule, tools are now purchased from manufacturers for a lower price than roads can afford to make them, and certainly of a better quality and finish. Foremen should be provided with suitable boxes and racks for their tools, and should not allow them to become mixed.*

There should be a systematic inspection of tools by the roadmaster. Every foreman should be required to have his full number of tools in efficient condition at all times. Spirit

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* The following list of tools is suggested as a proper outfit for every section gang:

Adze	1	Lanterns, red	2
Auger, 1½ inch	1	Lanterns, white	2
Axes, club	2	Level, track	1
Axe, hand	1	Line, ditch, 100 feet long	1
Bars, to three laborers	2	Lock, with five feet of trace chain.	1
Cans, oil	2	Mauls, spike	3
Car, lever	1	Picks, tamping, to three laborers.	2
Car, pole	1	Saw, cross-cut	1
Chisel, 1½ inch	1	Shovels, for each laborer	1
Chisels, track	4	Signals, danger	2
Drills, track, with six bits	1	Spike puller	1
File, 8-inch M. S.	1	Square	1
Gauge, track	1	Torpedoes	12
Grindstone	1	Wire, telegraph, feet	30
Hooks, bush, to each man	1	Wrench, screw, 14-inch	1
Jacks, track	2	Wrenches, track, for each laborer.	1
Keg, water	1		

Foy each five sections, one rail bender and one rail straightener.

levels should be tested and adjusted at each inspection. Every division of road should be provided with a hand derrick car, and a box car with wire ropes, blocks and falls, levers, jacks and blocking, and on every road where the traffic is of much importance there should be a steam derrick of at least thirty tons capacity, and a car fitted up for the accommodation of a considerable wrecking crew.

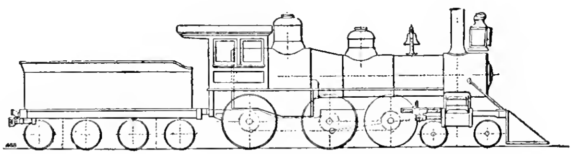
Steam ditchers and ballast unloaders are also an essential part of the equipment of any first class road, for they perform the services of very large forces of men at much less cost, and are ready for immediate service when it is frequently impossible to secure a sufficient amount of labor at the time required.

MANAGEMENT.—There are two distinct features to be considered in the organization of the roadway department. The first is the execution of that which is to be done; the next, the inspection of that which has been done. Under some circumstances, the duties of execution and inspection are combined in one individual; in the broadest sense, however, there should be no community of interests between the inspector and the man who is directly responsible for the work. The man who executes or directs the execution of work is naturally inclined to magnify its excellences and excuse its imperfections, but he who views it with the practiced eye of a critic, whose judgment is not tempered with self interest, will give an estimate of certain and just value. Road inspection will therefore be considered under a separate heading, as a distinct system instituted to meet the increasing exaction of modern railroading.

In the organization of the roadway service there should be no division of authority or responsibility; all orders should proceed from a responsible head, and all reports should ultimately reach his office and be consolidated by him for the information of superior officers. This head is variously termed the roadmaster, superintendent of roadway, engineer, etc. Under this officer come the supervisors, division roadmasters, or assistant engineers, as the case may be; also timber inspectors, pump inspectors and frequently bridge and building inspectors; then come the gang foremen, etc., who in turn employ their own laborers. Under such an organization, with a proper system of rules and accounts, a road may be extended to almost unlimited proportions by a simple addition to the number of divisions and subdivisions, and an enlargement of the central office. A division roadmaster or supervisor is rarely capable of supervising more than one hundred miles of single track or fifty miles of double track road. On our more important lines, a section of single track should not exceed six miles, and section houses should be placed as near a telegraph office or station as possible.

The foreman should have the care of track and property of the company on his section, and should be held accountable for their proper care and maintenance.

As far as possible the roadmaster should lay out the work for his foremen. Foremen should be shown the value of thorough system, of planning the week's work ahead so as to economize time and to accomplish a little more than the proper week's allowance. For this reason it is very essential for the roadmaster to establish the proper allowance of labor, and to issue a little in advance of requirements the necessary material. Foremen should not be permitted to work portions of a day at



Locomotive, A. D. 1894.

points widely separated, as the loss of time in going from one place to another will easily consume a large percentage of the day's time. The regular inspection, which foremen should be required to make at least twice a week over every part of their sections, should be made in such a manner that they will use as little time away from their regular work as possible.

The following rules are suggested for guidance of employes in the roadway department:

"GENERAL RULES.—Each employe whose duties require it must have the book of rules with him while on duty.

"Any employe who does not clearly understand the rules must ask an explanation of his superior officer.

"Employes must report violations of rules by other employes which endanger life or property, or which prevent them from discharging their own duty.

"Employes while on duty must refrain from profane or violent language, personal altercation, and from using intoxicating drinks.

"Each employe is hereby warned that while on the tracks or grounds of the company, or in working with or being in any manner on or with its cars, engines, machinery or tools, he must examine, for his own safety, the condition of all machinery, tools, tracks, cars, engines, or whatever he may undertake to work on or with, before he makes use of or exposes himself on or with the same, so as to ascertain, so far as he reasonably can, their condition and soundness; and he is required promptly to report to his superior officer any defect in any track, machinery, tools or property of said company affecting the safety of any one in operating upon or with the same.

"Supervisors, inspectors, foremen and conductors must keep a daily record of their occupation, showing in detail the work done, material used, and the time of each person employed under their immediate supervision.

"Red must not be worn in a conspicuous manner.

"Supervisors, conductors, section foremen, and foremen of all other gangs, during work hours, must not leave their respective division, train, section or gang without written permission from the roadmaster.

"In case of accident to train or road, the highest officer in the roadway department, or the oldest foreman in continuous service present at the time, will have charge of the work until relieved by some one higher in authority.

"Supervisors must pass over their divisions on trains, and foremen over their sections on hand cars, during stormy weather, and must know that all is safe before allowing trains to pass. Conductors must keep in telegraphic communication with the roadmaster and the master of trains during the continuance of storms, and be prepared to move on shortest notice.

"Hand cars must not be towed at the rear of trains, and must not be on the track after dark, nor in foggy weather, unless protected by proper signals in front and rear.

"Standard plans and specifications for the construction and location of all structures will be furnished, and officers and foremen must inform themselves of such standards, and work entirely in conformity with them.

"Trains must be expected at all times.

"Foremen and officers must provide themselves with reliable watches before entering upon their duties, and see that they are always in order and conform to standard time.

"When watchmen are left with danger signals, they must be supplied with tools and required to work.

"When dangerous places are found, or while work is being done that renders the road unsafe for the passage of trains, the person in charge must attend to the placing and maintaining of danger signals on the engineer's side of track in both directions. In no case must they be nearer than fifteen telegraph poles, and on a continuous down grade in the direction of the work the signal must be placed at least twenty telegraph poles from the work. When such points come on a curve, the signal must be placed at the further end of the curve. If either signal can not be clearly seen from the work and from an approaching train, a watchman must be left with it.

"Whenever signals of the roadway department are disregarded, immediate report must be made to the roadmaster.

"Slow boards must be posted at a distance of ten telegraph poles on each side of the place where the speed is to be reduced.

"When two or more hand cars may be following each other over the road, they must maintain an interval of at least two telegraph poles apart.

"SUPERVISORS OR ASSISTANT ROADMASTERS: Must test track levels once a week, and see that they are used in surfacing track.

"Must see that foremen are supplied with the full number of tools required, and that they are in proper order.

"Must carry with them on their hand car a standard track gauge, an axe, six torpedoes, a red and white lantern, and a red flag.

"Must examine switches, frogs and turntables once a week, and see that they are in proper order.

"Must see that turntables and car guards are provided with proper means to securely lock them.

"Must see that their foremen are provided with the proper forms for making reports, and with copies of all rules and schedules.

"Must pass over their respective divisions at least one a week on a hand car, once a week on an engine, and often as possible on the rear of a train.

"Must see that signs are placed where required, and are kept in proper order.

"Must see that fences are kept in proper order.

"Reports of the resignation, discharge, removal, suspension, transfer, death, injury, sickness, or marriage of any foreman must be sent at once to the roadmaster.

"FOREMEN: Must be familiar with the regular code of signals and the proper position and use of torpedoes.

"Must work when their entire attention is not required in directing their men.

"Must report promptly in detail to the supervisor any accidents to persons or trains.

"Must notice the signals carried by passing engines.

"Must examine every switch, frog and guard rail on their respective sections at least three times every week, and must keep them in good order."

Nuts and bolts must be kept tight.

Road crossings must be kept in good order.

Foremen must watch the telegraph lines, especially after storms, unite the wires when broken, and keep poles free from grass. They must promptly report to the roadmaster any derangement of wires they can not repair.

Old ties must be piled, on the day after they are taken out, not less than thirty feet from the rail, piles to be not less than one telegragh pole apart. Old timber that is unserviceable must be burned.

All rails or scraps of metal must be neatly piled at mile posts, stations or section houses, not less than six feet from the rail. Serviceable material must be kept separate.

Foremen must see that scattered wood or trash around wood racks, station grounds or water stations is properly piled up or burned.

Foremen must repair promptly any break in fences, and report the facts to the supervisor.

Bushes and weeds within the limits of the right of way must be cut.

Foremen, when working on track, must see that earth is not piled up in such a way as to touch any part of a train.

Track must never be raised off the roadbed where drainage is complete; the low places should only be brought to a surface with the high places.

Track must be raised level with track jacks. Ties must be uniformly spaced and tamped.*

Spikes must be driven perpendicularly — outside spikes three inches from the edge of tie nearest and inside spikes three inches from the opposite edge of tie, except at joint. Ties must be placed square across the track.

Track must be kept in proper gauge, and on curves of five degrees and upwards, guard rail braces must be placed on outside of both rails at intervals of six feet.

The ends of ties put in must be lined on the side of track on which the mile posts are located.

Ditches must be kept free from obstructions.

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* The following rules will be observed in laying new rail:

a. Defective ties must be removed where rail is laid, and ties properly spaced and lined.

b. Track must be put to true gauge, level, line and surface.

c. Shims of proper size for the degree of temperature must be used.

d. Spikes must be placed in the slots of angle plates.

e. The full number of bolts must always be used. Nuts must be screwed up tight.

When a foreman takes charge of a gang, he must receipt for all company property delivered to him by his predecessor.

Foremen will be held accountable for the proper care of the company's property on their sections.

Hand cars and tools must be properly secured when not in use.

Conductors of Railway Trains: Will report directly to the roadmaster. They must comply with the requisitions of the supervisors upon whose divisions they are working.

They must report by telegraph every afternoon to the roadmaster their probable work limits for the following day.

They must report to the roadmaster every cause of delay.

They will report to supervisors all material hauled to and from their respective divisions.

When hauling earth, they must see that the ditches and cuts where they are working are left in proper condition. They must not leave piles of material so high as to be struck by trains.

They will be held responsible for the careless handling of material. Steel rail and fastenings must be lifted, not thrown, from the cars.

Details concerning the track are infinite. In another volume* will be found those relating to the duties of trackmen in connection with the operation of trains. In addition to such rules and in addition to those already given, the following suggest themselves as necessary to a proper understanding of the subject. The major portion of them were compiled by me years ago—many of them from original sources. I do not claim them as my own.

Laborers must be in gangs of such number and force as the roadmaster may direct; to each gang there must be a foreman, who must work constantly with his gang, and be held responsi-

*"Operation of Trains."

ble for the faithful and efficient execution of the work under his care.*

The safety of life and property requires that sectionmen should be especially vigilant in foggy weather and during and after storms.†

They must see that all obstructions upon the track, or likely to fall thereon so as to endanger the safety of trains, are promptly removed.

In no case, except in the most absolute necessity, is a rail to be displaced or any other work to be performed, by which an obstruction may be made to the passage of trains during a fog or snow storm; the times for effecting repairs which involve the stopping of trains must, as far as practicable, be so selected as to interfere as little as possible with the passage of traffic.‡

Gravel or ballast unloaded along the line must be promptly spread upon the track, so as not to endanger the safety of trains.§

In lifting the permanent way, no lift must be greater than three inches at once, and then it must be effected in a length of at least twenty yards, in such a manner as not to occasion any sudden change of gradient. Both rails must be raised

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* "In each gang of platelayers or men repairing the permanent way, there shall be a foreman or ganger."—*English Standard.*

† "They must see that after all heavy winds, rains and other storms, and during the same, the men are out on the road ready to render such assistance as may be required, and to give proper warning to the trains, and to repair such damages and remove such obstructions as are necessary. In foggy weather, when a train can not be seen at three hundred yards, all the foremen and laborers must leave their ordinary work, and the foreman must range them along his portion of the line, over which they must walk up and down, driving such spikes and keys, or doing such other work as needs attention, and be ready to give notice of danger to the signalmen or the trains."—1854.

‡ "In all cases, before taking out a rail, the platelayer must have at the spot a perfect rail in readiness to replace it."—*English Standard.*

§ "No ballast must be thrown up to a higher level between the rails than three inches, and it must be thrown as much as possible on the outside of each line, and between the two lines, and be replaced as soon as possible. The rails must be kept clear of gravel, ballast, or any other material."—*English Standard.*

equally and at the same time, and the ascent must be made in the direction in which the trains run.*

Trackmen must keep the fences in good order at crossings and at each side of the track; they must see that all breaks are repaired without delay;† that cattle guards are kept in repair; that all gates that are found open are closed, and that all bars found down are put in proper condition.‡

When watchmen are employed, they must walk over the track and carefully inspect the same, at intervals between the passage of trains.§ It is the duty of watchmen (and switchmen and agents as well) to signal trains that disregard the regulations prescribing the time and distance that must elapse between trains that are following each other.‖

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* English Standard.

† "Surely, it is far better to stop a hand car and repair a fence than to subject a company to damages for killing stock, with the additional expense, occasionally, of a wrecked train. In a word, men, when passing over a road with a hand car, should be prompt to remedy every defect they discover. It should be a rule never to postpone any work of repairs that can be done on the instant."— *The Roadmasters' Assistant, page 118.*

‡ "Gangers must close and fasten all gates they find open, and report the circumstances, in order that the persons who are required to keep such gates closed and fastened may be charged with the proper penalties. The gangers must take care to maintain proper scotches on all sidings requiring them."— *English Standard.*

§ "Whenever any person has occasion to walk on the railway he must not walk on either line of rails, but on the right hand side of the line, off the ballast, clear of passing engines or trains."—*Great Northern Railway of England.* "Gangers must order off the railway all persons trespassing within the fences, and must do their best to obtain the trespasser's name and address. If any trespasser persists in remaining they must take him to the nearest station and give him in charge of the stationmaster or police there; or (if any police constable be nearer than the nearest station) gangers must give the trespasser in charge of such constable, and report at once having done so to the nearest station."—*Great Western Railway of England.*

‖ "The foreman and other men of the squads must look at every passing train, and if they see a train running on the same track, within ten minutes of another train, or anything wrong, they must signal the engineman with a red signal, and

Each ganger is required, in the event of storms or floods, to examine carefully the action of the water through the culverts and bridges on his length of line; and should he see any cause to apprehend danger to the works, he must immediately exhibit the proper signals for the trains to proceed cautiously, or to stop, as necessity may require, and inform the inspector thereof; and, until the inspector arrives, he must take all the precautionary measures necessary for securing the stability of the line.*

They must see that water courses under the bridges and culverts are not allowed to become clogged or obstructed.†

In wet weather, and during and after snow storms, they must use every effort to prevent delay or accident to trains.‡

Track foremen must carefully walk over and inspect every portion of the section under their charge at least once each day.§

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they must report to the trackmaster when an engineman does not obey the signals."—1854. "Where the line is not worked under the block telegraph regulations, if a passenger train approach within ten minutes of a goods, cattle, mineral or ballast train, or light engine, the men repairing the line must give the engine driver of such passenger train a signal to go slowly."—*English Standard.*

*Great Western Railway of England.

†"They will be particular not to allow standing water upon any part of their line, but keep the ditches open and free at all times, and keep floodwood away from the culverts, bridges and water courses."—1853.

‡"Their whole time will be devoted to their duties in the service of the company, and generally their services are more urgently required in bad, inclement weather than at any other time. In winter it is as much their duty to keep the track clear from snow and ice, as far as it is possible, as to keep it in repair. At this season every possible effort should be made to keep the road open, and insure the regularity of trains."—1853.

§"Each ganger must walk over his length of the line every morning and evening on week days (except where the engineers consider once each day sufficient, and have laid down such instructions in writing) and, where passenger trains are run, once on Sundays, and tighten up all keys and other fastenings that may be loose; and he must examine the line, level and gauge of the road, and the state of the joints, marking, and if necessary repairing, such as are defective."—*Great Western Railway of England.*

Each ganger must, when going over his length of line to examine the keys and fastenings of the rails, have with him a keying hammer and spanners or nut keys, and be prepared promptly to supply keys, nuts, packings, fastenings, or other parts of the permanent way that may be required.*

No wagon or other vehicle employed in the permanent way department must be left in any siding without the wheels nearest to the entrance into the main line being properly blocked and secured.†

Old and unused material of every kind upon the line of the road, or at stations or shops, must be carefully collected and preserved.‡

All luggage, goods or articles found on the line must immediately be taken to the nearest station, and a report made containing the best information that can be obtained respecting the train from which they may have fallen.§

Trackmen working in a tunnel, when trains are approaching in both directions, must, if unable to reach any recess in the walls, lie down either in the space between the two lines of rails, or between the line and the side of the tunnel, until the trains have passed. The width of the space depends on the construction of the tunnel, with which every man must make himself acquainted in order that he may select the place which affords the greatest safety.‖

Trackmen must desist from work upon a train approaching, and must not cross over to the other lines, but move to the side of the road, clear of all the lines, to secure themselves from the risk of accident by trains running in opposite directions.

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* Great Western Railway of England.

† English Standard.

‡ "They will protect the materials or property of the company (whether new or old) upon their line from depredation, loss or injury, and keep it properly and neatly piled up, ready for use or removal."—1853.

§ English Standard. "Anything which may have been lost from a passing train, such as a casting, nut, screw or bolt, or any piece of machinery, piece of freight, baggage, or other matter, they will pick up and carry to a regular station, and deliver to the station agent."—*Old Rule.*

‖ English Road.

In the event of any fire taking place upon or near the line, employes must take immediate measures for putting it out.*

Bridges and culverts should be carefully inspected after the passage of each train; but where this is impossible they must be examined daily, or oftener if sectionmen have occasion to pass over them. All defects should be promptly remedied, and in the event sparks, burning waste, fuel or fire of any kind is observed, it should be put out.†

Before removing any traveling crane, the person in charge of it must see that the jib is properly lowered and secured, and so fixed that it will pass under the gauge, and, when it has to be removed by train, it must, when practicable, be so placed that the jib will point towards the rear of the train.

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*"Careless firemen frequently throw overboard handfuls of dirty waste, which at any time may be ignited by a spark from a passing locomotive. Fire may be carried thence into the dry grass by the roadside, afterward into the fence, and so on to haystacks, buildings, wood piles, etc."—*The Roadmasters' Assistant, page 116.*

†"When a gang of trackmen engaged at work discover smoke on a line, they should at once attend to it. It should be a rule at all times never to neglect the least indication that a fire has caught on the line. On more than one occasion expensive bridges have been destroyed owing to a neglect to stop the hand car and remove a live coal of fire dropped by a locomotive, or to put out a fire caused by a spark from a smoke stack lodging in a decayed spot of timber. Some of the worst wrecks on record have been taken out of culverts where a stringer has been nearly burned through."—*Ibid, pages 116–117.*

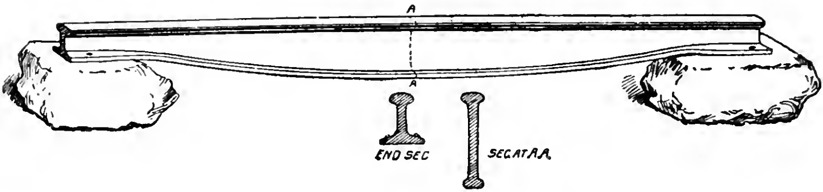
Carriage in Saxony.

CHAPTER XXV.

THE RAILWAY TRACK AND ITS EVOLUTION.

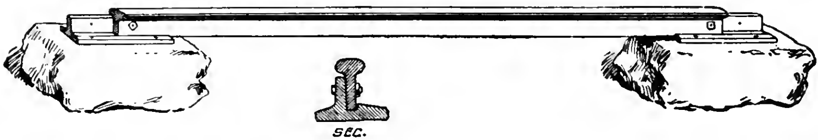
The track of a railway, next to its motive power, represents the central idea of such properties. Its evolution has, generally speaking, kept pace with improvements in other branches of the business. The devices that have been used in connection with the track and abandoned afford quite as much instruction as a presentation of those that have succeeded them. I, therefore, embrace in the accompanying illustrations devices of earlier days as well as those of the present time. Each illustration speaks for itself. Little or no explanation is needed. From the cuts which are given the reader can, without labor or weariness, trace the successive steps by which railroads have reached their present high standard in regard to matters relating to track.

For the graphic illustrations that I am able to give of the evolution of track I am in the main indebted to J. Elfreth Watkins, Esq., Curator of the section of transportation and engineering, United States National Museum.



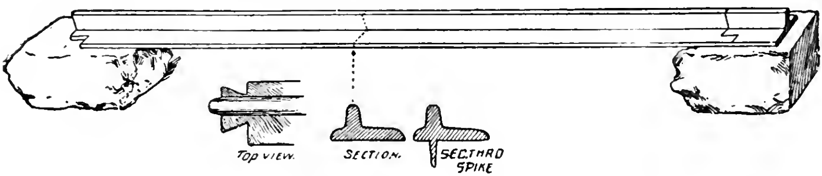
Jessop's Patent Edge Rail, A. D. 1789.

Rail of cast iron made in England in 1789 and patented by William Jessop, and used on a road in Loughborough. "The rail was fish-bellied, and was not supported by a chair, the wood or stone block being hewn to fit the end of the rail. Near the ends the rail had a flat projecting base, in which there were holes for the bolts which fastened them to the wooden block or sleeper."



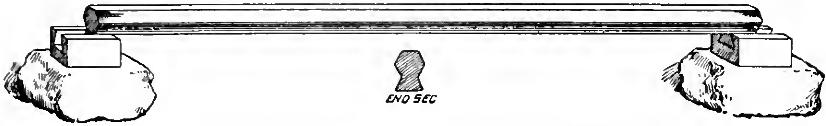
Edge Rails, Lawson Colliery, Newcastle-on-Tyne, A. D. 1797.

Rail cast in 1797 with joints and supporting chairs. "These were the first chairs adopted, and were cast the reverse of the ends of the rail, having two bolts through the stem of the rail at each joint. They were laid on the Lawson Main Colliery Road, Newcastle-on-Tyne, England, and were at first supported by timber but finally by stone blocks."



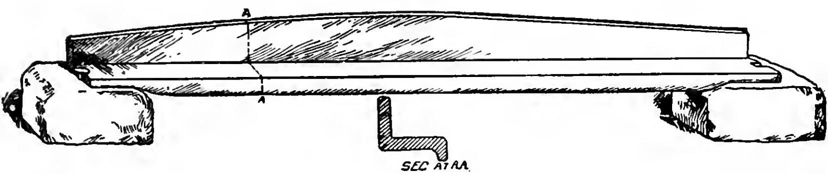
Tram Rail Designed by Charles Le Cann, Llannelly, Wales, A.D. 1801.

Cast tram rail designed in 1801. It required neither bolts nor spikes, and the inventor, Charles Le Cann, of Llannelly, Wales, received a premium of 20 guineas from the Society of Arts for the device. "It was ingenious in construction. Projecting pins, pyramidal in shape, were cast on the bottom of the tram rail at the points where the stone supports came under the rail, the joints being dovetailed into each other; the need of any other form of joint fixture was thus dispensed with. The rails were about five inches wide, and weighed forty-two pounds per yard."



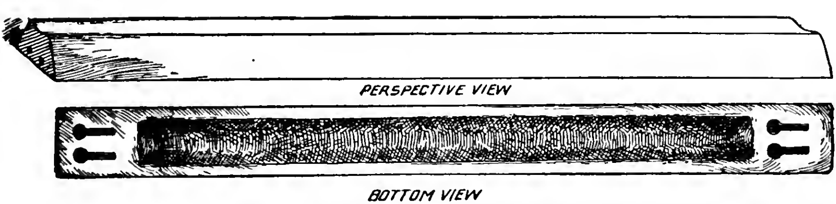
Wyatt's Hexagonal Rail, Bangor, North Wales, A. D. 1802.

Cast edge rail manufactured in 1802. It was four feet six inches long and was used in a slate quarry, near Bangor, North Wales. "The general shape of the cross section of this rail was hexagonal. At each end of the rail a dove-tail block, two inches long, was cast at the bottom. This was slipped into a chair, which had previously been attached by a bolt to the wooden or stone support."



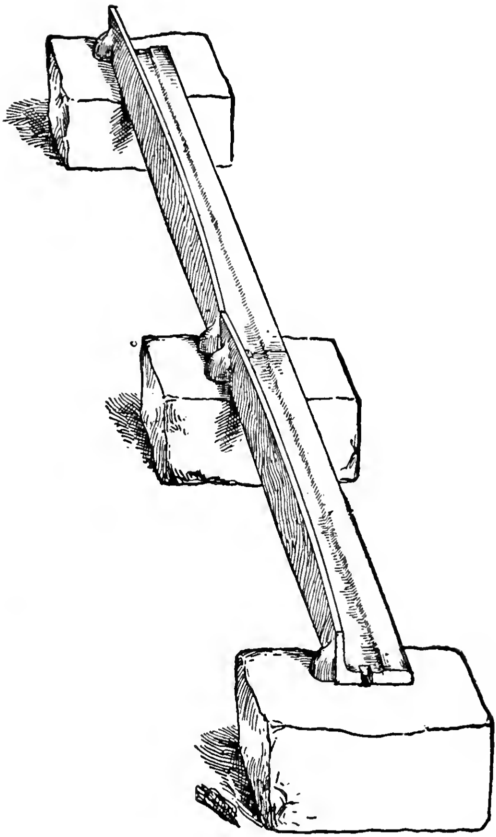
Tram Rail, Surrey Railway, A. D. 1803.

Cast tram rail of 1803, used in Surrey, England. It had a "flange higher in the middle, and a nib under the tread to add strength. This rail had a rectangular notch, half square, in the ends, the points being completed by one square headed iron spike, which was countersunk."



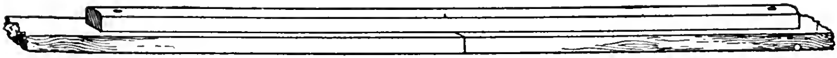
Woodhouse's Patent Concave Rail for Wagons, A. D. 1803.

Cast rail with concave top, used in 1803. It was intended to be embedded in common roads for use by wagons.



Tram Rail, Penydarren Works to Glamorgan Canal,
Wales, A. D. 1804.

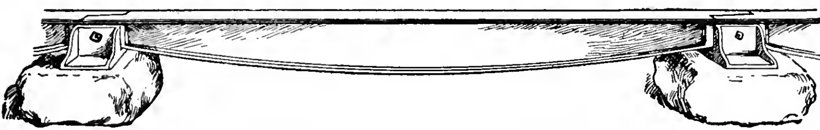
Two cast tram rails, three feet long, with stone supports, used in the Penydarren Works in Wales. These rails formed a portion of the original track upon which Trevithick's first locomotive ran in 1804. The rails themselves are in the United States National Museum.



Lord Carlisle's Wrought (rolled) Iron Rail, A. D. 1811.

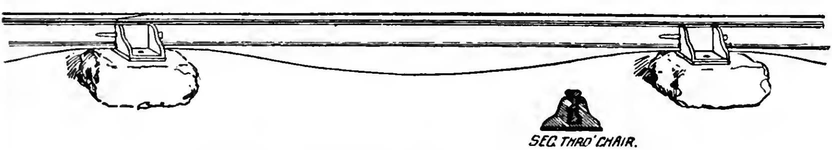
Wrought Iron Rail, Patented by John Birkenshaw, A. D. 1820.

Wrought iron rail, patented by John Birkenshaw, England, in 1820. It is partially described thus: "The upper surface to be slightly convex to reduce friction. The upper part to rest on supporting blocks, chairs and sleepers. The wedge form is used because the strength of a rail is always proportioned to the square of its breadth and depth. Hence this (wedge) form of rail possesses all the strength of a cube equal to its square. The joints are made with a pin."



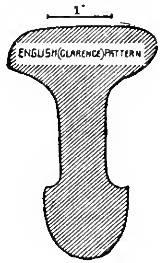
Edge Rail, Patented by Losh and Stephenson, laid on Stockton and Darlington Railroad, A. D. 1816.

Cast rail, patented in England by Losh and George Stephenson, in 1816. "A half lap joint was used, through which a horizontal pin was passed transversely and joined the rails together, at the same time fastening them to a cast iron chair. A large portion of the Stockton and Darlington Railroad was laid with this rail in 1825."



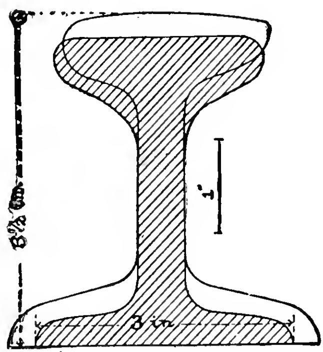
Fish-Belly Rail, Designed by George Stephenson and laid on the Manchester and Liverpool Railway, A. D. 1829.

Fish-bellied wrought iron edge rail used by Stephenson in 1829. Chairs were used at the joints; the rails were fifteen feet long and weighed thirty-five pounds per yard; the supports were three feet apart.



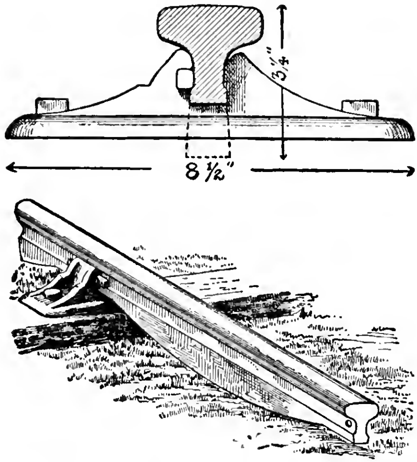
English Rolled Rail, Clarence Pattern, laid on the old Portage Railway of Pennsylvania, A. D. 1833.

Cross section of the original rail laid on the old Portage Railroad over the Allegheny Mountains in Pennsylvania. These rails were imported from England in 1832.

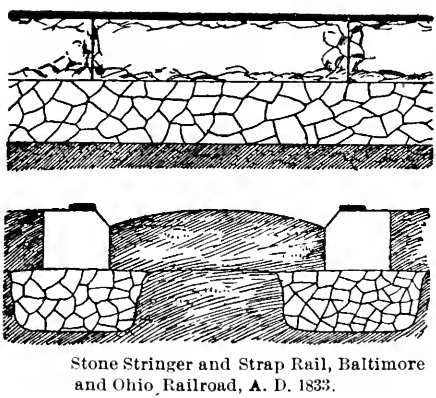


Stevens Rail rolled with Convex Top and Base, designed by Robert L. Stevens, A. D. 1830, generally used on American railroads since 1836. Shaded section shows rail as originally designed, 1830. Section not shaded shows rail as rolled, 1831.

Original design of the present rail. This rail was fastened to stone blocks with hook headed spikes; at the joints were iron tongues fastened to the stem of the rail, put on hot. This was the standard rail of the Camden and Amboy Railroad from 1831 to 1840. A few years after, on much of the Stevens rail laid on the Camden and Amboy Railroad, the rivets at the joints were discarded and the bolt with the screw thread and nut, similar to that now used, was adopted as the standard.

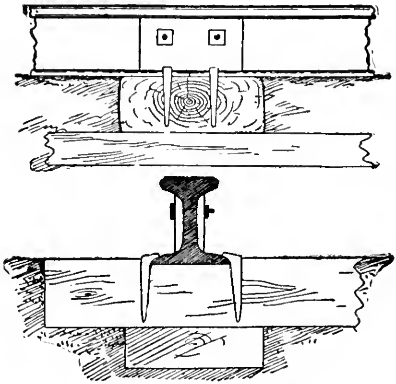


English Fish-Belly Rail, laid on the New Jersey Railroad near Newark, A. D. 1832.

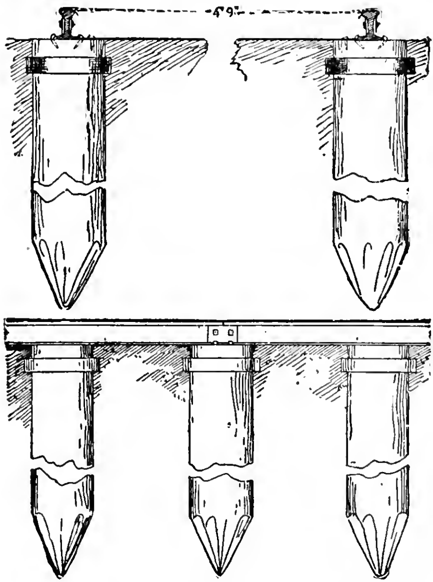


Stone Stringer and Strap Rail, Baltimore and Ohio Railroad, A. D. 1833.

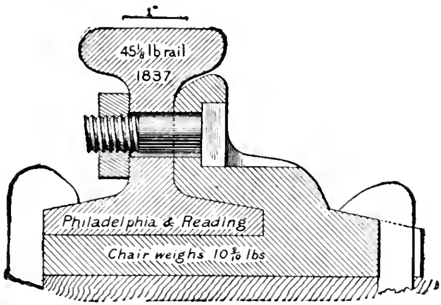
Old Strap rail and the method of supporting same commonly used in the early history of railroads in America.



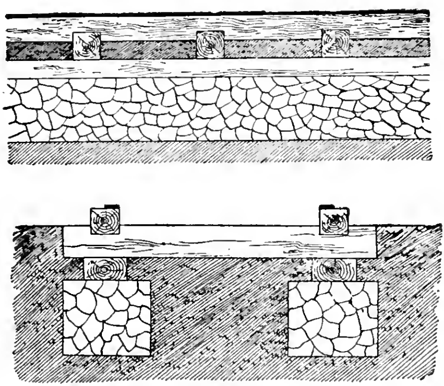
Standard Track of the Camden and Amboy Railroad, A. D. 1837.



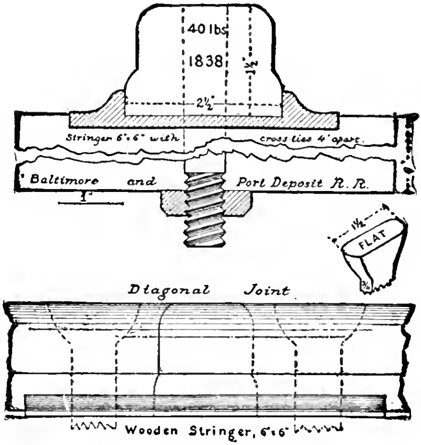
Track of the Camden and Amboy Railroad. Rails laid on Piling through Marshes, A. D. 1837.



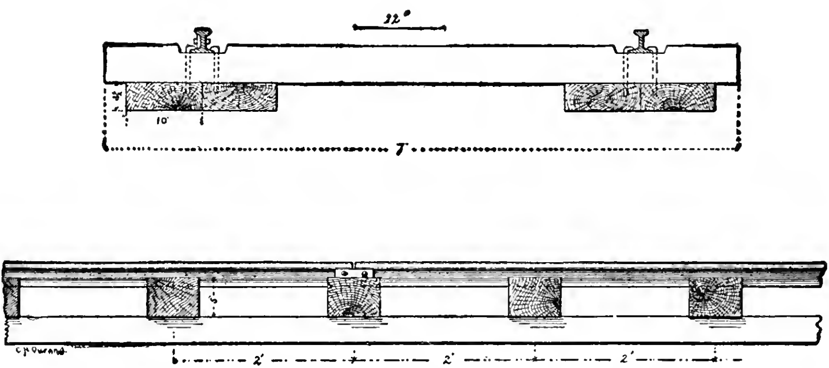
The Stevens Rail supported by Cast Iron Chair. Philadelphia and Reading Railroad, A. D. 1837.



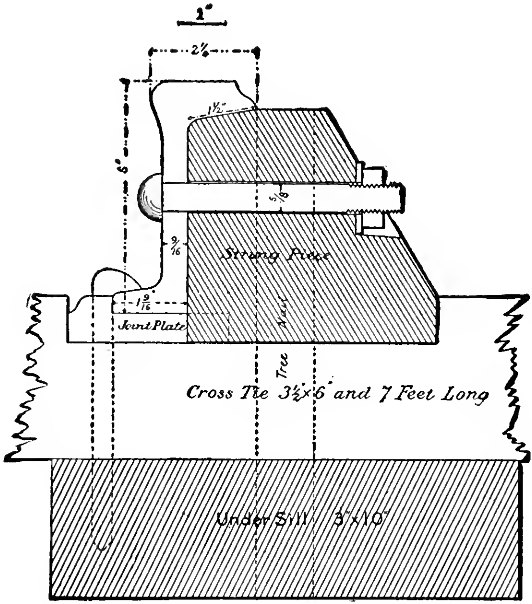
Wooden Stringer and Strap Rail, Albany and Schenectady Railroad, A. D. 1837.



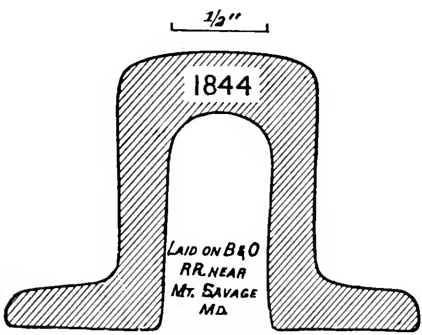
Thick Rectangular Rail, laid on the Baltimore and Port Deposit Railroad, A. D. 1838.



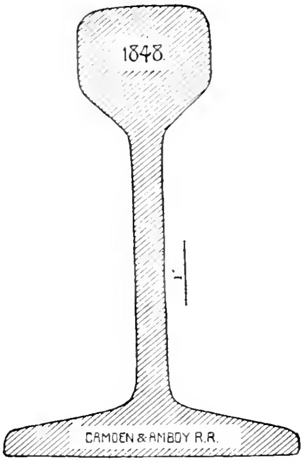
The Stevens Rail as laid on the Vicksburg and Jackson Railroad, in Mississippi, A. D. 1841.



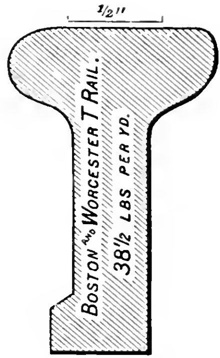
Compound Rail, Wood and Iron. Designed by B. H. Latrobe, A. D. 1841, for Baltimore and Ohio Railroad.



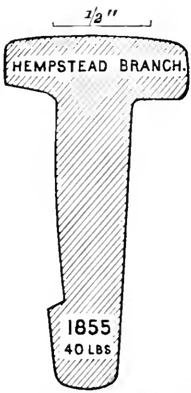
First Rail Rolled in America, Baltimore and Ohio Railroad, A. D. 1844.



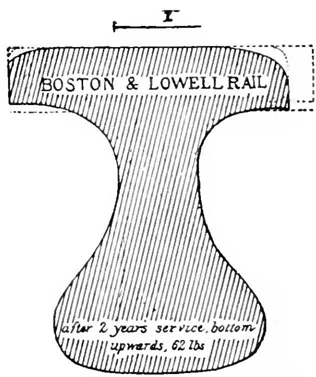
92 pound Rail, 7 inches high,
Camden and Amboy Railroad.
A. D. 1848.



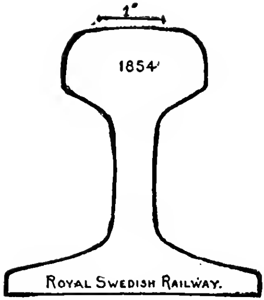
T Rail, Boston and Worcester Railroad, A. D. 1850.



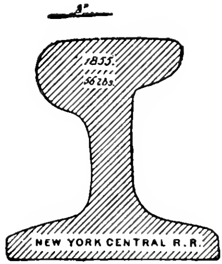
T Rail, Hempstead Branch, Long Island Railroad, A. D. 1855.



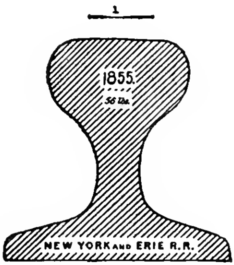
62 Pound Pear-Headed Rail, Boston and Lowell Railroad. Showing wear after two Years Service, Bottom Upward, A. D. 1853.



Stevens Rail adopted by the Royal Railway of Sweden, A. D. 1854.

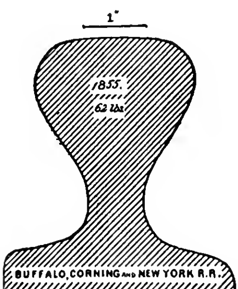


Pear-headed Rail, A. D. 1855.

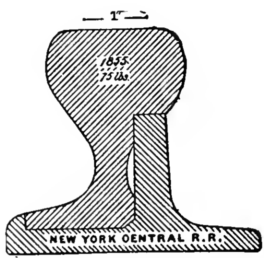


Pear-headed Rail, A.D. 1855.

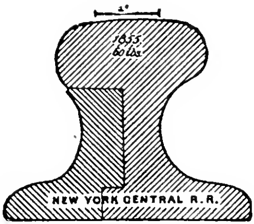
Pear-headed Rail, A.D. 1855.



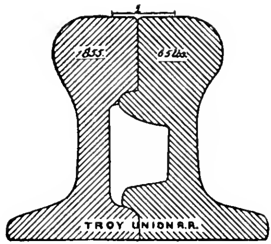
Pear-headed Rail, A.D. 1855.



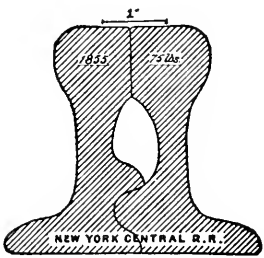
Compound Rail, New York Central Railroad, A. D. 1855.



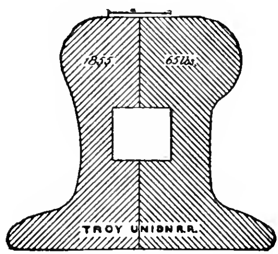
Compound Rail, A. D. 1855.



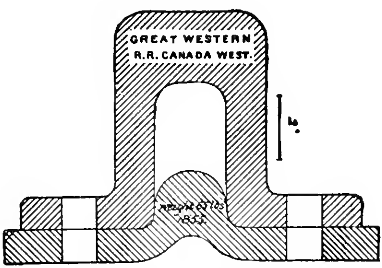
Compound Rail, A. D. 1855.



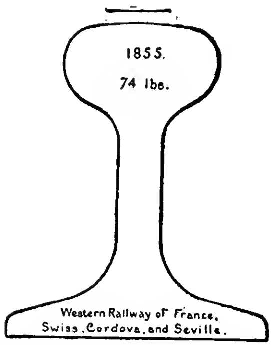
Compound Rail, A. D. 1855.



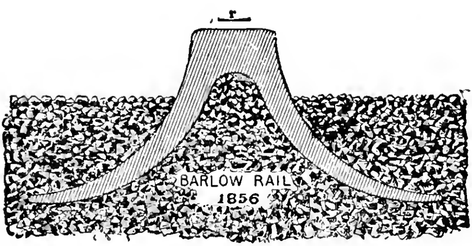
Compound Rail, A. D. 1855.



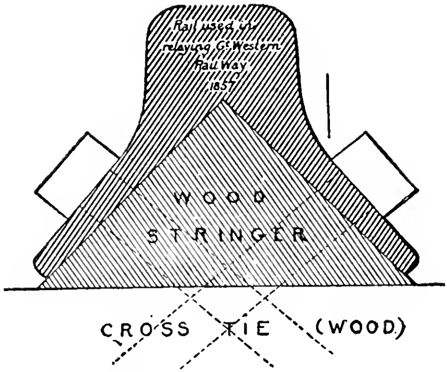
Box Rail, Great Western Railway of Canada, A. D. 1855.



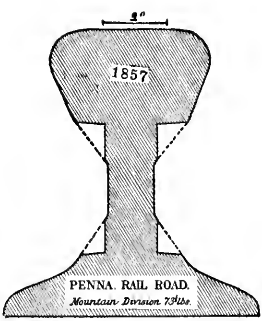
Stevens Rail in use ou the Western Railway of France, A. D. 1855.



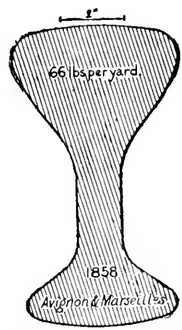
Barlow's "Saddle Back" Rail; laid without Supports, A. D. 1856.



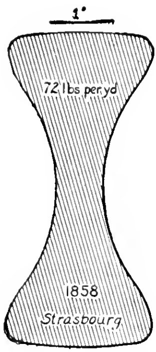
Triangular Wooden Stringer Capped with Iron, Great Western Railway of England, A. D. 1857.



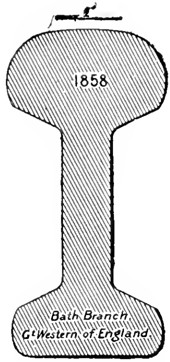
73 Pound Rail, Pennsylvania Railroad, Mountain Division. Under Head Planed for Splice, A.D. 1857.



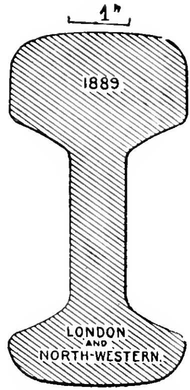
Bull-Headed Rail, Avignon and Marseilles Railway, A. D. 1858.



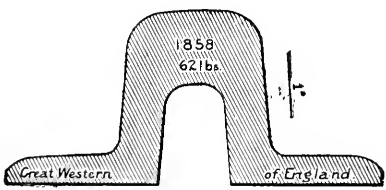
Bull - Headed Rail, Strasbourg Railway, A.D. 1858.



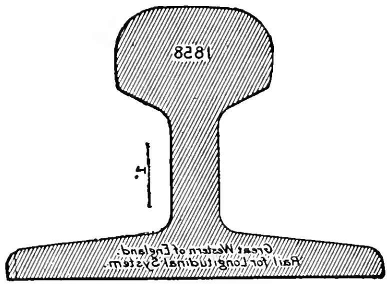
Bull-Headed Rail, Bath Branch Great Western Railway of England, A. D. 1858.



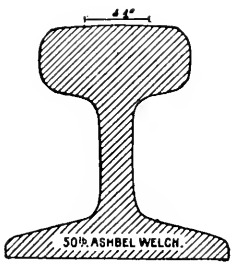
Bull - Headed Rail, London and Northwestern Railway, A. D. 1889.



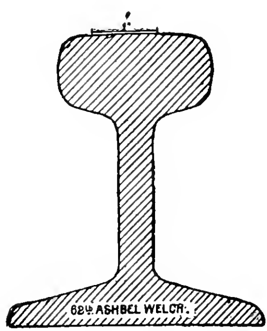
"Box Rail," Great Western Railway of England, A. D. 1858



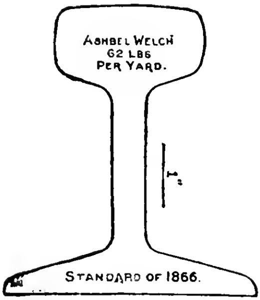
Stevens Rail laid on Great Western Railway of England, (Longitudinal System), A. D. 1858.



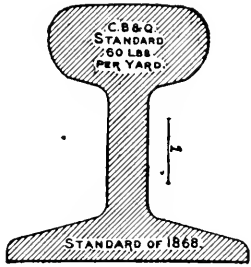
50 Pound Ashbel Welch Rail, A. D. 1866.



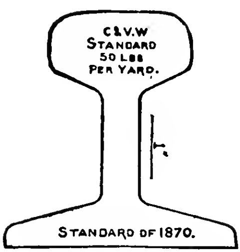
62 Pound Ashbel Welch Rail, A. D. 1866.



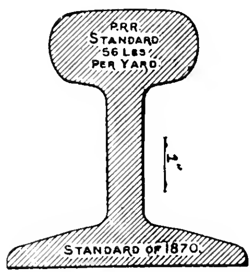
Rail Rolled by the Bethlehem Iron Company, Ashbel Welch Pattern, 62 Pounds, A. D. 1866.



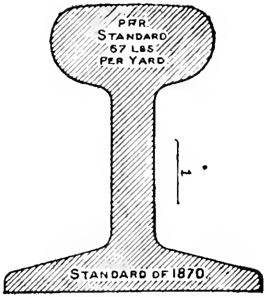
60 Pound Rail, A. D. 1868.



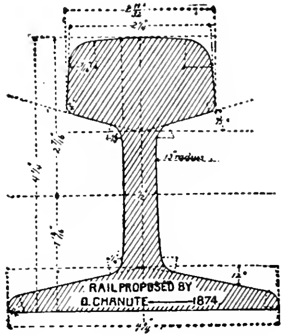
Rail Rolled by the Bethlehem Iron Company, C. and V. W. Railroad Pattern, 50 Pounds, A. D. 1870.



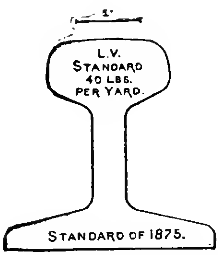
56 Pound Rail, A. D. 1870.



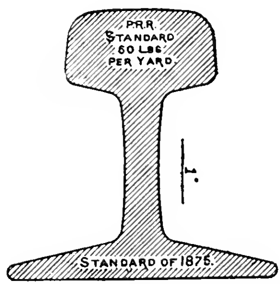
67 Pound Rail, A. D. 1870.



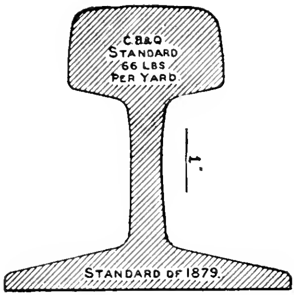
Rail Proposed by O. Chanute, A. D. 1874.



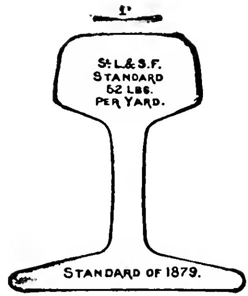
Rail Rolled by the Bethlehem Iron Company, Lehigh Valley Railroad Pattern, 40 Pounds, A. D. 1875.



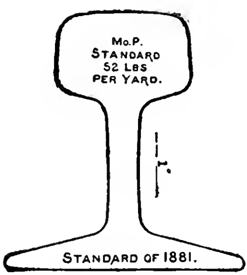
50 Pound Rail, A. D. 1875.



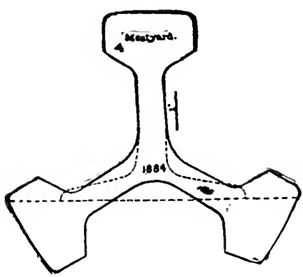
66 Pound Rail, A. D. 1879.



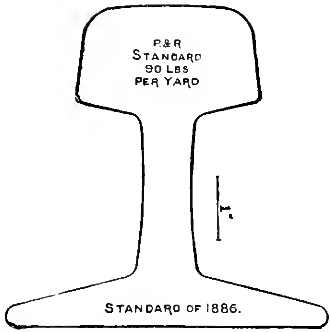
Rail Rolled by the Bethlehem Iron Company, St. Louis and Santa Fe Railroad Pattern, 52 Pounds, A. D. 1879.



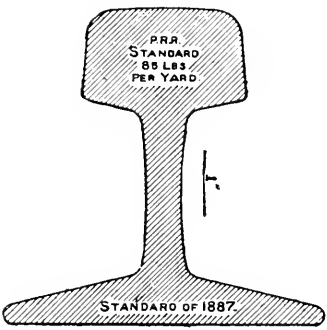
Rail Rolled by the Bethlehem Iron Company, Missouri Pacific Railroad Pattern, 52 Pounds, A. D. 1881.



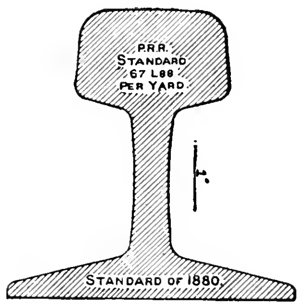
Rail Rolled by the Bethlehem Iron Company, "Meatyard Pattern," A. D. 1884.



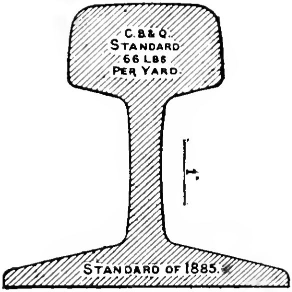
Rail Rolled by the Bethlehem Iron Company, Philadelphia and Reading Pattern, 90 Pounds, A. D. 1886.



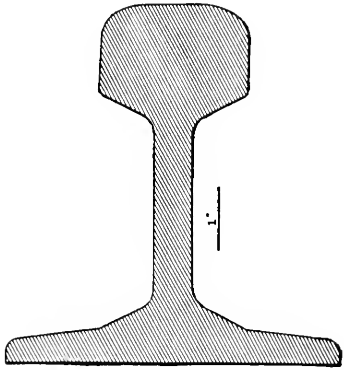
85 Pound Rail, A.D. 1887.



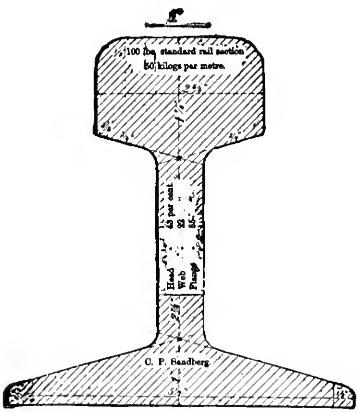
67 Pound Rail, A.D. 1880.



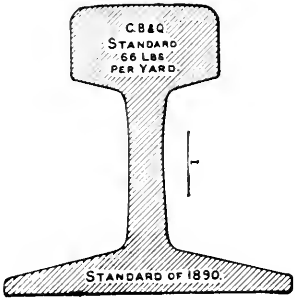
66 Pound Rail, A.D. 1885.



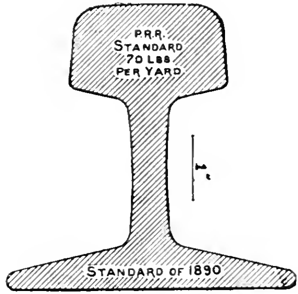
Stevens Rail, Chemin de fer du Nord, France, A. D. 1888. (Called the Vignole Rail in Europe.)



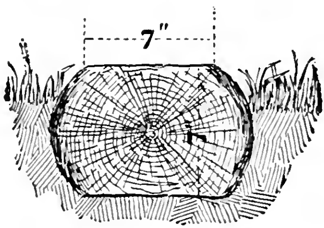
Standard Rail of Belgian Government Railways, A. D. 1889.
Sandberg Section.



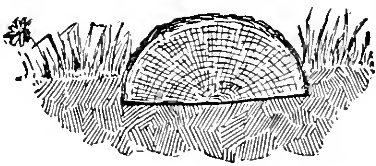
66 Pound Rail, A.D. 1890.



70 Pound Rail, A.D. 1890.

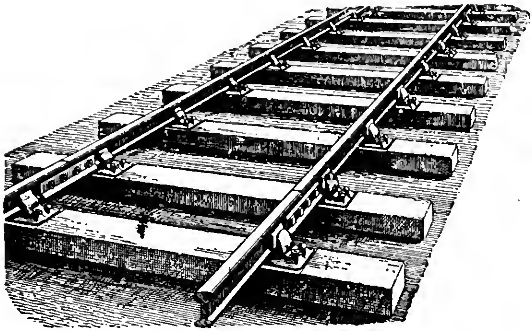


Cross Tie, Whole Log Hewn Both Sides.

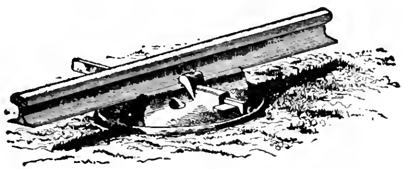


Cross Tie, Split Half Log.

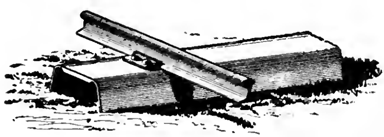
Cross Tie, Split Quarter Log.



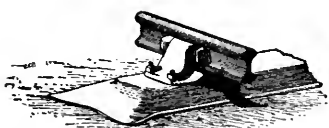
English Permanent Way.



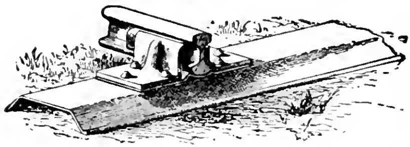
Metal "Pot" Tie System, Midland Railway of India, A. D. 1889.



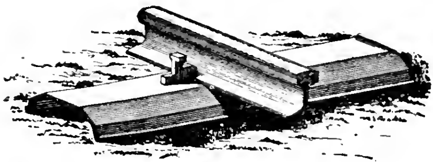
Metal Track, Normanton Line, Queensland, A. D. 1889.



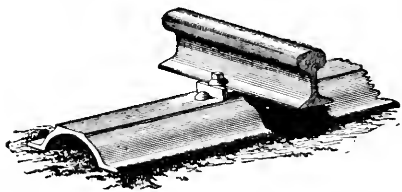
Metal Track, Midland Railway of England, A. D. 1889.



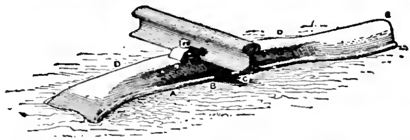
Metal Track, London and Northwestern Railway of England, A. D. 1889.



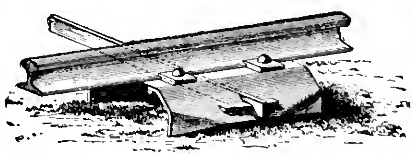
Bergh and Marche Metal Track System, Elferfeld Railway, Germany, A. D. 1889.



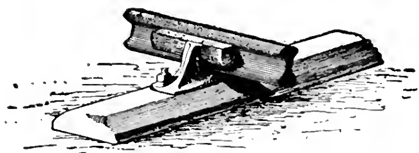
Metal Track, Great Central Railway of Belgium, A.D. 1889.



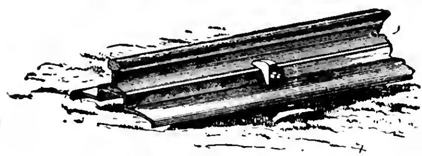
Metal Track, Holland "Post" Tie, A. D. 1889.



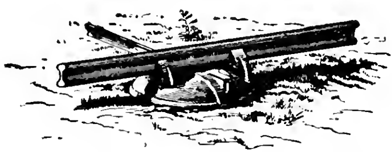
Metal Track, Egyptian Agricultural Railway, A. D. 1889.



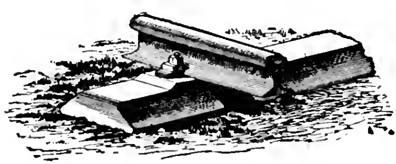
Metal Track, Vautherin System, France, A. D. 1889.



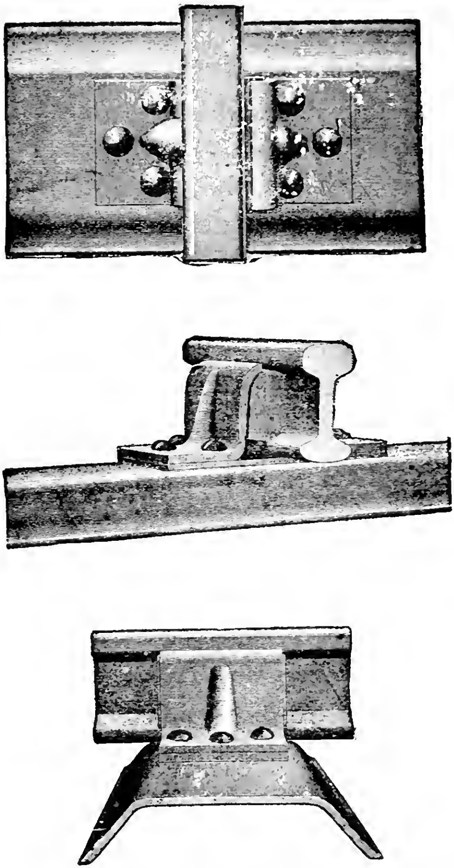
Haarman Longitudinal Metal Track, Right-Bank-of-the-Rhine Railway, A. D. 1889.



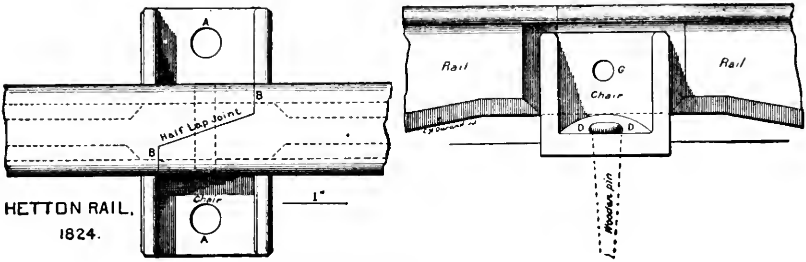
Metal Track, Central Railway, Argentine Republic, A. D. 1889.



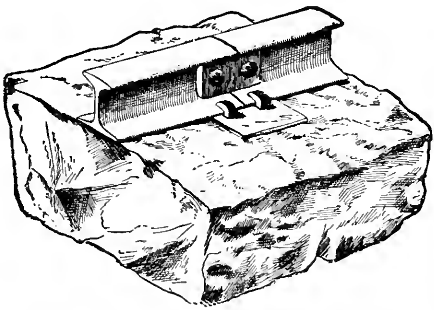
Metal Track, Bilbao and Las Arenas, Spain, A. D. 1889.



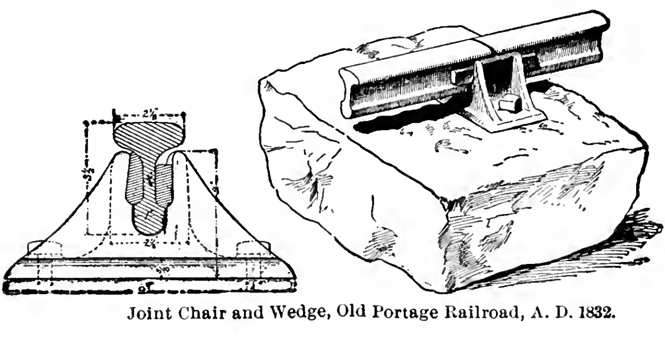
Steel Tie and Permanent Way, London and Northwestern Railway, A. D. 1885.



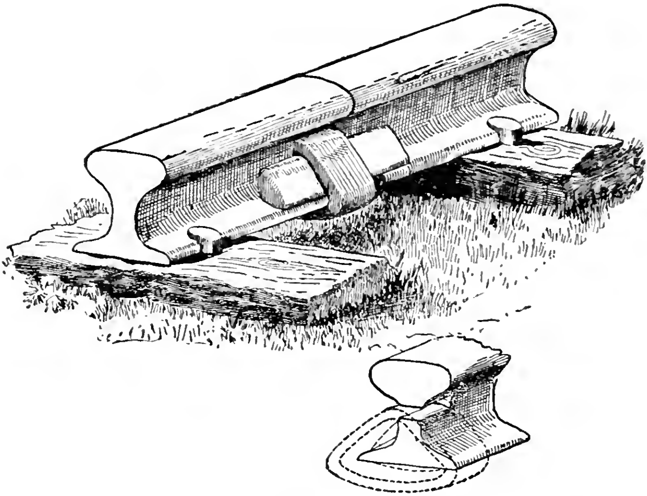
Half-Lap Joint, Hetton Rail, A. D. 1824.



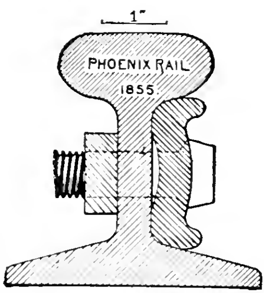
Stone Block, Rail and Joint Tongue laid on Camden and Amboy Railroad in A. D. 1831.



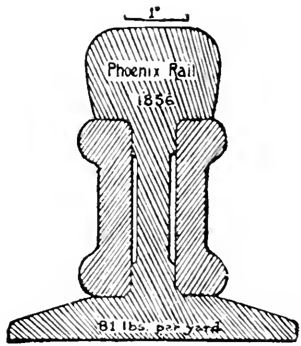
Joint Chair and Wedge, Old Portage Railroad, A. D. 1832.



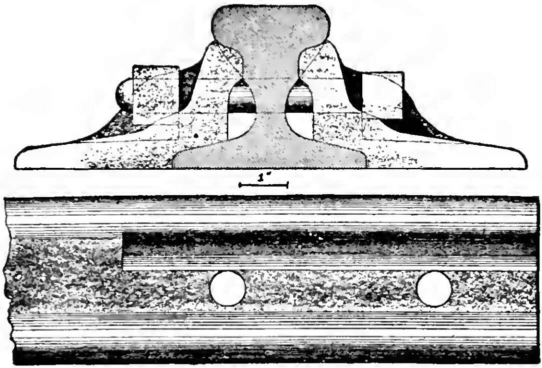
Ring, Joint and Wedge used on the West Jersey Railroad.



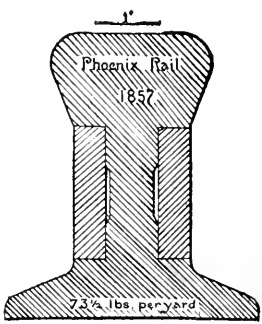
Single Splice Bar for Rail,
Rolled by the Phœnix Iron
Company, A. D. 1855.



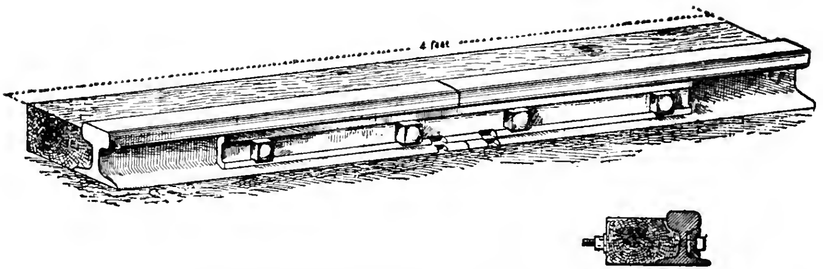
Double Splice Bar for Rail,
Rolled by the Phœnix Iron
Company, A. D. 1856.



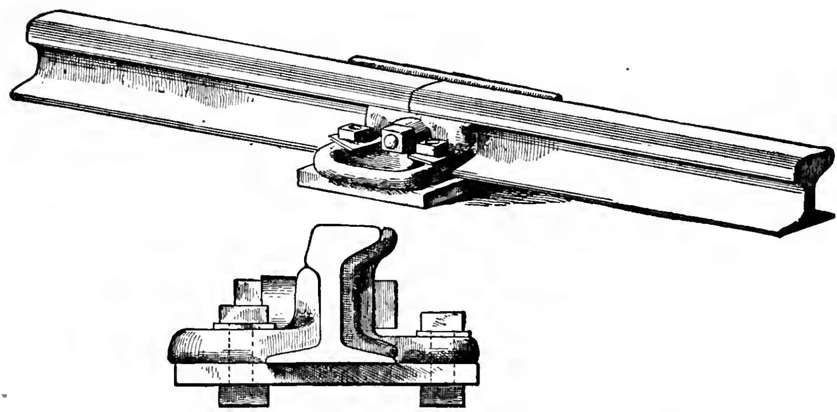
Erie Rail with Ends Stamped for Adams' Cast-Iron Bracket Splice, A. D. 1857.



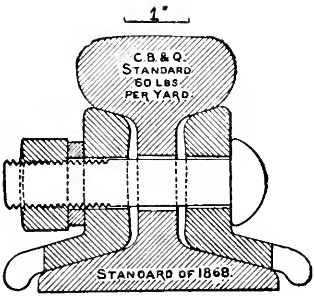
Double Splice Bar for Rail, Rolled by the Phœnix Iron Company, A. D. 1857.



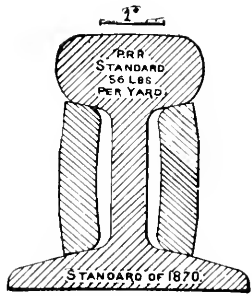
Wooden Joint Block, New Jersey Railroad, about A. D. 1860.



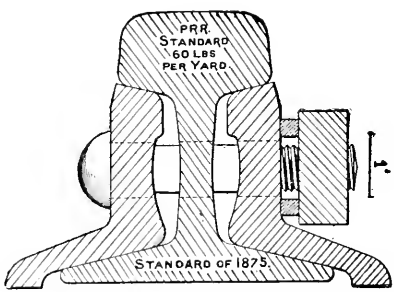
Joint Fixture used on Western Railroads, A. D. 1869.



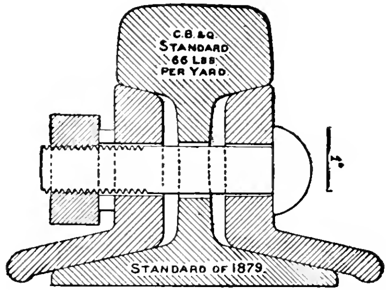
Angle Splice Bar, Chicago, Burlington and Quincy Railroad, 60 Pound Rail, A. D. 1868.



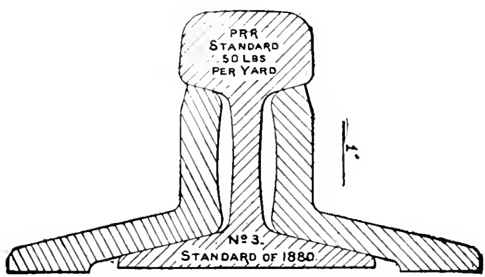
Plain Splice Bar, Pennsylvania Railroad, A. D. 1870.



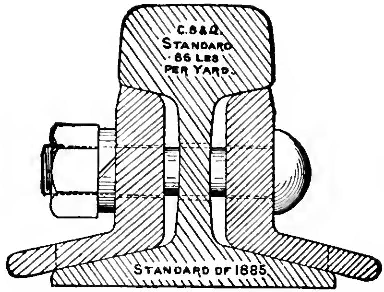
Angle Splice Bar, Pennsylvania Railroad, A. D. 1875.



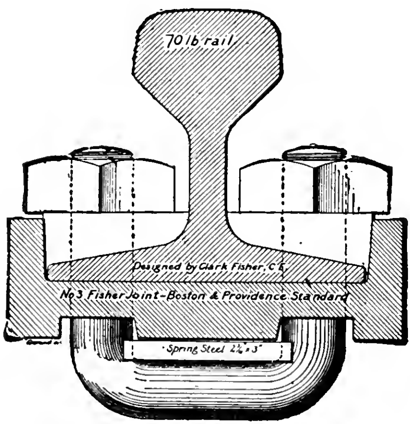
Angle Splice Bar, Chicago, Burlington and Quincy Railroad, 66 Pound Rail, A. D. 1879.



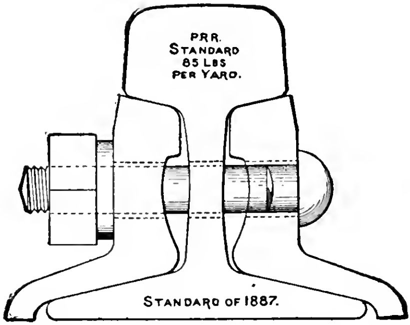
Angle Splice Bar, Pennsylvania Railroad, 50 Pound Rail, A. D. 1880.



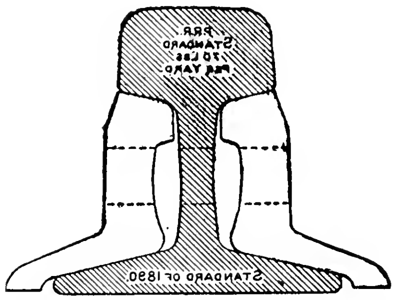
Angle Splice Bar, Chicago, Burlington and Quincy Railroad, 66 Pound Rail, A. D. 1885.



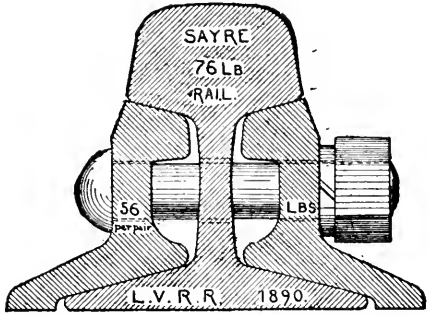
Fisher & Norris Joint Fixture as improved by Clark Fisher, A. D. 1888.



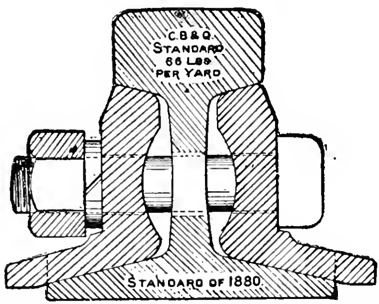
Angle Splice Bar, Pennsylvania Railroad, Standard for 85 Pound Rail, A. D. 1890.



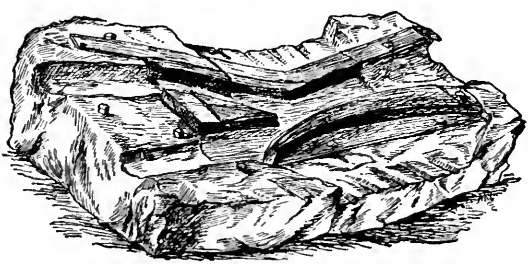
Angle Splice Bar, Pennsylvania Railroad, Standard for 70 Pound Rail, A. D. 1890.



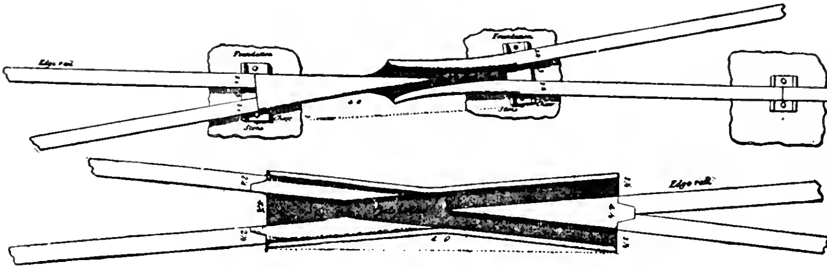
Double Angle Sayre-Fritz Splice Bar, Lehigh Valley Railroad, A. D. 1890.



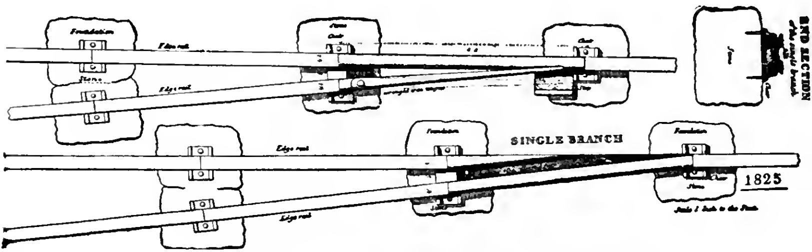
Angle Splice Bar, Chicago, Burlington and Quincy Railroad, 66 Pound Rail, A. D. 1890.



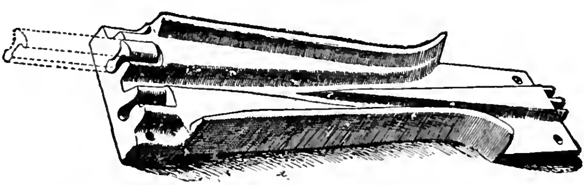
The First Frog.



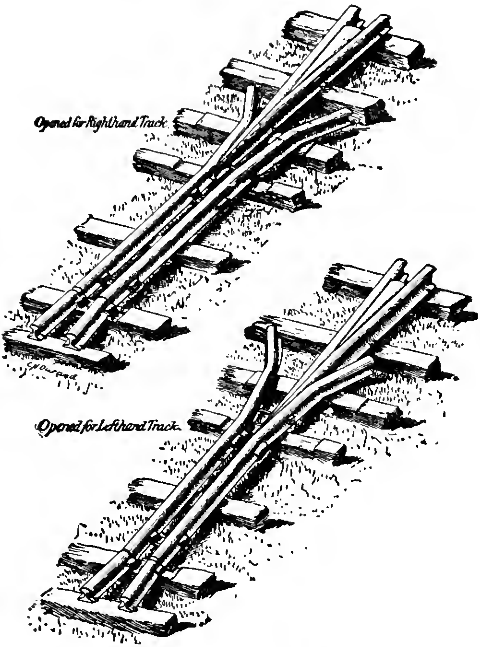
Frogs, Colliery Railroads of England, A. D. 1825.



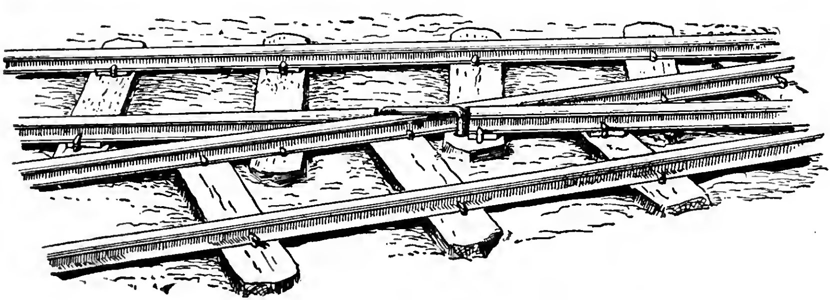
Switches in Colliery Railroads, England, A. D. 1825.



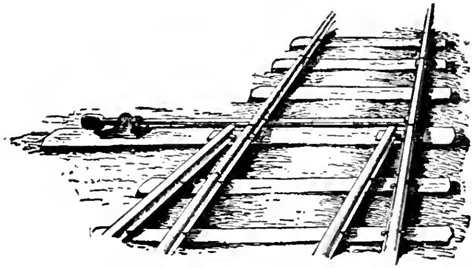
Frog, Old Portage Railroad, about A. D. 1835.



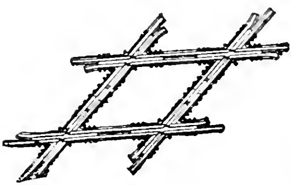
Rail Frog, invented by Joseph Wood, New Jersey, A. D. 1859.



-∩- Staple Iron used as a Makeshift for a Frog, Camden and Amboy Railroad, A. D. 1831.

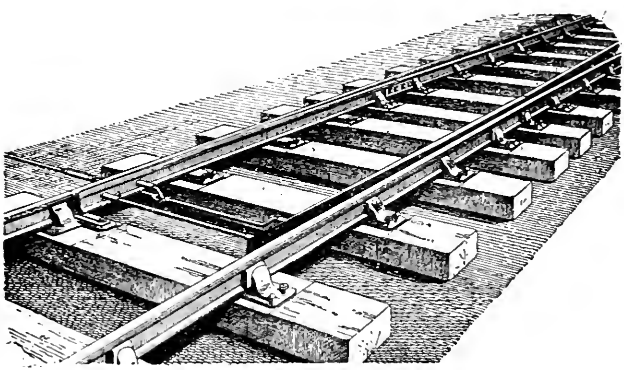


Switch with "Ball" Counter Weight.



Crossover, A. D. 1894.

Frog, A. D. 1894.



Split Switch, A. D. 1894.

APPENDIXES.

APPENDIX A.

ENGLISH METHODS OF CAPITALIZATION.

The capital of English railroads is generally represented by capital stock (called share capital), debentures, and debenture stock. The distinction between debentures and debenture stock is this: The former mature at a given date, while the latter is perpetual. In the early years debentures were generally used, but of late they have been almost entirely superseded by debenture stock.

Dividends may be declared at pleasure up to the maximum sum fixed by the government on capital shares. They may be paid at any time, or may be wholly omitted if the interests of the company require. It is a matter left to the discretion of the directors. In regard to debentures, the interest or dividend is payable at a particular time, the same as on a mortgage.

The share capital is generally of two kinds,—preferred and ordinary, the former being entitled to a certain percentage of dividend before any allotment can be made to the latter. In some cases the ordinary stock is of two classes, namely, preferred ordinary and deferred ordinary, the relation of these two in respect to dividends being the same as above stated in respect to preferred and ordinary stock. Often there are found special stocks which are known by various names and on which there is a guaranteed dividend, or whose dividend is drawn from specified sources of revenue.

In order that a company may issue debentures or debenture stock the assent of the government must first be obtained. Debentures are generally issued to the extent of one-third of the authorized share capital; but before same can be issued at least fifty per cent. of the share capital must be paid up. Railways are, however, allowed to issue debentures and debenture stock in excess of the amount of one-third of the share capital as above referred to, to enable them to make additions to their plants by the introduction of interlocking and block systems and continuous train brakes, which are chargeable against capital account, provided, however, that such additions are first ordered or approved by the Board of Trade, and in each case specific authorization must be given by the Board of Trade for the issuing of such debentures or debenture stock. The proceeds of debentures or debenture stock issued under these conditions can be used only for the construction work for account of which they are issued.

The money realized from the issue of share capital and debentures is usually received through the company's banks. In the case of share capital certificates of deposit are issued by the banks to the investors for the various installments paid in, which receipts are exchangeable for share certificates, a separate certificate being given for the nominal value of each share. When the shares have been fully paid up these certificates are converted into stock, a certificate being given for the total number of shares each investor may have, or for such multiples thereof as he may desire.

Money realized from the issue of share capital and debentures and debenture stock is applicable only for the construction of the railway and works authorized by the act of incorporation, and for the equipping of same with necessary motive power, rolling stock and machinery.

Interest warrants or coupons covering the entire length of time the debentures are issued for, are issued with them; these warrants are usually payable semi-annually upon presentation. Debentures are often so drawn that they can be renewed for a further period from the time on which they are first stated as falling due.

In reference to details of accounting the warrants for interest payable on debenture stock are made from the stock ledger kept for same, the amount being first summarized in a record kept for this purpose, on the dates on which the interest is payable. Warrants for the payment of dividends on the share capital are likewise made from the ledgers kept for the same. The ledgers for both these classes of stock are declared closed for a certain period of time preceding the date on which interest or dividends are payable, and transfers made in such stock during the period the books are closed are recorded after they are opened. The warrants for the interest on debenture stock and for dividends on share capital are posted directly to the holders of the stock. The records connected with the capital of railroads, while not complicated, are more or less extensive, as they must give a clear and full history of the entire matter, and a complete statement of the status of the various classes of the capital at all times. Among the more important information which the records show may be mentioned the following: The name, address and description of each holder of securities, the amount of same, the number and date of certificate or certificates, when interest or dividends are due and payable, when same are paid, in what manner, etc.

LIST OF PRINCIPAL RECORDS KEPT BY ENGLISH ROADS IN CONNECTION WITH THEIR VARIOUS CLASSES OF CAPITAL.

DEBENTURE SEALING BOOK.—Gives record of money received by company through its banks and the debentures to be issued therefor. This record is used by the proper officers in executing the debentures to be issued.

REGISTER OF DEBENTURES.—Gives the number, date and amount of the debenture, name, address and description of holder, number, date, and to whom transferred (if transferred), date of maturity, and when renewed, if renewed.

RECORD OF DEBENTURES TRANSFERRED.—Gives name, address and description of party from whom and to whom transferred, also date and number of debenture. (The Register of Debentures is written up from the Debenture Sealing Book and the Record of Debentures Transferred.)

RECORD OF DEBENTURE INTEREST COUPONS.—Gives record of interest falling due on various dates on each debenture and the number and amount of each coupon.

RECORD OF DEBENTURES FALLING DUE.—Gives record of debentures falling due on various dates, number of debentures, date of same, date of maturity, amount, etc.; also date and through what bank paid, or if not paid what disposition is made of same—whether renewed or converted into debenture stock.

DEBENTURE STOCK SEALING BOOK.

REGISTER OF DEBENTURE STOCK CERTIFICATES.

RECORD OF DEBENTURE STOCK TRANSFERRED.

The above three books give same information concerning debenture stock as do the similarly named records for debentures.

Debenture Stock Ledger.—Gives name, address and description of owner of stock, amount of stock owned by each. Entries in this record are posted from the "Register of Debenture Stock" and the "Transfer Record."

Debenture Stock Address Book.—This book is practically an index and trial balance to the Debenture Stock Ledger; it gives the name, address, description and amount of stock of each holder, and the folio of the ledger on which the account is found.

Debenture Stock Interest Register.—This book gives name of holder of debenture stock, his address and description, amount of stock held on which interest is payable, period for which interest is payable, rate, amount of interest, deduction for income tax, net amount payable, number of warrant issued, and when and through what bank it is paid. This book is written up at the dates when the interest is due, directly from the Stock Ledger, the latter being closed for a number of days to allow of this being done. The warrants are drawn from the data furnished by this record.

The records kept in connection with the share capital of the companies are practically the same as those kept for debenture stock as explained. A separate set of records is kept for each of the various classes of stock. One "Address Book," however, is made to answer for all stocks, the name and address being given in the middle of the page, on the left hand of which are separate columns for the folios of the respective ledgers, and on the right hand columns for the amount of holdings of the various classes of stock. In connection with the issuing of new shares, providing that an allotment is made, is kept an "Allotment Book," which shows the number and nominal value of the new shares allotted to each stockholder according to the terms of the resolution governing the issuing of same. This book also shows what portion, if any, of the allotment was renounced by the stockholder and what portion was taken and payments made therefor. In connection with this is also kept a share register showing the amount of cash payments made by each stockholder on the shares taken by him, also the number of such shares transferred, if any, before the same have been converted into stock.

APPENDIX B.

EXHIBIT SHOWING THE RELATION THAT THE COST OF VARIOUS CLASSES OF TRACK LABOR BEAR TO EACH OTHER.

Labor, handling rails	4.12	per cent.
Labor, handling ties	9.11	"
Labor, ballasting	13.25	"
Labor, ditching	6.11	"
Labor, freshet repairs	1.32	"
Labor, watching track	1.59	"
Labor, clearing track of snow and ice	6.82	"
Labor, clearing track of weeds and grass	6.42	"
Labor, general repairs to track, (including cutting rails)	51.26	"
	100.00	

TRACK EXPENSES.—RELATION THAT THE VARIOUS CLASSES OF TRACK EXPENSES BEAR TO TOTAL TRACK EXPENSES.

Labor, handling rails	2.34	per cent.
Labor, handling ties	5.18	"
Labor, ballasting	7.54	"
Labor, ditching	3.47	"
Labor, freshet repairs	.75	"
Labor, watching track	.90	"
Labor, clearing track of snow and ice	3.88	"
Labor, clearing track of weeds and grass	3.65	"
Labor, general repairs of track, (including cutting of rails)	29.16	"
Rails, ties, miscellaneous track material and tools	43.13	"
	100.00	

APPENDIX C.

EXHIBIT SHOWING THE RELATION THAT THE VARIOUS CLASSES OF MAINTENANCE BEAR TO THE TOTAL COST OF MAINTENANCE.

Maintenance of track..................	43.76	per cent.
Maintenance of bridges and culverts...	6.33	" "
Maintenance of buildings..............	9.03	" "
Maintenance of fences, gates and crossings...........................	1.95	" "
Maintenance of equipment	38.93	" "
	100.00	

PROPORTION THAT THE COST OF MAINTAINING THE PROPERTY OF A ROAD FOR TWENTY YEARS BEARS TO ALL OTHER OPERATING EXPENSES.

Maintenance of property..............	42.62	per cent.
Other operating expenses	57.38	" "
	100.00	

APPENDIX D.

EXHIBIT SHOWING THE PERCENTAGE OF THE TOTAL COST OF OPERATING THAT IS DUE TO MAINTENANCE OF ORGANIZATION AND THE PREVENTION OF THE DESTRUCTION OF A PROPERTY FROM NATURAL CAUSES.

NAME OF ACCOUNT.	PERCENTAGE OF THE TOTAL AMOUNT CHARGEABLE AS AN OPERATING EXPENSE THAT COMES PROPERLY UNDER THE HEAD OF FIXED CHARGES.		
Renewal of rails..................	2		
Renewal of ties....................	70		
Repairs of roadway and track....	57		
Repairs of bridges, culverts and cattle guards	75		
Repairs of buildings.............	70		
Repairs of fences, road crossings and signs.........	95		
Repairs of locomotives	8.5	In the case of a railroad not in operation the expense would be..	$5\frac{2}{3}$
Repairs of passenger cars........	9		$6\frac{4}{5}$
Repairs of freight cars...........	10		9
Telegraph expenses (maintenance)	10		
Agents...................... .	50	In making these estimates the wages of the force retained are reduced fifty per cent.	
Clerks	25		
Train force.......................	12.5		
Salaries general officers and their chief assistants	50		
Law expenses	50		
Oil, waste and tallow	1		
Stationery and printing	1		
Contingencies (and miscellaneous)	1		
Insurance	10		
FIXED CHARGES OTHER THAN OPERATING.			
Taxes	100	Except where taxes are based on earnings or special reductions can be secured.	
Interest on funded debt..........	100		
Sinking fund requirements.......	100		
Leases, contracts and agreements	100		

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