The Elements of Railroading

THE

ELEMENTS OF

RAILROADING.

A SERIES OF SHORT ESSAYS REPRINTED FROM THE RAILROAD GAZETTE.

BY

CHARLES PAINE.

PUBLISHED BY

THE RAILROAD GAZETTE, NO. 73 BROADWAY, NEW YORK.

1885.

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ELEMENTS OF RAILROADING.

CHAPTER I.

SURVEYING AND CONSTRUCTION.

THE SELECTION OF MEN—FINAL LOCATION—TACT—ACCURATE NOTES—SPECIFICATIONS—OVERSEEING—FOUNDATIONS—TRACKLAYING.

The organization of the engineering party for the survey of a new railroad is usually intended to be a temporary one, yet its results are often enduring in their effect upon the road and upon the persons engaged in the surveys; the men, who go as rodmen, chainmen, and axemen, naturally become attached to the road in one capacity or another, even if a long interval shall elapse between the first surveys and construction. When the ground is broken, they will surely be at hand, and persist in being identified with the fate of the enterprise.

It is, therefore, worth while, in the beginning, to select the men with care; and if the men, of course, all the more the officers who are to command them.

The chief engineer in charge of the surveys should be chosen for well-known ability and experience in construction, united to an acquaintance with the needs of a road in operation; and not for any other kind of availability. An ignorant and unskillful location may cost not only unnecessary sums in construction, but perpetual expenditures afterward in the cost of hauling trains, or large outlays to remedy the defects of the road as first built. We may imagine a piece of country in which the location or construction of a railroad would be a very simple matter; but a region which is at all difficult will present problems requiring a high order of talent for their solution.

These are truths which are perfectly familiar to engineers; but are so often ignored by capitalists, or by their representatives, who undertake the direction in the building of railroads, that it seems advisable to reassert them whenever there is a favorable opportunity to do so.

The best location can not be determined except upon the ground; the most trained and expert imagination can not take in from contour maps all the details which are seized on a view of the problem upon the natural scale. The maps may be of great value in its determination after a study of

the ground, or they may enable an experienced person to form an opinion as to whether a location is good or decidedly bad; but a line drawn in the office by the chief engineer, when he has not had time to visit the spot, is not sure to be the best. On this account, the final surveys should not be too much hurried; if a necessity for haste exists, then there is necessity also for more than one engineer to whom the decision of difficult problems may be confided; for, it is insisted upon, they ought to be decided in the field. It seems frequently to be supposed that it is the instruments which perform the location, and not the understanding and judgment which direct them.

It is a mistaken economy which strives to accomplish cheap surveys, or a cheap supervision of the construction of a railroad.

In setting out upon a railroad survey, it is not uncommon for a party to proceed like an army in the enemy's country, without the smallest regard to the rights of the proprietors over whose land they must pass; trampling growing crops, throwing down fences, cutting valuable trees, appropriating fence rails or fence boards to make stakes, and afterward expressing surprise at the unfriendly disposition of the owners of the soil. The dislike of the railroad company and of railroad men which this first impression engenders, frequently endures, in an agricultural community, for many years after the railway has gone into operation;

nothing could be more impolitic than such a beginning, and nothing is more unnecessary. Of course, it is not possible to avoid crossing the fields, but straggling through them can be prevented; when a fence is taken down it should be carefully restored; a valuable tree should not be cut, except upon final location; and then it should be explained to the owner that he will be paid for it. As "a soft answer turneth away wrath," so an expression of regret to him at the invasion of his domain, which duty has compelled the party to make, and an assurance that it shall do as little injury as possible, will often convert him into a friend, especially if he finds it to be true that he is not damaged more than need be. For this reason, the material for stakes should be purchased; the best way, where there is a saw-mill accessible, is to have them manufactured in bundles, and delivered at the most convenient points. They will be better stakes, and cost less than if the material for them is stolen, and they are made in the field by an axeman.

After the line has been determined, it is very prudent, and will prove most convenient, to fix it at frequent intervals by references, recorded in the note-books, to permanent objects beyond the margins of the works, such as trees, ledges, heavy bowlders, fence corners and buildings, where they can be availed of; and by reference-plugs when they can not. No one can foresee at what moment

operations may be suspended, nor for how long, nor what may befall the stakes or the center plugs, which are sometimes plowed up, often maliciously removed by persons who have a grudge to satisfy; and always exterminated by the operations of the contractors. With frequent reference points in his notes, the constructing engineer can smile at the attempts to annoy him in this way: and if the completion of the work should be delayed, even for a generation, his successor will bless him for the ready means which he has provided for restoring his line.

Having in view the various possibilities which may devolve upon another the completion of the work which he has begun, the conscientious engineer will require that all note-books shall be dated and shall state by whom the notes were written; and, so far as practicable, to what they refer. If the final location is arrived at, or what is presumed to be such, the note-books, plans and profiles having reference to it should be inscribed accordingly, and should be carefully annotated if any subsequent change is made. There is no minute detail which does not become precious to any one who follows a preceding engineer upon railroad work, and it is each one's duty to make his notes so full that they shall be easily understood by whomsoever he may be succeeded; yet the characteristic of many note-books, as also of many office plans and profiles, is meagerness; they contain nothing that could pos-

sibly be omitted, and rarely any thing by which the part of the world to which they have reference can be readily known. Of course those now referred to are the working plans. It is probable that their incompleteness is due to the haste with which nearly all office work must be done, and to the fact that no one is expected to use them except he who makes them or who has them made. Yet a title and a date, if only in pencil, will be a sure guarantee of future usefulness, and should be invariably required by instructions to all assistants and draughtsmen from their superiors. The discovery of such a date upon a plan which bore the outlines of the then condition of an important work once proved the chief means by which a great lawsuit was decided, for it enabled the principal witness to recall the circumstances under which he had made the plan, which was then only to be used for an approximate estimate; but, after ten or twelve years had elapsed, became valuable for a final one.

There should always be more than one copy of all notes of information which is likely to be permanently valuable. Immense damage and uncertainty may result from the loss of a note-book, if it contains, for instance, the only notes of the first cross-sections of borrow pits or other excavations; a loss which is not only possible, but, according to experience, is a frequent one. Even if the information which is lost could be recovered, it is

cheaper and more convenient to have recorded it in the office, than to be compelled to make another survey. Let no haste, or other consideration, tempt an engineer to permit any excavation to be attacked, before all the cross-sections of the surface have been taken which will be required for an accurate estimate; for he can not foresee the causes of delay which may intervene before he can perform the leveling, after the digging has begun.

Shrewd contractors are on the look-out for such instances of neglect, and will take advantage of them, when they claim, as they often do at the last, an underestimate. At such a time, when before the courts, the engineer's judgment or recollection as to the surface of the ground is no more valuable than that of the contractor's foreman; but his instrumental determination of it is generally conclusive.

Specifications generally do, and always should provide that borrow-pits must be finished to regular lines and surfaces, according to the direction of the engineer; yet they are almost always left unfinished to any line and in a condition to be an eyesore to every traveler; filled with scattered stumps, bowlders and pools of stagnant water, making the area over which they extend unfit for any use whatever.

Even if some small economy were effected by leaving them in this disorderly state, it could not justify the conversion of a fair piece of hillside or

meadow into a hideous pit, to deface the railroad margin and the neighborhood; but usually the contract price covers the cost of having the ground left in acceptable shape, and only the engineer in charge is to blame that it is not left so. He should remember that, although he may be building through a wilderness, his work is likely to make it "blossom as the rose," for population surely follows the railroad. Even in the wilderness the roadway should be neat and orderly, first, as a matter of discipline, and second, because it is easier and cheaper to keep it so than neglect it. The twigs and weeds can be easily mowed, and burned while small; if neglected, they will intrude beyond endurance, and when they have grown strong the task of clearing the roadway is a serious one. It is not alone as to borrow-pits that the specifications are not enforced, or purposely say more than they intend, leading to loose habits and bad work; for the contractor seeks to avoid compliance in particulars of importance, because others of less consequence are not firmly insisted upon. The just way is carefully to prescribe in them exactly what will be required, and no more.

In nothing is the mechanical law, that what is gained in speed is lost in power, more clearly exemplified than in the engineering department of a railway, both in surveys and in construction. If there is much important work, and it is to be *pushed*, the number of the engineers in charge

must be increased in proportion to the vigor required. One engineer, however competent, is physically capable of only a certain amount of oversight, and no satisfactory results can be relied upon except through supervision by persons of judgment and experience. The faults of construction which have been lamented upon so many railroads, after they have gone into operation, have been due chiefly to the insufficiency of the engineering force employed. If a sufficient number of assistants have been engaged, the low rate of pay allowed has not been enough to secure men of experience to decide wisely the innumerable problems which must be promptly settled, so that the work shall not be delayed. Left to himself, the chief engineer, if competent, will rarely fail to provide an efficient and capable staff; he is generally limited in this respect by the financial administration, and makes up by his own overwork so much of the deficiency as he can. The remedy for this must, perhaps, be left to time, showing by unfortunate experiences the bad results of a mistaken policy. Examples are plenty enough already, if they had their due effect.

It would be better for the company that the chief engineer should err in having too many competent assistants, rather than by having employed too few; for the loss in the first instance would be limited to a few salaries, and to the period of con-

struction; in the last instance the damage may be incalculable and perpetual.

The most critical of all work upon a railway is the construction of foundations, whether for the more important bridges or for culverts which are comparatively insignificant in magnitude, but which may involve, by their failure, the most serious destruction of life and interruption of traffic. The decision of the vital questions affecting these smaller structures, as the depth to which the excavation shall be carried, and the sufficiency of the bottom, is very often left to the sub-assistant, which is really a criminal neglect of duty on the part of the division engineer, if it comes from laziness or indifference on his part; if from having too much else to attend to, he is certainly bound to protest to his superiors against being compelled to neglect the most important service upon which he can be employed. There are occasional failures of works of masonry due to their faulty workmanship, or to an insufficient thickness of the walls, but they are rare in comparison with the numbers which fail from defective foundations, and it is to this part of his work that the engineer, the less experienced one particularly, should give his most earnest study. With all the information which he may derive from text-books and from the published examples of the works of others, he will find occasions for the use of his best common sense to apply his learning to the case in hand.

The great value of concrete in foundations is slowly coming to be appreciated, yet is not availed of largely in railway works, except those of the most imposing character; while the cheapness, convenience and superiority in all respects to any other sort of base, should recommend it for universal use. It enables the engineer to build his superstructure on a monolith as long, as wide and as deep as he may think best to construct, which can not fail in parts, but must go all together, if of suitable proportions.

We are favored in this country with cheap natural cements of excellent quality, seldom quite equal to the artificial cements in strength, but sufficient for all needs in walls and foundations, if properly chosen and carefully inspected; but nothing is more likely to vary than one lot of cement from another of the same manufacture. It demands, therefore, great care in its use to obtain the best results; but these are so valuable when attained, that no masonry should now be built without cement mortar. The common mortar of quicklime and sand is not fit for thick walls, because it depends upon the slow action of the atmosphere for hardening it, and, being excluded from the air by the surrounding masonry, the mortar in the interior of the mass hardens only after the lapse of years, or perhaps never; the mortar of cement, if of good quality, sets immediately, and continues to harden without contact with the air, and, so far as is known, forever.

At the time when tracklaying begins, the engineering force is fully employed in hastening the completion of the grading, running lines and centers, and is probably harassed also by the demand for final estimates from impatient contractors. It will often be convenient, therefore, to place the inspection of lumber, sleepers, rails, spikes, bolts, angle-plates and similar supplies for the superstructure, in charge of a separate department organized to receive and forward these materials to the places where they are to be used. The inspector can usually act as a tallyman and as a forwarding agent also; he should be governed in his inspection by the specifications from the engineers.

However this may be arranged, it will be found advantageous to have all supplies inspected, and as near to the place of manufacture as possible; for there will often be some materials offered which ought to be rejected, and there will be no loss suffered from transportation, and therefore less occasion for protests on the part of manufacturers when they are thrown out before shipment.

Steel rails need to be examined to insure that they are not brittle, that they are straight, of exact height, not depressed at the ends (a common and serious defect, and not to be remedied in the track, is this depression), and that they do not vary unreasonably in length. Of course they must be inspected for flaws; but the mills do that

usually quite thoroughly, since they have a good market for rails of second quality. The common defects in spikes are brittleness and imperfect points; in joint-bolts, bad material, loose nuts, shallow threads; in angle-plates, a variation from the true section which makes them fit badly—a serious and not uncommon fault. It will require careful tallying and careful accounting to keep track of all the materials, to insure that none are stolen, and, more than all, that none are wasted. If track is laid by contractors, the proper allowance of them per mile should be determined and delivered to them upon receipts; otherwise the spikes and joint-bolts will be scattered and buried, as if they were without value.

CHAPTER II.

REAL ESTATE AND RECORDS.

TITLES — THE LAND DEPARTMENT — ACQUIRING TITLES — TITLE RECORDS—MAPS—A MODERN INSTANCE—PRESERVATION OF RECORDS—RETAINING POSSESSION—MISCELLANEOUS REPORTS.

The titles by which real estate or landed property is held have always been the object of peculiar care among civilized nations, and one of the most important functions of our civil government is to provide for the accuracy and safety of the records by which they are perpetuated; so that one could expect that the conveyances taken by a railroad company would be cared for almost instinctively; yet it has been the misfortune of many a railway president or manager to find that his predecessors had given no attention to the preservation or completion of the titles to the property belonging to the company over which he had been called to preside.

It will often be found that the original deeds, or the awards in condemnation proceedings, have never reached the office of the company; they have perhaps been handed to some local attorney who acted temporarily for the company, and may be lost in one of his dustiest pigeon-holes; indeed, conjecture can scarcely go astray in guessing what may have befallen a railroad company's title deeds, if they have not been carefully looked after by some person who has had exclusive charge of them.

In the organization of a railroad company for the purpose of building a new railroad, after the engineering corps has been created, the very first necessity is the establishment of a land department with a capable officer at the head of it, who shall be responsible only to the president, or to the officer, by whatever name, who is charged with the chief responsibility in the construction of the road. The person selected for the head of the land department should have had some familiarity with land titles; if he is an experienced conveyancer, so much the better, and he must be an energetic man, who will insist on having a perfect title to each piece of property paid for. A weak man will accept almost any title that is offered. A fair lawyer of the right character is likely to prove as serviceable as any person, if he is one of those who have been trained to be methodical in the care of papers, and if he can write a legible hand.

The papers concerning land titles should not be trusted to the care of the engineer's department, as they often are; that department has too many other matters to attend to; its *personnel* is too apt to change frequently, while it is desirable that the person who has become familiar with the titles of the property shall remain in charge of them.

The engineering department should prepare a small map of each property which is to be purchased or otherwise acquired, to be firmly and permanently attached to the papers; this will render the description clear to all parties and will serve to correct any clerical error which may occur in the description.

Generally it is best that the engineer's department shall prepare the description, to be revised by the conveyancer. The most thorough examination should be made of the validity of the title to be acquired, for any plausible possession of a property will seem to most holders to justify them in giving a warranty deed to a railroad company, provided that company will pay for it. Such examinations or *searches* are most readily conducted by a reputable attorney who has been long settled in the county where the property is situated, for he will be already familiar with the history of most of the older titles in his neighborhood; yet his approval of a deed should always be accompanied by an abstract from the county records, to be carefully scrutinized by the conveyancer at head-

quarters. The president, or whoever approves the vouchers for the purchase of real estate, should refuse to sign one until it has been first certified by the conveyancer that the title acquired by the company will be good and sufficient.

The title deeds having been signed, sealed, and acknowledged before a magistrate, they must be sent to the appropriate recorder's office, and an entry of the date when they are sent should be made in some proper place. A convenient method of keeping in view all the proceedings relating to the procurement of rights of way and other properties is to make a list, in a suitable book, of all such properties in regular order, beginning at one end of the line and following through to the other end, with columns ruled in which to insert under proper headings the date when condemnation proceedings, if any, were commenced; when concluded; when deed was taken; amount paid as consideration; kind of deed, as warranty, quit-claim, or award; date of forwarding to recorder; date when returned; number and file in which the deed is to be kept; with a broad column for remarks. The entries in this book should be, at first, several lines apart, to admit of interlineation which will be required, because of discoveries which will be made of several ownerships, in what is supposed to be one property, and because of borrow-pits, station grounds and other pieces of land which will be wanted later on.

It is well, for these reasons, to give the deeds, when filed, only a provisional number, at first in pencil, corresponding with the number in the list in the book, until the final number shall have been arrived at, when they should be carefully numbered in red ink and filed in the order of numbering. Stout paper boxes, of a size to contain fifty or one hundred deeds, should be provided for them, and lettered on the outside, showing the numbers contained in each; it is sometimes convenient to note on the outside of the boxes the names of the county or townships in which the property covered by the contents of the box is situated.

The railroad company should have blank forms for its deeds prepared by its conveyancer and printed, so as to secure uniformity in style and shape, and as a convenient means of insuring against the omission of important clauses, also to save much writing, which would be necessary in using the ordinary blanks.

The deeds and all other valuable papers of any well ordered railroad company should be kept in a vault, or at least in a safe, taking care that the safe is one which will carry them through a fire; for it is incredible, almost, how often such documents have been imperiled, and how often lost, by a neglect of this most evident precaution.

As soon as the exigencies of the surveys will permit the engineer's department should be required to prepare an atlas of the property of the

railway company on a scale of not less than one inch to 100 ft., preferably upon a larger scale, showing the right of way, every outlying corner or lot, every borrow-pit, carefully surveyed and figured in the clearest manner. It is best to tint the boundaries of the railroad company with some pale color, using always the same, upon the inside of the line, to make the area owned by the company distinguishable at a glance. The atlas should be duplicate or triplicate, being traced easily on thin paper by a boy in the office, the sheets to be afterward bound into an atlas. The properties shown in these volumes should bear on the maps the names of the owners from whom they are bought, character of title, when paid for, consideration paid, so as to avoid a reference to any other list or document for such information, which is that most frequently required. It is very useful to have the names of adjoining owners in their proper places in the atlas, for it will often save a visit to the place or a special survey when additional width is required.

The distances and courses to all corners should be carefully surveyed, and their relations to the railroad boundaries should be shown and figured on the atlas. Many railroad land maps and atlases would be found not to contain one figure which would determine the exact relation of the railroad line to any other line or point whatever. It is also desirable to note in the atlas the relations of

the "center lines" to the boundaries, to the corners and to the first track laid, if only one track is laid; for without such a notation, the coming generation may be totally in the dark about them.

In the history of a certain railroad company, its board of directors and its policy were changed; from having contemplated a single track as the extent of their undertaking, during which period the first track was laid in the center of the right of way, the possibility that a second track might at some future date be required entered the presidential mind, and it was decided to lay the first track thereafter six feet to one side of the center of the right of way; yet no minute of any change appeared in the land-maps, neither in the deeds nor elsewhere, so far as the successors to the builders of the road could find. The fences had been built so irregularly that they gave no certainty, scarcely a hint, of the change, and by no means indicated where the change had been made. Suspecting such a change, however, correspondence was had with the former chief engineer and with his principal assistant; they both *believed* it had been made, did not recollect where, and both remarked that the land-maps ought to show it. Finally it was remembered that among the assistant engineers who had been stationed on many parts of the road was a painstaking man who kept a diary, and from that invaluable record he kindly sent an extract which gave all the information

required. Several law suits were necessary to maintain the boundaries established by this memorandum; yet, as about one hundred and fifty miles of road were affected by it, they had to be carried through.

The land atlas is a convenient place in which to note the position, character and elevation of bench-marks, referred to the base of levels adopted for the profiles of the line; and a profile of the natural surface plotted upon the maps is sometimes of the greatest value and convenience. It is well enough to add the grade line; but that is so much departed from, even during construction, as to be of little importance. The base adopted for its levels should be noted upon the title page of the atlas; also the date when the atlas was made. Indeed, every plan or drawing which issues from an engineer's office should be very distinctly dated. In order that one copy of this valuable atlas, which we have taken so much pains to describe, shall be certainly preserved, the several copies should not be kept together, that is, in the same building: the distribution of them depends upon the final organization adopted. The most natural destination would be one copy to the superintendent's office, one to the chief engineer's, and one to the attorney's, provided each of these had a fire-proof receptacle for his copy.

Although great trouble, uncertainty and expense must attend the loss of the title deeds of a rail-

way company, yet such losses occur every little while even with companies which are believed to be quite perfectly organized. Mention is made of a great railroad corporation which stored these papers for fifteen years in a cupboard, in shameful disorder; at last a fire destroyed every vestige of them and of its land-maps, so that its whole line required to be resurveyed, and it was years before the company's records could be restored.

The cost to a corporation of a vault for the storage of its valuable papers would be small, in comparison with the expense which their loss entails; so that it may be held to be obligatory upon the officers of a company to provide, from the first, for the positive safety of its valuable documents. A vault need not be burglar-proof, only dry and fire-proof; it can be cheaply built inside or outside of almost any building; it should be convenient of access from the offices, otherwise the papers will not be regularly returned to it.

But, however carefully the records and titles may be preserved, the land acquired may be lost by neglect, as hinted in the preceding anecdote of the unrecorded change in the position of the first track. The boundaries of the railroad company's property should be remorselessly fenced, with perfect exactness, from the beginning; heedless of the requests and suggestions which will be made by adjoining proprietors, who will wish to use the

margins of the railroad territory until they shall be required for the uses of the company.

At first, such requests do not appear unreasonable; but they should always be refused, for if the property is not included within the fences from the beginning, it is very likely to be forgotten until too late; the second fence will follow the line of the first, and so on. Twenty years, a short period in the life of a corporation, will give the adverse party, who has occupied it, permanent possession, of which advantage will surely be taken; a less period gives a right of way across or over land which has been used for a lane, or for the public to travel over. It might be worth while, upon roads approaching the age of twenty years' existence, to have the position of their fences compared with their correct place, before it is forever too late to get possession of what land has not been fenced in.

It is more than probable that many railway companies are the owners of houses occupied by their employés or by strangers, from which they ought to receive rent regularly, but do not; it sometimes happens that only some old trackman or other ancient employé knows that the buildings belong to the company. From this it will be seen how important it is to prepare for the treasurer and paymaster a rent-roll from the beginning, on which the location of every house, name of occupant, if any, and rent collectible monthly should duly appear.

Akin to the preservation of a company's title deeds, is that of the materials for its history, such as the reports made from time to time by its chief officers, and particularly the annual reports, whether printed or not; but especially if printed, for such documents are mistakenly believed to take care of themselves. The secretary is naturally the proper officer upon whom to devolve this duty. We shall never know how few railroad corporations possess even one complete file of their annual reports; yet it is known that many of the most important of them have not such a collection.

They should be bound in volumes as fast as they accumulate enough to warrant it. There should be several copies of each report so preserved, for the volumes will constantly be wanted for reference by the various departments; quite as likely by the law department as by any.

All contracts of importance should be printed, so that copies may be distributed to the officers whose duty it is to execute them, and as a security against loss.

It is not uncommon tofind division superintendents, master mechanics and others acting under contracts of which they have no knowledge, having never even seen a copy of them.

CHAPTER III.

DRAINAGE.

RESULTS OF BAD DRAINAGE—DITCHES AT TOP OF SLOPE—TILE DRAINS—POLE DRAINS—DRAINING YARDS—DITCHING—PROVISION AGAINST FLOODS.

There is probably no written book treating of the construction of roads or of railroads in which the necessity of drainage is not more or less insisted upon; yet in the building of our railways it really seems to be the last matter to be attended to. Examine any newly opened road, and you will see that the engineers have been careful to have the works completed with care, to conform to the standard sections. The assistant in charge of any division has possibly quarreled with the contractor a half-dozen times about each cutting, in order to get the slopes dressed to a true plane, instead of being left a warped surface. It would

be a marvel, nevertheless, if any measures had been taken to preserve the slopes, or the ditches at the bottom of them, which are relied upon to drain the ballast. Generally the first hard rains of spring, aided by the thawing of the frozen earth, suffice to break down the slopes, fill up the ditches, and reduce the force engaged upon maintenance of way to a condition of despair; for the ballast must become saturated with water, the outer portion of it gets filled with mud, destroying its usefulness in great part; it is not unusual for the track to be floated by the mud and water, before the ditching train can remove enough of the sloughing banks to enable the water to run away at the sides of the cut. Matters are the worst in clay cuttings, of course, although bad enough in any wet soil; that is, in any soil which does not drain itself, as sand or gravel will do, if the clay substratum is not too near. If the sloughing is very bad, it is probable that a heavy stone wall will be decided upon as the proper thing to hold the slopes back; or, where stone is scarce, the pile-driver will be called into requisition to drive a stout row or two of piles to resist the forces of Nature; but the cause of the sloughing is unaffected, it continues to undermine the banks, frequently topples over the wall, and after a few years surmounts the piles or crowds them into the cut.

Meanwhile, the mud-train has had to struggle

each fall and spring with the mud which would get over, through or around the protection which had been erected.

Now, in most cases, all this trouble could have been avoided, the perfect form of the slopes and ditches, as well as the integrity of the ballast, would have been preserved, and no one would ever have thought of building a slope wall or driving piles to hold back the mud, if the engineer who built the road had looked to the drainage.

It may be broadly stated, as a general proposition, that if the water is removed from any bank of earth, that bank will stand at a slope of one and a half to one, the usual earth slope, or at a steeper angle ; if the water is not removed from a wet bank, the slope will take a flatter angle, depending upon the degree of its saturation. The most effectual mode of removing the water from a wet cut is the cheapest one to adopt; but remove the water you must, if you wish for peace and quiet. It is best to begin at the top; most railroad men begin at the bottom, because that is nearest to the track, it may be supposed. If the cutting is through sloping ground, as most cuttings are, one side of the cut will be exposed to the flow of water from the ground above it, which should be intercepted by a ditch at the top of the slope ; a short distance back from the edge is the best. If the surface soil is porous, resting upon a clay subsoil, the ditch should be lined, if possible,

with cement or bitumen, or with plank if necessary; the object being to catch the water and *carry it away*, as an eave-trough does, not letting it soak down into the clay below, which is usually too wet already.

The next place to give trouble is the foot of the slope; the water which falls upon the slope, that which percolates through the bank, and that which comes from the ballast, unite to soak and thereby to soften the earth at the bottom of the slope, which has to sustain the entire load of the hill above, which it can do only so long as it is dry and consequently firm; as soon as it becomes soft it must yield to the pressure from above. Get this water away as quickly as you can; you can not be too quick about it. If your cut is upon a very steep grade, it is possible that you may be able to run the water off in the ditches, at the foot of the slopes; if on any ordinary grades, the best way is to lay TILE DRAINS in the bottom of the ditches at a depth, say 5 ft., sufficient to have them secure from frost, and so ready to work continuously day and night, summer and winter, which they will do if put below frost. If any springs are discovered in the slopes of the cutting, they should be piped into the main drains which you lay in the bottom of the ditches; if the whole is wet, it can be perfectly drained by lines of small tiles laid diagonally down the slopes, at intervals of from 20 to 40 ft., according to the amount

of water to be taken care of. A little experience, with a little good judgment, will enable any one to proportion the sizes of tiles used to the length and wetness of the cutting to be drained. Beginning at the mouth of a cutting with tiles of 5 in. in diameter, they may diminish in size to 3 in. at the summit of the grade to which the tiles are laid, or at the upper end of the cut. Two or three lines of tiles may be laid in the same trench if the quantity of water requires more room than is afforded by one line. The tiles for piping off the water in the slopes should not be of less than 2 in. bore. The drain tiles of round section are the best, as least likely to be removed out of line, as a little reflection will show. They are frequently made with flat bottoms; these, if canted or rolled over by any cause, must get out of line, and so interrupt the continuity of the drain. They should be one foot in length; the frequency of the joints is an advantage, as it allows the water to get readily into the drain. Whoever begins the use of drain-tiles will suppose that he must provide some porous material, like gravel, to cover them with, in order to afford a free passage for the water into the drain; but he need have no anxiety about that, for the water is bound to get in if the drain is there. A good stiff clay is the best covering for the tiles, as it does not wash nor fall into them at the joints as fine gravel does. In some very soft quicksand cuts, in which the fine

sand filled the tiles rapidly, destroying their usefulness, a thick sod was laid in the bed of the ditch, the grassy side up; the tiles were laid in this and covered with another sod, grassy side down; the ditch was then filled up with earth. The result was a very successful drain. When round tiles are used, the bottom prepared for them should be semi-circular and as nearly as possible of the exact size of the tiles, which is easily accomplished by having tools of the proper form and dimensions. The men who are accustomed to laying these drains have acquired much skill, and in ordinary soils do not disturb or handle any more material than is necessary to allow the insertion of the tiles; they will often make an opening of less than one foot in width at the top of a ditch 5 ft. deep; and they will contract for laying such drains at a price per rod which will astonish the inexperienced engineer or track-master. If an expert can be got to superintend the first operations, he will be cheap at almost any price; yet no one who will act upon these hints can go far wrong; nor will the cost of his work be any thing like that of not draining his road bed, if it is wet. When the drain is completed, if he will notice the flow of water from it and calculate the quantity which flows out each day, and consider that it never entirely ceases; he will begin to wonder where it all went to before the drain was built, and he will be entirely satisfied that the cost of

the drain was small compared with the resulting benefit. In a double-track cut, perfection of drainage is secured by laying another line of tiles between the tracks.

If, in summer, there should be little or no water passing through the drains, the moles, snakes and even muskrats will harbor in the ends of them, obstructing them with their nests. To guard against such intrusions requires some precautions, as building a small trap, or catch basin near the mouth of the drain ; a U trap has been used with success made of baked clay like the tiles. All such devices require to be cleaned out frequently, for the mud brought down in the water is deposited in them ; if not cleaned out, the drains would become obstructed, which would injure them seriously.

In very wet cuts, where the quicksand flows in faster than it can be removed, a good drain can be laid of poles, roughly trimmed of their limbs, laid heads and points, so as to keep the drain of uniform section. Such a drain from 12 in. to 18 in. square, will pass a great quantity of water, and one in each ditch will drain almost any cutting ; if there is plenty of water, it will last forever, and keep itself clear; if there is not a large flow of water, it will soon become filled up.

Let any person in charge of roadway select his wettest cutting for experiment, if he has any doubt as to the efficacy of the mode of drainage here

recommended ; and he will certainly find his track lie as still in the winter, in an excavation so drained, as if it were on a bank of gravel. But it is not important to use the methods here described ; it is of vital importance to get rid of the water, in one way or another.

The drain tiles will be found of inestimable value for the drainage of large station yards where ditches would be inconvenient, and even in such places as will admit of surface ditches, because they can and should be placed deep under the surface ; for it is of great benefit to remove all water to a distance of 5 or 6 ft. from the ballast upon which the tracks lie. Capillary attraction will raise moisture from 5 ft. in depth in sand or loam ; and when freezing weather begins, the dryer the ballast and the soil upon which it rests may be, at the depth to which freezing extends, the less heaving of the ground there will be, and consequently the slighter will be the disturbance of the track. In bad soils, the grounds surrounding shops, engine houses and station buildings are wet and uncomfortable in autumn and spring, or in any wet weather. This may be completely prevented by tile drains, provided an outlet for them can be secured. Of course the more fall there is for any drain, within reasonable limits, the better for the drain ; yet even when carried level they will do a great deal of good. By their use, the thickness of the ballast or of gravel under tracks

and around stations may be reduced about one-half—an economy which will pay well for laying the tiles, where ballasting materials are scarce.

Among the most difficult places to maintain in busy yards are the crossings of tracks, particularly those that cross nearly at right angles. Knowing this, the person in charge of the track generally excavates deeply at such a point and fills in with broken stone or with the best material he can get, providing in this way an excellent drainage well for the adjacent road-beds. If he will supplement his labors by laying drain tiles in each direction through the bed of ballast which he has prepared for his crossing, taking care to give them a free discharge, he will find that he will need do nothing more for that crossing until it is worn out. Some idea of the quantity of water discharged by these drains may be conveyed to the inexperienced if they will notice the flow from the eave-spouts of a small shed during a smart shower, and remember that an equal volume of water falls upon the same area of track or yard, soaking the ground permanently, if means are not provided for its removal. A perfectly dry cellar under a warehouse in a wet clay soil was secured by the use of these drain tiles; and in another instance they maintained the bottom of the pit of a transfer table in an excellent dry state. A water section was secured near a very wet cut

by turning the drain into a cistern ; and it happened in this case, as it might in many others, that the cistern afforded the most convenient outlet for the drains that could be had.

There are thousands of miles of imperfectly ballasted or wholly unballasted road-bed in this country, lying near the natural surface of the ground, which would be rendered passably safe against the worst effects of wet and frost, if only a deep ditch were dug on each side of the road-bed to allow the water falling on the surface to flow quickly to a considerable depth below the surface on which the sleepers rest. The chief reason why broken stone and gravel make the best ballast is that they permit the water to pass through and to flow away from them so rapidly; if other materials can be so treated as to approximate to their condition, they will approach just so nearly to them in value for supporting the track. On poor railways, where expenditures must be kept at a minimum, and where the track-master is allowed only men enough on each section to operate the hand-car, it often seems quite impossible to get any ditching done, however sore the need. The section foreman's idea of usefulness and duty is confined to "keeping up the joints and centers;" he and his men are always tamping the ties and disturbing the road-bed, when they are not screwing up the joint bolts or riding over the section on the hand-car. These are important

matters, of course, but may be overdone, while ditching is left undone. Under this conviction, in the straitened circumstances which have been described, and determined that the necessary ditches should be cut before the autumnal rains, the section foremen, upon a hundred miles of new road in operation, were told that they must not touch a joint, neither surface nor tamp any part of the track, unless it became positively dangerous; they must devote their time and energy to ditching; any foreman found doing any thing except ditching would be dismissed, unless he could offer an acceptable excuse. These orders were issued in August, with the result that by the first of November the entire line was well ditched, at all important places, and the track passed through the winter and spring very comfortably, notwithstanding a lamentable want of ballast.

The neophyte placed in charge of a division of track should be warned that the section foreman of common mold always begins a ditch at the upper end, and, however well he may carry it on, he never opens the lower end of it, so that it may discharge freely, until the track-master finds the ditch full of water and orders the necessary outlet to be provided. It is best, therefore, to give special directions about this, in each case, to begin with.

The earth thrown out of the ditches should be evenly spread over the surface outside of them,

making a gentle slope toward the ditch, whenever possible. The sooner this is done the cheaper it will be done; for freshly moved earth shovels much easier than that which has been consolidated by rain. When the earth has been spread in this way, the roadway can be cultivated or easily kept clear of brush and weeds, and as nothing is more discreditable than a disorderly roadway, this is a matter worthy of attention.

All this has no reference to what is considered the main drainage system of a railroad, which looks to provision for passing the streams and rivers safely through or under it; only on rare occasions over it. There are many large and scientific treatises on these matters, which should be studied before the tyro undertakes to act as engineer in their construction; yet there are a few hints not found in all the text-books, which may be useful.

In this country, the habits of all streams are likely to be very much altered by the building of a railroad into any new part of it. Generally the marshes will be ditched, the woods will be felled and other changes made, which will concentrate the water into fewer channels than it originally flowed through, and it will reach them much quicker than it formerly did; consequently the water-way provided for them should be very much greater than that which they would require

if they could be expected to retain their original size. The very best judgment and the largest conceivable allowance may altogether fail (and often do fail) to anticipate to what dimensions any stream may attain; but as a minimum the following has proved a tolerably safe rule: Ascertain the area occupied by the stream, at its highest known flood; double this to arrive at the area to be provided before the water shall rise above its previous flood level; and allow at least a half more of room for extra floods, before your structure can be considered full.

But, however much room may have been provided, the labors of the engineer may come to naught from the neglect to construct or maintain a clear channel for the water to enter in a direct manner or to flow freely away from the bridge, or arch or culvert. So often are these channels neglected, particularly under deep embankments, where it is somewhat difficult or fatiguing to visit them, that the track-master or superintendent who has some such structures under his charge, which he has not lately looked after, would do well to take a hand-car or special engine at once and see how they appear. They have been often found blocked with brush and flood wood, when they appeared clear and right from above; or the channel has begun to wash out at the lower end of the paving to a depth which the next flood would render dangerous; or the last flood started

an opening into the embankment behind one of the wings, etc., for all which evils there is an easy remedy, if taken in time; but after the next storm it may be too late.

CHAPTER IV.

MAIN TRACK.

THE IDEAL TRACK—BALLAST—SURFACING—JOINTS—SLEEPERS.

The foundation of all good railroading is a good track, without which, no matter how superior all other appliances and equipments may be, there can be no success. Speed, safety and economy in operating expenses, all depend upon the character of the track. Every other department of the administration may be pinched or slighted with less evil results than that of the *maintenance of way*. Doubtless the absolute minimum of expenses would exist upon a road where the condition of the track should be perfect, with nothing to be desired in the way of betterment. It might, indeed, cost too much, rendering the interest account too large in comparison with the traffic carried over it; but the expenses of operation, as repairs of roadway, of engines, of cars, would be less than have ever been realized.

An ideal track, such as this, may not be altogether attainable, yet it should be continually approached, with the knowledge that *every departure from the ideal condition is a certain cause of expense.* This perfect condition demands, first, that the surfaces of the rails shall be exactly true to the plane of the grade, so that no vertical shock shall be given to the wheels as they roll over the track; and second, that the line of the rails shall be so true that the flanges of the wheels will seldom touch them, and then without a jar. If the speed of all trains were uniform, the elevation of the outer rails could be so exactly adjusted as to fulfill this second demand upon curves, as well as upon straight lines; since, however, the speed of trains varies widely, it is necessary to "split the difference" and to accept an elevation too great for low speeds and really less than is desirable for high speeds. It is safer, with our tendency to higher speeds, to adopt a higher elevation than the average rate would require. This second demand will also compel an addition of width to the gauge, in proportion to the rate of curvature. A neglect to "spread the gauge" in this way, in the turn-outs for sidings, is a frequent cause for derailment in switching. This widening of the gauge may be larger in amount than is necessary to conform to the rule, rather than too little. Every one should know where to find the rules and tables for the super-elevation of

rails and for the widening of gauge, for they are advertised in the *Railroad Gazette.*

Too little care is taken, in general, to secure perfection of line. After curves have once been laid according to *centers* from the engineers, they are left for years, perhaps forever, subject to the eccentricities of vision of each succeeding section foreman. No human eye can be relied upon to run a true curve unaided. So, after track has been raised to final grade, each curve should be carefully run with a transit, and centers, not more that 50 ft. apart, should be permanently fixed as a constant guide for the trackmen. Perfection can not be arrived at upon straight lines without the use of the transit, and it would be profitable upon the larger roads to furnish for each section a cheap, plain transit, without graduated circle or compass, to secure better alignment and to save the time of men when lining track. Upon small roads, where there is no permanent corps of engineers, it would pay well to employ a force temporarily, to fix the lines by permanent stakes.

It is not very difficult to put a piece of road into a condition nearly approaching the ideal perfect state just described; the important problem for practical men is, how to keep it so. In a perfectly dry climate this problem would resolve itself into a question of the proper number of suitable sleepers, and of any material under them, which should have sufficient stability to

prevent their being pressed into it by the passing loads; but in our climate, the rain or snow will saturate and render semi-fluid all materials which will absorb much moisture; as soon as wet, these materials, such as loam or clay, yield to the pressure, and the labor which may have been expended in adjusting the track is lost. Following this comes the frost, which heaves the wet soil up, carrying the track along with it, until the spring, when the particles of ice which have distended the earth are melted, and it slumps down, affording no support whatever to the track. Evidently those materials which will hold the least moisture are the best to use for maintaining a track, and the best among such is broken stone, whether in the form of gravel or broken artificially; of which, it has been found by experience, that about two feet in depth, upon well settled embankments or in thoroughly drained cuttings, will maintain a severely worked track in fair condition throughout the year. By so much as this thickness of ballast is reduced, by so much will the labor be increased which will be necessary to keep the track in an equally good state; yet even six inches in depth under the sleepers will be of great value. Broken stone is superior to gravel in general for ballast, because there is usually some admixture of loam or clay, or of too fine sand, in gravel in its natural state. If these objectionable materials were to be screened out, or, still better,

washed out, a very excellent ballast might be in many places procured, at a less cost than by breaking up stone. Where a good supply of water can be had the cost of washing gravel need not be excessive. In hydraulic mining the ordinary cost of washing gravel for gold is stated at from two to four cents per cubic yard; for the hardest material, cemented gravel, it sometimes amounts to 12 cents.

Of natural materials the next in value for ballast is very coarse sand, because it will retain less moisture than any other except stone in a coarse form; yet it has not stability enough to support a track permanently, which, when ballasted with sand, requires a constant and large expenditure of labor in raising and retamping it. Sand is objectionable also as always more or less dusty. Furnace slags, and even hard-burned brickbats, have been used with much advantage where stone and gravel could not be got. They are friable, and, like soft stones, do not endure well the tamping necessary to consolidate the ballast under the sleepers. The harder the stone the better, if it can be broken into cubes of from one to two inches on the side, by hammers or in the crusher. It is not worth while to put expensive ballast upon new, unsettled embankments, for it will be lost; where track must be laid upon them before they have become consolidated, it should be surfaced with the best cheap material at hand.

A track laid upon good ballast of sufficient thickness, if once well surfaced and tamped, should require very little labor upon it afterward, except as renewals are needed; but when laid upon a material containing loam or clay, it will need to be constantly readjusted; yet it may be raised and tamped too often. The only hope with bad materials is that they may become consolidated, and shed the rain instead of absorbing it. This can be promoted by giving the surface as steep a slope from the center of the track each way, to the edge of the embankment or ditch, as the proper bedding of the sleepers will allow. If the earth has been freshly stirred, it will soak in all the water that falls upon it and becomes mud; of course, all the labor which has been expended in raising such a track is lost during the first heavy storm. Bad materials should never be tamped after the approach of the rainy season; the only way then to raise the low places is by wooden shims between the sleepers and the rails until the dry season comes round again. The poorer the ballast the more grass will grow in it; when allowed to vegetate undisturbed it will soon work much harm to the ballast, and ought therefore to be promptly removed. Special tools are made for cutting up the grass in gravelly road-beds, without disturbing the surface too deeply, and more rapidly than it can be done with a shovel.

Next in importance to good drainage and good

ballast, in the maintenance of a railroad, is a first-rate joint for the rails. For a very long time, in this country, experiments were confined to seeking the cheapest device which would carry a train safely; it did not enter the minds of men to invent the best possible joint regardless of cost, as they ought to have done first; when, having found a perfect standard, they might have calculated how far they could afford to depart from it. It is likely that they would have become satisfied, very soon, that the best joint is the cheapest in the long run; for it is a difficult thing to hold together stiffly the adjacent ends of two shallow bars, such as our rails, under the impact of the heavily loaded wheels of a railroad train. The first fish-plates used were little more than a hinge; the short angle plates leave something to be desired; laid between the sleepers, they certainly have not fulfilled the expectations of their advocates; lengthened to extend over three sleepers, one of which is under the joint, they make a splice which carries the wheels better than any thing yet tried.

For a long time, it has been an unsettled question whether to lay the joints, in the two lines of rails which constitute a track, opposite or alternating; theory, of course, would counsel that they should alternate, yet the weak joints used at first caused a track so laid to impart a rolling motion to the train, which was more disagreeable that the

square jump made when the joints were opposite; a remembrance of this still survives among old track-masters, who are reluctant to believe that this objection has been overcome by strengthening the joint; nevertheless, they may convince themselves of the truth by riding over a good track so laid, or by inspecting the diagrams taken by Mr. P. H. Dudley's admirable testing car, which prove it conclusively.

The best *sleepers* (the name cross-tie is a mistaken use of a word which belongs to the bridge builders) are of white oak; they should be peeled, with ends squared exactly to length. As they cost less here than steel rails, we can afford to use more of them under the rails, rather than to increase the height or weight of the rails, one or the other of which things ought to be done, on many of our railroads; for the sleepers should be so near together that there will be no sensible deflection of the rails between them, under the heaviest loads, which is not the condition now generally existing. An extensive use of iron or steel for sleepers will not probably prevail in this country, for many years yet. The impossibility of getting strong, durable timber sleepers at reasonable cost, has led to the use of metal ones in countries where there is very little or no frost; in this land, where every thing is more or less rigid in winter from freezing, the superior elasticity of wood under the rails will continue to make wooden

sleepers preferred ; and if they were to be creosoted, they might prove not only better on this account, and cheaper, but even as durable as the iron ones. It is a question at this time, worth the attention of managers, whether or not it would be profitable to creosote them ; probably the slightly increased cost of handling would be more than repaid by the increased durability of the sleepers, to those roads which import their supplies of them through one or two depots.

Chestnut and the best Southern yellow pine rank next after white oak in value for sleepers; other woods are either very much inferior to these in durability in their natural state, or are to be had in too small quantities to make it worth while to classify them. There are many kinds which would be very valuable if creosoted ; the requisites then would be that they should possess a firmness of fiber sufficient to stand up under the load of trains, and to hold a spike. There are several other processes for preserving timber which would be of value, yet creosoting has established itself as the most satisfactory one for sleepers.

CHAPTER V.

TRACKMEN AND SIDINGS.

THE TREATMENT OF TRACKMEN — TOOLS AND EQUIPMENT—SHOVELING SNOW—LOCATING SIDINGS—FROGS AND SWITCHES.

Although the better the track the fewer the men required to keep it in good order, yet a certain number will be required upon any track to look after it and to make immediate repairs when needed; and, as in other work, experience is of value in the performance of the duties of a laborer on track. If he is possessed of a little judgment he will waste less time about a job than if he has none; so that old trackmen who have been under the training of a good foreman are entitled to be classed as *skilled laborers*, and a railroad company should try, by a little increase of wages and of privileges, to keep them in its service rather than to allow them to be replaced by green men. The same is true as to foremen in a greater degree. They are, indeed, every-

where paid as skilled men; yet the value to a company of a trusty man, who is acquainted with his section and who has learned how to keep his men well at work, and how to teach them, is not always appreciated. Such men are rare and are the most necessary to the proper maintenance of the track. It should be the aim of every trackmaster or supervisor to increase their number; for this reason, and to add to the efficiency of the track force, it is advisable to have at least two foremen in embryo, upon each section, distinguished by authority and by a small increase in wages from the other men; the higher in rank may be called assistant foreman and the other spiker. These small allowances in their pay will be well returned to any company, if the track-master has selected the promoted men with judgment. It has been found useful, as a means of discipline and of instruction, to require frequent written reports from the section foremen; they should not be too long nor relating to unimportant matters; but they may embrace all the statistics which would be useful, and convey lucid information as to any notable events which occur on the section. Printed forms containing questions to be answered assist in giving an idea of the information wanted.

It is common enough to find a severe economy as to the number of men employed, upon roads where very little attention is given to economizing their time, by providing them, for instance, with

hand cars which run easily and with cold chisels which will stand to cut a rail, or claw-bars which will really pull a spike; and on such roads the working trains will generally be equipped with the least useful engines, which will get stalled in the pit or even on the main track, resulting in the loss of hours of the time of the men. A little reflection, or a brief calculation, should convince any railroad officer that such neglect involves the most useless waste. Better to pay the highest price for the hire of a serviceable locomotive, rather than to use an incompetent one for a working train. On roads where this train is required to serve at distant places, boarding cars with arrangements for lodging the men will prove very economical of their time, and will more than repay the cost of fitting up. The force may then be laid off at any siding, at night, without unnecessary running to headquarters.

It is not everywhere made one of the special duties of the trackmen to clear the road of snow in the winter, depending upon the snow-plows run by the locomotives to accomplish this; yet a force on foot, armed with shovels, can often anticipate the plow, or lend great effect to its finishing work by roughly trenching the drifted cuttings. In fact, the quickest mode of opening a badly-drifted road is by shovelers rather than by locomotives. It is an excellent plan, on such a road, to authorize each section foreman to hire as many men as

he can after a violent storm, to help in clearing the track. The whole neighborhood will generally assist with great cheerfulness, and the drifts will have disappeared in no time, if the wind has gone down. Immense service in clearing away the snow cheaply may be rendered, on tracks not too busily occupied by traffic, by snow-plows of rough planks, such as are used for common roads, drawn by oxen. Such means are not to be despised, even on great main lines, where several locomotives frequently fail to drive through the most magnificent regulation plow on wheels. The principle of overcoming the enemy in detail, or in small detachments, is well illustrated in the successful "fighting of snow-drifts."

Whenever a siding is to be laid, leading out of a main track over which the trains run rapidly, a new source of danger is introduced into the operations of the road, and it should be a matter of grave reflection how to construct it in the manner which will involve the fewest chances of accident. The most convenient or the least expensive position for the switches may be where they will be the most concealed from the view of approaching trains; and it would be better, in the long run, to spend a larger sum for the sake of having them visible from afar, or to protect them by interlocked danger signals, at a safe distance.

In England, the risks from "facing points," that is, from switches leading out of the line from

the direction in which the train is moving, were formerly regarded as so considerable, that on many roads none were permitted; any train taking the siding had to run by and back in; and although the exigencies of traffic have now compelled the use of "facing points" there, they are generally guarded by devices for locking them which insure that they are *well home*, before a train is allowed to pass.

In the United States, the enormous number of accidents occurring at switches and frogs goes to prove that a distrust of them is warranted and that we can not guard them too carefully.

There are a few suggestions which may be borne in mind, when a siding is to be located. It is better to place it on the outside of a curve than on the inside; for, when occupied by a train, the view of the line from the main tracks will not then be obscured. The *cross-overs* from one main track to the other may almost always be arranged so as to avoid facing points; even if safety switches are used, it is safer to run from than against the points of the frogs. It is prudent to place switches as far from bridges or deep ravines as the circumstances will admit, so that if any thing about them were to fail, the locomotive may not certainly plunge into a gulf. When sidings are upon a grade inclined toward the main track, they should open into a safety-end by a switch which should be kept set for the safety-end, ex-

cept when communication with the main track is desired; so that if cars are moved down the grade by wind or by gravity, they will not foul the main line. If the switch which leads into the safety-end is interlocked with that in the main track, so that it shall always move with it, it will avoid mistakes on the part of trainmen. This is a much safer arrangement than beams of wood or iron fastened across the siding, although even that device is better than to make no provision against one of the common causes of accident. It is often convenient, upon a road with double track, to place a siding for meeting and passing trains between the main tracks and communicating with both of them. In such a case it is best to make it long enough to accommodate two ordinary trains or, better, two of the longest trains, for they will be quite sure to reach it together. In general, however, sidings are more convenient, even for *meeting points*, if at the side of the main tracks; if not too far from the one to the next, having in view the volume of traffic upon the road, they may be laid out alternately on one side and the other of a road with double main track, avoiding to a great extent the use of the cross-overs; for a train may wait a short time to be passed at a siding which leads out of its own track, rather than run further and be delayed by crossing over the other main track and back again. It is in favor of outside sidings, that

others can be led out from them without adding to the number of switches in the main track. Sidings upon the passenger side of the tracks should stop short of the passenger station, say 200 feet, if possible, never passing before it, if avoidable. Although 6 feet has been the standard width between the adjacent rails of contiguous tracks, a greater width is very desirable on many accounts. The latest instance of a double track road has 8 feet between the main tracks. Unless parallel sidings are to be used for transferring freight from car to car, a greater width than 6 feet should be taken, if possible. It is generally desirable to have a bunting post, or some other kind of a stopper at the ends of *stub* tracks, although where they are not too long for the engineer and trainmen to communicate easily together, as in passenger yards, the absence of any stopper is an effectual restraint upon careless shunting. The very best stop, where there is room, is a bank of gravel or cinders, about two feet deep, across the track; and it may be given a neat appearance by walling it in on the sides and rear. Iron brackets gripping the rails are neatest, however, and occupy least room.

It is impossible to touch upon frogs and switches without also touching inventors; yet there are general principles to which they must conform to reach the best results. For instance, as to frogs: no doubt the best are made from steel rails; no

doubt the best mode of fastening them together is by clamps and keys, so far as possible, instead of by bolts; no doubt that the rails should be worked in the planer instead of in the fire, at least in the present state of the art; no doubt that a frog for the main track should have a spring rail on the outside, to avoid the jar which is otherwise caused in passing over it at high speed. In yards, where the trains take first one track and then another, and at low speed, the movable wing rails may not be worth their extra cost. Opinions vary as to the most desirable angles to be used; it is common to use a less angle (a higher manufacturer's number) in turning out of the main line than is used in the yards. In frogs, as in almost all things used on a railroad, it is best to have a few fixed standards; the supply to be carried for repairs will be thereby much reduced. The safe use of a frog requires a guard rail, which should be strongly braced opposite the frog point, not relying upon spikes to hold it in place, as is often done. New roads will find it convenient and economical to have them furnished with the frogs, as they require to have a part of the flange cut away, and this is better done by the planer than by the cold chisel.

The standard switch of the world is some variety of the split switch; for places where it is to be constantly used, no doubt the most convenient of any possible form.

It is light, easily adjusted and taken care of, and admits of operating by an interlocking apparatus more readily than any other. It is, however, a fearful danger, if out of order. If not fitted with springs to admit of running through it when mis-set, without breaking the tie-rods, it is likely to be so run through, and to wreck the next train which passes over it; if it is fitted with springs, a little thing may prevent the point from closing, which will as surely cause an accident. Our annals are full of disasters from these causes. The only safe way is to know, by one means or another, that the switch is certainly all right before each train passes. When interlocking signals are used, the arrangements usually provide for locking the point securely in its place before the danger signal can be lowered.

Admitting the advantages of the split switch, where it is in constant use and can be watched over and attended, no switch at all is the best, where it can not be so thoroughly looked after; and the nearest approach to this is the Wharton safety switch. It is not agreeable to call names, but there is nothing with any other name to class with this. It is not a switch except when it is required for use, for it forms no part of and does not interrupt the main track; it lies inert at the side of the track, untouched by the wheels except when needed to cross them into the siding; consequently it suffers little from wear and tear; it

does not admit of rapid shunting, but should be passed over rather slowly. For use in the main tracks at country stations and sidings, which are entered by only a small portion of the traffic, it is the safest and most suitable switch yet offered.

There was a time when frogs, switches and signals were better made by each railway company for itself than any which it could buy; but this is so no longer. The manufactories devoted to the construction and perfection of these devices have now sufficient patronage to enable them to employ special tools, which will do the work better and cheaper than can be done in ordinary shops. It is therefore unwise for companies, whose shops are too small for their locomotive and car repairs, to encumber them with the manufacture of frogs and switches.

CHAPTER VI.

STATIONS.

ROOMY SITES—LOCATION—OFFICES AND WAITING-ROOMS—WATER-CLOSETS, ETC.—FREIGHT HOUSES—WATER-WORKS.

It is plain, upon the slightest consideration, that there are many circumstances which may affect and even control the site chosen and the arrangements adopted for any station; yet there are certain general principles which may be stated, according to which one would wish to build it if he could.

Upon a new road in a new country, the choice of a site will not be difficult, although there, as everywhere, an ample space of land, nearly at grade, is the first desideratum; to this, many other good reasons for another location ought to yield. For instance, a limited area, somewhat too small for present, or at any rate for future needs, may be available nearer the business center of the town; and persons interested in that property may be very anxious to have the station estab-

lished in its neighborhood; yet it is certain that the interests of the railway and of the town, so far as its future is concerned, will be promoted by the selection of the larger ground; for it is important to all parties that the station shall be large enough to allow all necessary facilities to be constructed upon a liberal scale.

However grand our anticipations may be respecting the future of any town, it is more than probable that they will be short of what may be realized in the course of twenty or fifty years; so that no harm will result to the company if a large margin of room is secured for expansion. Generally, such land can be bought, before the site of a station has been fixed upon, at the price of farming lands; and often, soon afterward, the prices for any additions to the station grounds are at the rate for town lots. It not seldom happens that the establishing in a town of one enterprising manufacturing company creates more business for the railway than its station grounds can accommodate, which is not a flattering commentary upon the foresight of its constructors.

The consideration of proximity to the business should have some force, yet not too much; for when the freight or the passengers are once mounted on wheels, a small additional distance to be traversed is of little moment.

It is very desirable, when it can be done, to

place the passenger buildings all on one side of the line, throughout its length; it makes it simpler for the passengers who are unfamiliar with the road to debark, in the night especially; and it allows of greater uniformity in the signaling arrangements. There are sometimes reasons for a departure from the general rule, but they should be important ones, such as the greater part of a city being on the other side of the track, although if the drive between the city and the station can be easily carried over or under the tracks, that ceases to be a good reason.

It is preferable to have the passenger station on the south or west side of the tracks, so that the offices which face the tracks will have an eastern or northern exposure; for this will make the occupants of them more comfortable than if placed so as to receive the direct rays of the western sun. It is a species of cruelty to require telegraph clerks or others to write all day in the glare of the sunlight; the temperature of the rooms in summer is pleasanter, too, when facing north or east.

The size of the offices is the first thing to be taken into account; a mere cupboard is not a fit place to transact any business in, still less is it a suitable place in which to compel a person to pass the greater portion of the working hours. For one person a space of 12 by 12 ft. is the least that should be allowed; two persons can get along

with less than twice this room; but when desks, chairs, ticket cases and so forth are allowed for, not with much less. It is better to allow for an increase of force at large places, rather than to have to alter and enlarge after; and it is of more importance to give room enough to the employés than to the public, for the first must occupy their offices for longer periods than the passengers do the waiting-rooms.

But the waiting-rooms should not be scrimped in size nor in comfort; at large stations, such as important junctions, passengers find it convenient often to remain at the station between trains, particularly ladies and children; the more attractive and convenient the rooms are, the oftener they will go over the road. A fire-place in each waiting-room adds not only to the cheerful appearance of the room, especially in spring or autumn, when a little fire only is needed, but it insures ventilation in the easiest way, which is a valuable result, for all public rooms should have ventilation to be comfortable, although we have become accustomed from long habit to tolerate bad air. A few chairs, of a strong pattern, which can be moved about, should always be provided in the ladies' room for the use of mothers with infants, or for persons who would like to sit in a group; it is not possible for more than three persons to talk together upon a bench, and an infant can not be suitably dandled or nursed upon one.

These are trivial matters, but they concern the rights and comforts of travelers.

So does the matter of lighting the rooms. Nowhere are the waiting-rooms so well lighted, in the day time, as in the United States; in part because we have the most cheerful sun, and in part because we have taken care to avail of it; but generally it is impossible to read at all in them after dark; not often because there are not lights enough, but that they are placed too high.

It is often difficult for the passenger to see his money or ticket, while he is buying it at the window, with sufficient distinctness to enable him to correct a mistake, if one were made.

There should be ample shelves outside of the ticket offices and telegraph offices near the windows, upon which the travelers may open out their wallets or write their dispatches. The telegraph office should have a projection on the track side, with windows commanding a view up and down the line; the hexagonal form is not so good as the rectangular, for the vision is more distinct through a pane which is parallel to the eyes than through one which is oblique.

There is more reason to fear that passenger buildings will be placed too near the track than too far away; there is too little room between the station door and the track, at almost every one in this country. This limited space is uncomfortable upon almost all occasions; and when there is

a crowd, as upon excursions or festivals, it becomes really dangerous. Not less than 24 ft. in width of platform, in front of the building, should be allowed at country stations, and more in proportion should be given as the population of the place is larger.

If drainage can be had, or if it is not necessary, the station should be provided with a cellar, to contain fuel and a furnace or steam apparatus for heating the entire building. There is no other convenient or so neat mode of storing the fuel; the risk of conflagration and the nuisance of dirt are both lessened by having only one fire to attend to, and that out of sight.

The matter of drainage will settle the question of water-closets also; if that can be secured, they are the most convenient of any form of privy, for water can be pumped by hand into a tank sufficient to provide for them, where other means do not exist. But water-closets must be kept warm enough not to freeze. Where drainage can not be had, the dry earth closet will answer the purpose perfectly; it requires no skill nor unusual labor, only energy on the part of the agent to see that it is properly attended to. The horrible vaults which have so long disgraced our civilization should not be tolerated by a respectable railroad officer, even if the improved sanitary vigilance of the towns would permit their use. There has not been any invention yet, however, which

will secure neatness on the part of the public which uses the privies; they must be watched, and attended to when necessary, at once; if neglected, the Augean stables were nothing in comparison with what they will attain to; yet that does not excuse a public corporation, which fails to provide decently those conveniences, which it professes to afford its patrons.

The urinary vessels always give much odor unless the urine is discharged into cold water; if the water, which is generally discharged at the bottom of the vessel, were allowed to fill it and to overflow at the top there would be no odor. Try this! In winter they must not be allowed to freeze, of course.

A cheap means of providing more waiting room, at a station likely to be crowded, is to place benches outside, under shed roofs or overhanging eaves; they will be frequented in any tolerable weather by smokers and by many other persons who prefer fresh air. A well with a good pump in it and a cup attached is a comfort at every station; or a drinking hydrant and even a fountain where water is abundant; either is much more attractive than a water cooler, apt to be not too well attended to. As to the surroundings, let them be neatly kept, at any rate. The addition of trees and grass with graveled paths suggests itself. Flowers are beautiful and attractive, but require more care and more expense, while they are of

less consequence. The ash heap, so common at country stations, does not seem to be needed, and the ashes spread over muddy roads will serve some good purpose if distributed not too thickly.

One side of the track being selected for the passenger side, all extra tracks, freight yards and so forth will fall naturally to the other side. The signaling arrangements which have been provided for the single or double main track will not have to be disturbed, whatever the changes the increase in freight business or yard room may occasion. If additional main tracks become necessary, as has already occurred in the life of many other railroads, it will be a simpler problem to arrange for them, if carried along on one side of the existing tracks, than if on both; and it will not be necessary in any case to move the passenger buildings. On roads already built, where a similar scheme has not been borne in mind during construction, opportunities occur to carry it out gradually, if decided upon. New buildings are frequently required and alterations are made in old ones, which can be brought into conformity with a general plan, if it exists. Much foresight and judgment are required in any scheme to avoid future changes, but this admits of keeping quite free of them on one side of the line. On general principles, it is advisable to place water tanks, and such other structures as will admit of it, at the outer limits of the premises. The most desirable

location for the freight house is on the other side of the tracks from the passenger station, not quite opposite, for that interferes with the view from the windows of the station, and gives a confined air to the arrangements generally; not too far away, for it is well to have it so near that one agent and one telegraph office can conveniently serve both the freight and the passenger station, at all but quite large towns.

The freight house should be put, at first, where it is expected permanently to remain, leaving space enough between it and the main track to admit of laying all the parallel tracks which can ever be wanted in the future. This will cost a little more to begin with, but will avoid the trouble and expense of moving the building at a future time, as also the suspension of business involved in such moving; and as the track-scales, stock-yards, platforms, cranes and other conveniences are constructed along the track which accommodates the freight-house, to place this in its permanent place is to save future alterations in the position of these. Some managers are quite unwilling to incur the expense of track-scales and cranes or derricks at stations, even of considerable importance, but experience has shown that they are a profitable investment.

Freight houses are almost always too small; built too small in the first place, they are reluctantly increased in size; business suffers in con-

sequence; cars have to serve as warehouses and are detained when in very great demand, because there is no place in the freight house for their contents.

Water stations, to be good, or at all satisfactory, must be expensive; the effort to build very cheap ones has proved this proposition, so that it is scarcely worth while to try the experiment again. A small reservoir with small pipes and supplied by a small pump cannot be relied upon to yield a large supply. To change these every little while, in order to keep pace with the growing demands of the traffic, involves the sacrifice of nearly the whole of each successive plant. It is better, therefore, to build, at first, a minimum number of water stations and to have them first-rate ones, than to construct a larger number of poor ones. This number having been fixed upon, and the desirable site of each station determined, the sources of supply which are available near each are to be examined. A sufficient quantity at all seasons of the year is the first necessity, and the next that it shall be as free as can be from the salts of lime, which form the scale in boilers. Running streams are less likely to be of hard water than springs or wells, at least during the rainy season. A convenient test of water for boiler use is to prepare a solution of white soap in rain water, or better in distilled water. A few spoonfuls of this stirred into a glass of the water

to be tested, will produce coagulation of the lime and soap, according to the quantity of salts in the water: and by treating a glass of each kind of water to be compared with the same measure of soap solution, a very marked difference will appear in a short time, if it exists. Three or four spoonfuls of a solution of oxalate of ammonia in distilled water, poured into a glass of water to be tested, will cause the salts of lime to be precipitated, and in the course of a few hours all will have settled on the bottom of the glass; by comparison of the quantity so precipitated from any two kinds of water, a very accurate knowledge can be had of their relative values for steam boiler use.

It will doubtless be found that at some of the places selected at first, sufficiently pure water in ample quantity can not be found, and some redistribution of places may be necessary. If a storage reservoir of sufficient size, not too far off, can be availed of to supply the stand-pipes, from which water is taken into the tender, by gravity, it will be best to use that as the direct source of supply to the stand-pipes; but the head of water above the rails should not be less than 25 ft.; any height above that, up to 300 ft., is all the better. With 25 ft. head, and a pipe of 8 or 10 in. in diameter between the reservoir and the stand-pipes, past the station buildings, the flow into the tender will not be too slow, and hydrants near the buildings will be available for sprinkling and use-

ful in case of fire. It is advisable to use standpipes (of not less than 7 in. opening) at first, upon a new road, even though it may be intended afterward to use the Ramsbottom troughs, or "jerk-water" system for filling the tenders while the train is in motion; because the troughs can not well be maintained except upon thoroughly settled level planes, with the track in perfect condition.

If a natural elevation for the reservoir is not available, Burnham's frost-proof tank, or its equivalent, upon posts is the next best means of storing a large quantity at a sufficient height. This may be filled by gravity or by pumping according to circumstances, remembering that one may go a long distance for a gravity supply rather than to have to pump by steam. Where there is a favorable exposure to the wind and not too large a demand to be supplied, wind-mills will pump very cheaply and satisfactorily.

Generally, it has been expected of a small windmill that it should pump as much as a more costly steam engine; whereas, a larger sum may be afforded for the wind-mill than for the steam pump, because it requires no fuel and less attendance: wear and tear are also less. Where a quantity of more than 25,000 gallons per day is needed, it is better probably to use a steam pump than a windmill. In all cases, it is advisable to use larger pipes than have been generally employed for pumping through: for the demand upon them is

almost sure to increase. A pump that proves too small can be easily moved to another place where it will be useful, and a substitute provided which will be satisfactory, without much loss; but it is a very expensive job to replace a long line of pipe. It is also in favor of the larger pipe that it takes less coal to pump a given quantity of water through it than through the smaller one.

Wooden pipes bound with a spiral of hoop iron and coated with coal tar are least costly and have proved very satisfactory and durable in wet soils. In other soils, cast-iron pipes coated outside and inside with coal-tar preparations are certainly as good as any.

It is important and useful to have standard patterns and uniform arrangements in the water works of a railroad company as in any other department, and an experienced, intelligent superintendent of water works, who is penetrated by this conviction, will be of untold value to the company which he serves.

CHAPTER VII.

SHOPS AND ENGINE HOUSES.

LOCATION—BUILDINGS—HEATING—FOUNDRY—INTERIOR FITTINGS — SANITARY ARRANGEMENTS — CRANES — ROUND-HOUSES—TURN-TABLES.

The best location for the machine shops for repairs of locomotives, upon a road less than two hundred miles long, is at one of the termini; upon a longer road, they should be placed as near the middle as may be; upon a very long road with branches, as near the center of traffic as may be; always supposing that a sufficiently large tract of nearly level ground can there be obtained upon which to place them. It would be wiser to pay a large sum for a suitable area, well situated, than to accept another unsuitable, or one not well situated, for nothing. Generally, however, the erection of shops is regarded as of so much advantage to any town or neighborhood that the necessary land will readily be given by its citizens to secure them.

If near to a city of from ten to fifty thousand inhabitants, not in it, but so near that the workmen and their families can easily go to the town "to trade," it will be an advantage. It is a very common mistake to take too little land, even by donation, at first, and afterward to pay for additions much more than the entire area finally acquired would have cost in the beginning, because of the enhanced value of property due to the shops. This increase in the value of adjoining lands may be certainly counted upon, and ought to be availed of, by any railway company which pays for the land used for its shops, by buying the adjacent ground, to be sold or leased to employés and others.

The area required for the buildings and yards about them will vary in every instance with the particular road for which they are designed; but from an examination of the grounds occupied by similar establishments already erected, and observing that they are almost always in need of more room, a liberal mind may arrive at an approximation to the probable requirements. It is better to err, in a matter of so much importance, upon the safe side, and to be sure of enough.

It is much more economical for any road to have one grand machine shop, at which all the principal work of construction and of heavy repairs shall be done, than several smaller ones. The best and cheapest work is done by costly special machinery,

which ought to be provided for any great establishment, but can not be afforded for several shops; such machines are generally capable of doing all the work that could be required of them for the largest road, and need not be duplicated if the important repairs are concentrated at one place. The number of high-priced men to be employed is lessened by having the work which requires the best skill and superintendence all executed at one shop; and this will also assist much in securing uniformity and interchangeability of parts in engines and cars. Small adjuncts at engine-houses, fitted with a forge, drill, lathe and small planer, are necessary, of course, and are not referred to here in speaking of shops.

The shops for the construction and repairs of cars should be at one of the termini, on a short road; and at both of them and in the middle upon a longer road; it is convenient and economical to associate one of them with the principal machine shops, if not upon a very large scale: if it is to be a great shop, it will require a separate outfit of tools and a special staff of foremen, so that there will be no advantage in such a connection. Usually only one of the car shops need be upon a grand scale; but cars are less substantially built than locomotives and are very much more numerous; there is therefore a necessity for more shops in which to repair cars than for repairing engines.

The cost of buildings of equal character is somewhat in proportion to their cubic contents. In disregard of this fact, many shops have been built with high roofs and with trusses of wide span, involving not only useless cost but other disadvantages without corresponding gain. Shops built with walls high enough for the uses which they are to serve, with low roofs, as flat as may be, say with a slope of 1 in 12, carried by light trusses of short span, supported by posts, are in every respect the best as well as the cheapest. They are more easily warmed and ventilated; they can be better lighted; the shafting may be more readily suspended; the posts are a positive convenience for the attachment of cranes, tool racks, etc. When it is desirable to use traveling cranes, as it is in erecting shops and others, a clerestory can be carried up on the posts for their accommodation.

It is best to make the walls of brick and the posts and roof trusses of iron; if the roofs are covered with tarred felt and gravel, or something equivalent, and if the planking of the roof is whitewashed upon the inside, the buildings will be almost fire proof; and the roofs will be much more accessible in case of fire than those with high trusses are.

The low roofs are convenient, if built with a due amount of strength, for the attachment of a light hoisting apparatus at any point desired;

such are required over every engine pit and are useful at all tools where heavy parts are handled. A skylight can be inserted at any place where one is wanted, to the great saving of artificial light, in the course of a year; and the intensity of the illumination from a skylight low down is immensely greater than from one high up. If walls are of brick it is best to make them hollow, with a 2-in. space in them, well bonded; which excludes cold and damp, costs little or nothing except oversight during construction, and saves fuel permanently. Insert windows everywhere that it is possible, high as the walls, wide as the panels—in the doors and over them, if necessary to insure abundant light, always indispensable to good or rapid work. Where brick and iron are not available, or would be too costly, wooden buildings, with the same general features which have been described, are recommended.

All shops require a firm floor, which, over such large spaces, must rest upon the ground. Wooden floors perish rapidly, requiring constant renewal, to the great interruption of work and at considerable cost. It is better to use some of the many forms of mineral pavement, such as asphalt on concrete, or blocks of asphalt, which are wholesome, easily cleaned, durable, and easily repaired when injured. Being impervious to damp, such floors are better than any other kind, when laid on the earth, regard being had to the health of

the workmen, which is likely to suffer from damp or decaying wood; and, with such floors, other foundations are not required for ordinary tools; a block of wood or metal under each foot, to give a broader bearing upon the asphalt, is sufficient.

The only proper mode of heating shops is by steam-pipes carried in accessible trenches lined with masonry and covered by iron gratings; the pipes may, without loss, be carried upon the walls; the other is the better way, unless the trenches are likely to be wet; yet there is no objection to the use of the trenches for draining off clean water if it does not touch the pipes, which may be supported above the bottom on brackets or trestles. Excellent radiators for steam heating may be made from old boiler tubes which are unfit to use in boilers, and are cheaper, for those who have the old tubes on hand, than any other kind.

One of the most important of all shops for a railroad company is a good foundry, fitted to make every casting that can be required, from the largest to the smallest. It need not necessarily be a very large foundry, but it should not be a very small one, and it should have all the best appliances of cupolas, cranes and ovens. It will generally be found profitable for the foundry to make castings enough to at least consume the scrap iron which is accumulated by the company; it can always be run at a profit, if reasonably well

managed, and it maintains a wholesome check upon the foundries from which supplies are purchased; yet, perhaps, the greatest advantage to be derived from it lies in the quickness with which important castings can be furnished to the several departments of the road when a sudden breakage occurs, sometimes saving great delays, which may be costly and are proverbially dangerous. Indeed, most experienced men will agree that a good foundry is the greatest convenience which can be mentioned.

It is not intended here to enter into minute details concerning the interior fittings of shops, for they would vary much according to circumstances, but a few things deserve mention which have a general application. It is better to drive the main line of shafting directly from the engine than to use a belt between the engine and shafting. This of course compels the use of an engine without a driving pulley, and there are many suitable varieties of such manufactured.

It is preferable to suspend the shafting, both main and counters, by iron hangers, as may be done from the roof trusses, if low as described, rather than to encumber the space with the masses of timber which have commonly been used. This arrangement is safer against fire, does not accumulate grease or dust and does not obstruct the light as the timber does.

Tracks of standard gauge should pass through

or close to all the shops or departments of each shop, to admit of unloading heavy machinery and supplies as near to the places where they are to be set up or used as may be. Tracks of the same gauge or narrower should connect all the large and small shops, with turn-tables at all intersections, so as to admit of carrying every thing from any one point in the whole system to any other point, on a larry, without unloading. The relative positions of the several shops toward each other should be studied, with a view to make the journeys of the things which go from one to the other shop as short as possible; and also to work through any shop from one end toward the other, where successive operations are required on the same material; this is especially important in car shops, but should be had in view in all shops. Grinding machines, wood-planing machines, and such others as create objectionable noise or dust, should be apart from the main shops, in separate rooms. Hot and cold water with set-basins should be provided in sufficient numbers and convenient for the workmen to wash easily and rapidly. Good water-closets, self-operating, well warmed in cold weather, and so connected with the shops that the men need not go into the cold to reach them, should be attached in proper number to each shop. They will require an attendant, who may also do sweeping and other chores.

Shops and wash rooms and water-closets should

all be well ventilated, which can be accomplished, with hardly any expense, by carrying up flues in the piers and walls with openings into the rooms near the floors, and occasionally also near the roofs. These flues become frequently of great convenience, when there is occasion to set up a stove or a hand forge, temporarily, in an unexpected place. Probably there is nothing so important and which costs so little, which has also been so much neglected in buildings of all kinds, as the provision of flues for ventilation. Large shops should have suitable ventilators also in the roofs; but they will not be allowed to be open much in winter. There is a common opinion that high roofs and lofty rooms are more easily ventilated than low ones, which is contrary to the facts, for ventilation is accomplished by establishing currents of different temperatures. This is more readily effected in a small space than in a greater. A large passenger shed presents a good example of the difficulty of ventilating wide and high spaces, if the persistency with which any smoke from engines remains in it is observed.

Almost all lifting about shops which requires more than the strength of one man should be done by cranes or hoists, for the interest on the cost of such will not usually amount to another man's wages; where machinery and shafting are already in motion, it requires generally no addition to the existing engine or boiler power to do

all the hoisting that can be needed. The most convenient of all means of reaching distant points, or those which are not easily accessible by shafting, is by hydraulic pipes, which can be carried anywhere, if protected from frost. Hydraulic machinery is now made for performing almost every kind of work, and hydraulic cranes are among the most convenient of all tools. When a hoist is needed in the vicinity of a boiler, a direct-acting steam cylinder is often the cheapest form to employ.

Engine houses, with walls, roofs and floors of the same type as the buildings for shops which have been described, will be very satisfactory. They will be very much warmer and freer from smoke than the high-roofed buildings. The engines should run into them from the turn-table with the smoke-stack first; this brings the forward part of the engines near the windows, and, in the *round-house*, which is the best and only convenient form of engine shed, the engines will thus be where the tracks are widest apart and where there will be the most room for working at any repairs. The smoke-pipes, which should always be immediately over the smoke-stacks of the engines, will then be at the rear of the building; and, on account of ventilation and for convenience in draining, it is best to make this the higher part of the roof, with the inclination toward the doors. As the arc of the circle at the front of a round-house

is very much shorter than the arc which bounds it at the rear, it will require much less in length of eave troughs to provide suitably for the discharge of the water in front than at the rear. Every thing which is of iron which comes in contact with the smoke from coal-burning engines, if not kept thoroughly protected by paint, will be rapidly consumed by oxidation; therefore, iron smoke-pipes upon engine houses are quickly destroyed. Suitable pipes of terra-cotta may now be obtained and should be preferred. A pit is required under the engine at each stall of a properly constructed engine-house, for convenience in repairs and cleaning. The bottoms of these have been usually built concave, as the pits also serve to discharge the water into when the boilers are cleaned or blown out; consequently the wiper has generally stood in a pool, more or less deep, of water. It is better to make the bottoms convex, with narrow channels at each side, so that the wiper may go dry shod. These pits should discharge into a drain carried along their ends nearest the turn-table, where it will be the shortest. This drain should receive the water from the roof, and if its walls are carried up to the level of the floor, and it is covered over suitably, as with an iron grating, it is the most convenient mode of providing an accessible trench or culvert in which to carry the main water and steam pipes, from which to

lead other pipes into the engine pits, supplying water to the tenders and for washing out or filling boilers, and steam for the heating of the engine house. When the radiators are arranged along the sides of the engine pits, the rising heat is brought to bear most effectually in the winter upon the icy-coated parts of the machinery, enabling the wipers to get to work effectively upon a newly arrived engine in the shortest space of time; and by having the whole system of pipes arranged in this way, over drains, the small leaks which are apt to occur at joints and valves do no harm nor do they keep the floor wet, as when they are carried above it. Catch-basins and settling basins, easily reached for frequent cleaning, should be arranged where the pits discharge into the trench which carries the pipes, and again where this trench discharges into any sewer, for there is nothing so likely to become choked by waste, rags, and all other substances which can interrupt a drain, as the sewer from an engine house. The whole system of pipes, for steam, for water, for drainage and for gas, at engine houses and shops, is likely to be tapped continually at new points, to provide for new conveniences; it is therefore unwise to put the pipes under floors, or in any place where they will not be easily accessible.

The doors of engine houses should be provided with glazed sashes, to light the buildings in winter

when they are closed. Cast-iron sashes have been found to bear the rough usage from which such large doors frequently suffer better than any others; they assist in stiffening the frames of the doors. Cast-iron hinges, made like strap hinges, and so proportioned that they will not be too strong near the edges of the doors, but will break off when an engine runs out of the house before the doors are opened, are better on this account than wrought-iron ones; for these will assist the engine to tear down the front of the house; the cast-iron ones will allow the door to be carried away without further injury, if properly made.

The form and size of the ground, on which the round-house must be placed, frequently limits the distance at which it may stand from the turn-table; it is preferable to have space enough between the front of the house and the edge of the turn-table for the longest engine to stand; it is in favor of as much distance here as may be, that the longer the radius which describes the front wall, the shorter, for a house of equal depth, will the rear wall be. The depth of an engine house, to be comfortable in use, should be at least 10 ft. greater than the length of the longest engine likely to enter it. The locomotives have grown in length, slowly but constantly, from the beginning until now; it may be presumed they will continue to do so; on this account the depth of the round-houses should be made rather too great for present

needs, and the same reasons apply to the construction of the turn-tables, which should be of sufficient diameter to accommodate engines somewhat longer than are now in use.

Probably no one would now build a wooden turn-table, although it is but a few years since they were common enough. Wrought-iron tables, of sufficient strength, are doubtless the best of any, if kept well painted; if they are to be neglected, cast-iron ones are better. Almost all wrought-iron tables are deficient in stiffness. They should be made heavier, and it is better to specify the dimensions of the parts for a builder, as for a bridge; they will rarely be satisfactory if bought, as many are, without other specifications than the length of the girders and the depth of the pit. Yet, however good the turn-table itself may be, it will not turn an engine satisfactorily if the foundations of the center and of the circular track are not perfectly unyielding; they must be of good masonry, extending below the frost and well drained; the circular track must lie perfectly level.

CHAPTER VIII.

TELEGRAPH LINES AND FENCES.

POLES, WIRES, ETC.—USES OF THE TELEGRAPH—TELEGRAPHERS—FENCES—BARBED WIRE—POSTS—GATES.

The telegraph has become the indispensable ally of the railroad; by its aid the capacity of a single track is doubled, and that of a double track may be very much increased; aside from its use in the movement of trains, it facilitates the rapid transaction of business to such an extent that it has become quite as important an aid to the commercial as to the operating department.

It has been sometimes attempted, even upon roads of considerable traffic, to do the business of all departments upon a single wire, no doubt from a mistaken idea of the capacity of the wire rather than from a failure to appreciate the advantages of a prompt service. It would be a grave error to allow any other business to hinder the dis-

patching of trains, or even to interrupt it; for it will not do to confuse a telegrapher, during the transmission or receipt of train orders, by hurrying him with other matters.

It is best for a new road to build its own telegraph line, and to operate it, at first; in the rapid construction of a new road, it would be found of great advantage to erect the line as soon as possible after the location of the road had been finally determined; for the benefit derived from constant and instantaneous communication with headquarters would more than pay the extra cost of building it without the aid of railroad transportation. If the line were not too long, it could be temporarily equipped with telephones instead of telegraphic instruments, which would postpone the employment of skilled telegraphers for a while. A distance of one hundred miles or more can be talked through very satisfactorily at the present time; and with the improvements which are announced every few days, we may expect to talk well through a thousand, before long. The cost of building a telegraph line is not very considerable for a railway company, and a better bargain with any telegraph company for connections, for interchange of business, or for operating the line jointly with the railway, can be made after the telegraph line is completed than before. It should, however, be a thoroughly well built line, upon the best model up to date. The poles are larger and

longer on the best lines, the wires are of greater diameter and of better material than they were a few years ago. This is the result of a long experience with lines of an inferior character; they cost more to keep in repair than good lines and were not to be relied upon. The size of the poles is perhaps the most important feature of a new line; for that limits the number of wires which can be strung upon them, and, as it is very sure that they will be loaded to their full capacity within a few years, it is best to set up those of the largest size which are now used in the best practice of the older telegraph companies. Cedar poles are regarded as best of all; white oak, chestnut and yellow pine are very good, where more conveniently obtained. The standard length of telegraph poles was formerly 24 ft.; it was found that after the part in the ground had decayed, that which had been above ground was still good. This led to the adoption of 30 ft. as the usual length, permitting the poles to be cut off at the ground when decayed, and to be reset. From 32 to 36 poles per mile is the number required. On some roads the telegraph poles serve as mile-posts, boards with the proper figures upon them being nailed to the post which is nearest to the mile-stake. By attention to this in building the telegraph line, or by resetting the poles at the mile stakes, the position of these could be cheaply perpetuated and the cost of mile posts avoided. If,

then, the intermediate posts were somewhat carefully spaced, they would be of very great convenience as reference stakes for the track department; if those at the mile stakes were to be painted white for their whole length, and those at the half and quarter miles for only a part of their length, they would afford a scale of distances which could be read in passing at the highest speeds, and be of value to the officers of the road in many ways.

The ordinary cross-arm is calculated for six wires; if it is probable that arrangements will be made with a telegraph company for connections and for the use of the railroad's right of way, it will be wise to put a second cross-arm on the poles before they are set, and to have the *gains* cut in the poles for a third cross-arm; for such work can be more easily done before the poles are set than after.

But these remarks are not applicable to an obscure branch line in an unsettled country, where possibly a single wire will serve the railway and telegraph companies both, for some years.

When possible, the poles should be set more than their length from the main track, so that if they should fall from any cause they will not obstruct it. If there are more passenger stations upon one side of the line than the other, it will save crossings of the tracks, which are objectionable, if the poles are set upon the station side. In

marshes it is frequently difficult to maintain a telegraph pole erect because of the softness of the ground. This can generally be accomplished by sinking a barrel without any head where the pole is to stand, then setting up the pole inside the barrel and filling between the pole and barrel with gravel or small stones.

Insulators of many varieties have been experimented with, and there are several especially fitted for peculiar situations; nothing has been found to be better for general use than the cylinder of glass screwed on to an oaken pin, a coarse thread being molded in the glass to correspond with a similar one on the pin.

No. 9 wire was formerly universally used for telegraphic purposes, now No. 6 has the preference for long lines and No. 4 has its advocates; this refers to iron wire, of which none but the very best is fit. There are several kinds of wire of greater conductivity invented and experimented with; none established as equal to iron for main lines, as yet.

It is not intended to treat of the manifold applications of electricity to railway working; words would be wanting to represent their value and convenience; space would be lacking in which to simply mention their variety; there are excellent books on train dispatching, on block-signaling and many other special uses which should be studied by those who wish to be informed.

Unfortunately, the currents from a battery are not of sufficient strength to do much work; they can sound a bell or move a hand upon a dial, conveying almost any information by concerted signals; they may be arranged to set other more powerful forces at work at any distance, and in this way render very important service in signaling. It should be oftener remembered that we have at hand this power of notifying in advance the approach of trains, whenever it can contribute to safety or convenience to do so; and at a trifling cost, even by means which are automatic, so that there is no attendant required. The incessant whistling in great yards might be totally dispensed with, and much more certain information conveyed by a line of bell signals at the switchmen's cabins. Telephones should communicate between the offices and the principal points in all important yards and termini; indeed, they can scarcely be placed upon a railway where they will not repay their cost by facilitating the transaction of business.

In the construction of its telegraph line a railroad company will need the services of experienced men, as well as in its use and maintenance afterward. The setting of the poles, the stringing of the wires and other particulars of the work can be accomplished by experts in a fraction of the time that persons without practice would require. As in all other departments the first

requisite is an energetic superintendent who thoroughly understands the details of the building and testing of a line, as well as the art of telegraphing. It will be of great advantage if he also knows something of modern progress in electrical science.

The telegraph offices should be well lighted by night, which is much neglected, as well as by day; and they should be well ventilated, because there are fumes from all varieties of moist batteries, which taint the air in addition to the ordinary causes of vitiation; they should be contrived so as to excluded the public and loafers from the apartments in which are the operators and the messengers. Upon railroads, there is a disposition among all classes of employés to make the telegraph office a sort of club-room, probably because they can there learn the latest news; and on the part of the telegraphers there is a natural inclination to relieve the tedium of their office hours by social chat. It is, however, due to the accuracy and privacy of this most important mode of correspondence and of giving orders, that the telegraph office shall be entered only by the telegraphers; as little as possible even by the higher officials, who can set a good example by remaining outside, unless they must enter upon business.

This is not the proper place in which to discuss the unfairness of the statutes in regard to fencing, which, in most of the States of this Union, throw

the burden entirely upon the railroads in opposition to the common law, and compelling the railroads to build fences, professedly to insure the safety of trains, allow the farmer's cattle to pervade the highways and to frequent the railroad crossings by day or night, without responsibility on the part of the owners for damages to property or for the destruction of human life, which may result from their neglect to keep their beasts confined. If the railway companies were themselves to give attention to this matter, it is scarcely doubtful that they might, in the interest of safety to trains, secure legislation which would prevent animals from frequenting the railroad crossings; at least an enactment such as that which was passed in Canada at the suggestion of the Railroad Commissioners, prohibiting the loosing of cattle, at large, within two miles of any railroad.

Fences are not a very important item in the first cost, nor in the annual accounts of a railroad, if originally well built and afterward well maintained; but if improperly built or if neglected, so as to be chargeable with the payments on account of stock killed, they become a formidable source of expense.

At the present time there is no variety of fence which can compare in suitableness for a railroad with that of barbed wire; which is as cheap as any good fence, easily built, neat in appearance, not likely to be set on fire, sure not to spread fire,

does not harbor weeds, occupies the minimum of space, does not cause drifts of snow, and is a thoroughly satisfactory fence against all but the most unruly animals and sheep. The introduction of extra wires, tying all together by vertical stays between the posts, would probably make it sufficient to exclude sheep; but their thick fleeces render them insensible to the barbs which secure the fence from the assaults of other animals. Until the farmers shall have used the barbed wire fence for their own fields, as they will do more and more, there will be instances of the mutilation of stock because of the animals' unfamiliarity with the fence; and where it is new to them it is desirable that they should have a cautious introduction to it; if led up and caused to examine it and to prick their sides and noses a few times against it, they will avoid it as carefully as a burned child does fire.

The usual height of a *lawful fence* is 4 1-2 ft.: if an animal jumps over such a fence the law considers it to have violated propriety and will hold the railway company guiltless if it be killed in consequence; but the owner of the beast will seek for a place in the fence which is less than the full height, and, if such is found, will probably recover damages, upon a verdict of his countrymen. To avoid contentions of this kind, and because a high fence offers less temptation to a jumping beast than a low one, it is recommended

to make railroad fences several inches higher than the legal standard, although this will require five wires instead of four; these should be fastened to the sides of the posts furthest from the tracks.

The barbed wire, when properly strained, stands so firmly on few posts that there is a temptation to use fewer of these than experience will justify. The wire manufacturers, in order to cheapen the cost of this fence in comparison with other varieties, encourage a reduction in the number of posts used; 15 ft. between posts is better than a longer distance, although many recommend and use spaces of 20 ft. and more. The life of a fence is in its posts; the more durable they are, the less the fence will cost per year for maintenance; of common woods, cedar, locust, chestnut, white oak, are relatively valuable, in the order named, for fence posts; it is preferable to have them peeled before setting; to be permanent they must enter the ground at least 3 1-2 ft. in this climate, because of frost. There are various ways in which the life of wooden fence posts may be prolonged, as by charring the part which enters the ground; or by coating it with hot coal tar, if the wood is seasoned, or still better by burnetizing, kyanizing, or, best of all, creosoting them. These processes of injecting the wood with preservative substances will render almost every wood suitable for fence posts and nearly imperishable; and as no wear and tear is endured

by them as there is by sleepers, the whole value of the preservative process may be realized when applied to fence posts. There are promising devices for iron posts to hold barbed wires; it is likely that, with the cheapening of iron and with some modifications in design as experience will suggest, they will become useful and perhaps supplant the wooden posts, where timber is not abundant. When wooden posts are pointed at the bottom, they are thrown up out of the ground by the action of the frost, and it is presumable that the *pointed* cast-iron footings which have been proposed for iron posts, will be acted upon in the same way; they ought, it is concluded, to be the largest at the bottom.

The wires of the fence must be kept very taut; and, in order to maintain the necessary strain, it must be thoroughly braced at all the openings and corners; the strains upon the wires and the diagonal bracing have a tendency to raise the braced post, which should therefore be anchored; a cheap mode of doing this is by spiking a piece of board crosswise on each side of the post, at the bottom.

One of the cheapest possible forms of gate is also the best for use at *farm* crossings; it is made of four horizontal strips of fencing united by two vertical strips at each end and two in the middle, well nailed together with clinched nails. This should run back and forth, with the bottom of the

top strip resting on a pin, between two posts set near together at one side of the opening in the fence. When half open, if the posts are set right, the gate can be swung half round, nearly at right angles with the line of the fence, leaving a clear opening of the width of the gate. In the post against which the free end of the gate shuts, there should be a hook on which to hang it when closed; the hook-headed track spike answers very well for this purpose, but the post must be bored to receive it, to avoid splitting.

CHAPTER IX.

LOCOMOTIVES.

RUNNERS SHOULD BE ROTATED—LOCOMOTIVES CONTINUOUSLY WORKED—INTERCHANGEABILITY OF PARTS—INSPECTION DURING CONSTRUCTION—LOADING FREIGHT ENGINES—PREMIUMS TO ENGINEMEN—FIREING—PAINTING—PATTERNS, WEIGHT, ETC.

Upon every railroad there is, or ought to be, one or more master mechanics, whose duty it is to look especially after the design, construction and repairs of these engines; there are, besides, manufacturers and inventors devoted to their improvement, and most complete books concerning their principles of action and details of construction. Nothing will be attempted here, therefore, beyond some consideration respecting the use of them after they are ready for the road, and as to the selection of them when they are to be built or purchased.

During the first half century of railroading, the locomotive was regarded with some super-

stition, if not with awe, by those who ought to have become too familiar with it to be its dupe; it was the fashion to marry it to one man for life, or for so long as the pair could agree together; no one but the familiar engineer was thought to understand the caprices of the petted machine; no one else could get her to pull a heavy load or a quick train; he only knew her secret springs of action, and when he was tired the locomotive stopped.

Scientific men wrote about the fatigue of metals, and the unscientific believed them to mean that continuous effort was bad for the engine, even though it showed no symptoms of prostration. In consequence of these ideas, dimly entertained, no doubt, or, like other superstitions, accepted without consideration from the earliest habit, the locomotive worked less than half the time, on the average; the remainder of the day it was being polished and wiped and screwed up, and decorated with fancy pictures in the cab, and such other fanciful things as its betrothed engineer could pick up.

These foolish notions found defenders, for a long time after they were seen by sensible men to be mistaken, on the ground that the sentimental regard of the engineer for his own engine, would retain it in more perfect condition than could be attained in any other way.

The locomotive is a machine of iron and brass,

without sensibilities, and may be run day and night perpetually (except for a little wiping) until worn out or repairs are necessary. To save the investment of capital, we should get every hour's work out of it that we can; it should be maintained in such good order that any man can run it successfully, who can run a locomotive at all. Unless in case of necessity upon the road, the runner should have nothing to do with the adjustment of its brasses or with its repairs; it would be preferable that he should not know upon which locomotive he was to go on the road; he would soon find himself compelled to be the better engineer. It is doubtless comfortable for him to run upon one particular train, to learn all its stops and its schedule by heart, and those once well learned, to have little else to do than to open and shut the throttle; yet this is scarcely fair sometimes toward the other men; and there is no doubt that rotation, first in first out, will procure the most wide-awake set of men, the smartest competition between them, the fairest apportionment of labor, and the surest readiness for every emergency. In the very first of the trials of this system, there will be some men who will not do perfectly well with trains which they have never run before; but in a brief period the strife for precedence in credit will make every man ready for every train.

It must be a familiar experiment with almost all superintendents, to have replaced an old passen-

ger man, who failed to make time with the express, by an active young freight runner, who would make up something with the same engine.

A false notion still prevails with regard to the amount of wiping which is necessary for an engine. Experiment has demonstrated that if the guides and more exposed bearings are wiped once in 100 miles, the engines suffer no injury if run continuously 500 miles without general cleaning; to all appearance they might have been run 1,000 miles. The saving to be made by less wiping is not an important one; it is the saving in the time of the engine, which is of great value. Thirty years ago, 100 miles was commonly supposed to be as far as an engine could be prudently run without being laid off, and the runs were generally made shorter than this; they are fixed now according to the endurance of the men, or the length of the divisions of the road, or the location of the engine-houses; when there is need of all the engine-power available upon the road, there is no reason why one engine should not run continuously over several divisions, changing men as often as necessary. As to men, we know about how many miles or how many hours of running they will safely bear; but as to a locomotive, we do not know its limit of endurance, which depends somewhat upon the dustiness of the road-bed, the speed of the train, the quality of the oil used, perhaps; but can be readily determined for each road by a little ex-

perimenting, with unprejudiced observation. The improved condition of the track, and also the vastly improved construction of the movable parts of the locomotive, have altered its demands for readjustment, so that it may be run much further than it could under the unfavorable circumstances which once prevailed. To increase its duty in a given time, is one of the readiest means of lessening the investment of capital, upon which it is already difficult to pay the charges. To wear out old locomotives by honest work and to replace them with modern improved machines, is surely better than to give them half or less than half the service to do, which they might render if kept constantly employed; and as they are capable of much longer periods of labor than those who run them, the only way to accomplish this is by divorcing the engine from its runner, making it ready to pull a train whenever there is one to go. There will be, on most roads, isolated instances of branch trains or remote switching engines, upon which the men can not be frequently rotated; yet they should be often changed, to prevent them from becoming slothful and indifferent, which is more or less the effect upon every person of a monotonous life.

The most satisfactory results of this mode of operating the locomotives will be perceived when they are of few classes, alike in their most important features, and all in a first-rate condition for use. It is very unwise to keep any engine at

work, which is not in good order, for it is not only wearing itself out unduly, but is causing money to be spent in extra fuel, in tinkering and in delays, which were better expended in restoring the machine to the best condition of which it is susceptible.

If the engines are out upon the road, earning money, they will not need so much engine-house room as if they must be housed during the half, or a greater part, of their existence. When there was much brass to be *shined up* on each engine, and a great area of decorative painting to be wiped off upon each tender, it was desirable that the fireman or the wiper should be under cover while engaged in cleaning the machine; now that the engines are built more for business and less for show, it is only needful that they shall stand long enough over the steam pipes, in cold weather, to have the machinery well cleared of ice, so as to be thoroughly wiped; they will not then suffer any damage from exposure, if properly attended to by the hostler.

It is found to be better for boilers to be kept constantly warm than to be frequently cooled, because when cooled they suffer a contraction and consequent strain; it will also result in a saving of fuel to keep an engine, which comes off the road hot, from growing cold, unless it is to stand too long; for the quantity of coal required to fire up a cold boiler will keep a hot one warm a long

time. The expense of keeping an engine fired up, out of doors, in cold weather, is not very great, if it stands still, as it may do if provided with injectors; it ought not to stand very long, however; it should be at work. Of course, there should be ample room in round-houses and in shops to make all repairs promptly, with the men and machines comfortably sheltered.

Upon most railways the locomotives have been purchased from several manufactories at various periods, and differ from each other in every possible way, so that there are only a few of one pattern, which compels a very large stock of the smallest parts to be carried, in order to be ready to make slight repairs without delay. Opportunities occur, when there is a considerable breakdown, or when an engine goes into the shop for general repairs, to make alterations which will bring it into conformity with the larger number of locomotives, and it is desirable to make such changes at a comparatively large cost, for the sake of finally bringing about uniformity.

Nothing is more important upon a railroad than interchangeability of parts in every thing which is subject to wear; whether pertaining to pumps, to tracks, to cars, to signals, or chief of all, to engines. In equipping a new road, it would be inexcusable not to decide upon certain standards and to adhere to them, no matter where the locomotives were to be manufactured. If it were pre-

ferred to have them built by several makers, the patterns prepared by one could be duplicated and sent to the others, so as to secure, if not perfect interchangeability, yet a sufficiently near approach to it to admit of the substitution of standard parts, when any renewal is required, without extra cost.

There is more frequent necessity for the renewal of the smaller parts of a locomotive than there ought to be ; the breaking down of the engine while upon the road occurs oftener than is creditable to our constructors or to our master mechanics. It is proper for the superintendent to expect, when a machine is sent out to take a train, that it will run through, without hindrance from defects in the machinery. It is said to be a very rare occurrence in England or in France to have an engine disabled upon the road, and this is affirmed upon the best authority; probably when any thing breaks there from not being strong enough, they renew it with something stronger, and when any part wears rapidly they renew it before it is entirely worn through. It seems, from the continual break-downs, as if no such lesson was taken to heart upon many American railways. Some improvement may be accomplished in this respect by keeping a careful account of the break-downs which occur, and of the parts which fail ; an interested master mechanic will require all the broken parts to be sent to him and will gather

instruction and warning from them. When engines are bought from the manufacturers there are sometimes more frequent failures of small parts than upon the engines which are built in the shops of the railroad company, probably because such work is done by the piece in the manufactories and by the day in most company's shops. The manufacturers doubtless secure the best work they can. It is for their interest, as well as incumbent upon them as honorable dealers, to do so, but their inspectors may not always be so reliable as they presume them to be. On this account, when engines are being built by them for a railway company, it is advisable that it should send its own inspector to supervise their construction. It is likely that he will find many things to correct and to object to, as he would even in the company's shops; so many defects as he prevents there, so many less will there be to remedy after the engines are upon the road. There are frequently two or more modes of doing the same work as to which the manufacturers may be indifferent, but as to which the company's master mechanic or designer may have decisive reasons for a choice; at such times, the presence of the inspector is an advantage to the manufacturers, as it surely will be, also, if he in any respect secures a better engine than would otherwise have been obtained.

Until recently, there has existed a prejudice

among many master mechanics against loading the freight engines to their maximum capacity, arising partly from a fear that the engines would be more rapidly worn out than if they hauled only such trains as they could easily pull through, and partly from the faulty manner in which the account of the performance of engines is usually kept. Careful accounts have proved that the repairs per ton hauled are not increased, but on the contrary are much diminished by loading the engines with all they can possibly draw; indeed, when the repairs are calculated by the mile run they are not sensibly increased by the greater loads. The quantity of fuel consumed per mile, not per ton, is of course increased, and as the reports of fuel burned are rendered by the mile, the master mechanic who is doing the best work in this respect, may compare unfavorably with one whose engines are hauling fewer tons over similar grades. Because of this imperfect method of making the locomotive reports, those of one road, or of the several divisions upon any road, can not be compared with any justice, unless by some one who is acquainted with such details as the grades upon each division, the quality of the fuel and the speed of the trains, none of which find place in the published returns. Such comparisons would be so desirable, if they could be generally made, that the master mechanics could undertake nothing at their conventions which

would be more useful, than to devise a system of accounts by which the performances of locomotives, upon their several railroads, could be really compared.

It has resulted satisfactorily upon the roads where the experiment has been tried, to pay premiums to the engineers and firemen for the savings which they effect when compared with others, or with a standard of performance which is fixed as a reasonable one by the officers of the road. The cost of fuel for engines is from 5 to 6 per cent. of the total of the earnings, or from 9 to 10 per cent. of the total of expenses, upon the average of the railroads; and it is of very great importance, therefore, to secure economy in its consumption by all the means which are possible. It is not difficult to put into effect a method by which it may be certainly determined whether one man is burning more than another or more than the average; and if a premium is paid for unusual economy, the greater number of the men will strive to earn it, and those who succeed will fairly deserve to receive it; perhaps the spirit of emulation which is excited, and which makes honorable mention more precious than money, may have even more effect than the hope to gain a pecuniary reward.

The combustion of coal in the furnaces of locomotives has been the subject of very elaborate investigations and experiments, and is probably

fairly well understood as to its theory; to secure the best results in practice has puzzled the best wits in the engineering profession; nevertheless, it is the custom to send as firemen upon the locomotives the least informed class of men, who have had no opportunities to learn any thing of their business, and who get only the very slightest hints from the engine-driver, who is presumed to know, and to instruct his fireman how to fire. The art of *stoking*, as it is called in England, has there been carried to such a refinement that the most expert stokers, who are employed to fire the agricultural engines during the trials, get very high wages, as the foremost jockeys do; a fact which is cited here to indicate of how great value, in firing, a knowledge of the art may be. A plain, brief manual upon this art, which would enlighten the enginemen and firemen as to what is going on in the fire-box, and how to insure the best results, would be of inestimable value to the railroads of this country; while this need remains unsupplied, there should be instruction of the men practically by the most expert firemen upon the road, or who can be found anywhere, who generally know more about it than the average engineman, and who should be detailed to ride a few trips with every new man, and during their spare intervals with the older men, to teach them all they can as to saving fuel. The nuisance of smoke, upon roads which burn soft coal, may be mitigated by judicious firing.

The best color for locomotives and tenders is black; when the paint is defaced it is most easily matched, it is more enduring than any other and can be mixed and applied with the least demand for skilled labor; to the accustomed eye, it looks the best of any. The less polished work of brass or of iron upon the engines, the less rubbing and care will be required to keep them bright. There has been a great reduction effected in the labor of firemen and wipers already, by painting many parts which were formerly kept bright, yet there is room to carry the reform still further.

Not much valuable advice can be given as to the best model or pattern of engine to be built or purchased without a knowledge of the conditions to be fulfilled, which depend upon the characteristics of the road, the kind of service for which the engine is wanted, and the amount of traffic to be provided for. It may be safely affirmed, that for any service it is better to have engines of more than necessary power, rather than those which are too feeble, or only just of sufficient power; for there will be occasions, as in snow storms, when it will require the utmost efforts of the locomotive to pull such a train as it is accustomed to haul with ease. It would not be wise, however, to provide a large surplus of power in a locomotive which will have only a certain determined work to perform, simply to meet occasional exigencies; yet as a general rule, trains upon any road increase in

weight, in speed, and in number. A large boiler produces steam more cheaply than a small one, which is also favorable to the choice of a heavier rather than a lighter engine.

It was once supposed that locomotives for very fast express trains must be limited to one pair of drivers; the improvements in mechanical work have made it possible to run the fastest trains in the world with two pairs of drivers coupled; and some of the fastest trains in this country are now run with Mogul engines, which have three pairs of drivers coupled. The power of a locomotive is limited by the amount of adhesion to the track which is obtainable through its drivers, and because that adhesion is due to the weight borne by them, which in its turn is governed by the consideration of what can safely be borne at one point by the rail or wheel, it is apparent that the maximum weight of an express train has been increased about three-fold by this advance in mechanical construction.

It should be always remembered that the cost of running a very heavy train is but little more, comparatively, upon the same road, than the cost of hauling one which is much lighter, and the cost per ton per mile is rapidly reduced by an increase in the capacity of the locomotive. This has led to a very great addition to the weight and power of engines lately built for roads of large traffic, especially when such roads have also heavy grades

which must be surmounted. There is no longer any mechanical objection to an increase in the number of coupled drivers sufficient to carry the entire weight of the engine upon them, so as to avail of it all for adhesion to the track.

The weight of the engines which may be employed upon any road is or should be limited by the load which the bridges and other structures will carry, without improper strain — a limitation which has not received always the consideration which it merits.

CHAPTER X.

CARS.

QUALITY OF AXLES — WHEEL TREADS — ROUND WHEELS — TRUCKS AND SAFETY ATTACHMENTS — INTERCHANGEABILITY OF PARTS — INTERCHANGE OF CARS — LUBRICATION — LIMIT OF LOADS.

It would require several chapters, or perhaps a whole book, to treat adequately of the various kinds of cars and of the uses for which they are intended; it is chiefly upon those features which are common to all varieties that it is intended to comment here.

The Master Car-Builders' Association has adopted and printed drawings of a considerable number of standard parts, to which the railroads which form portions of through lines are expected to conform the cars which run off their own roads in exchange for the cars of other roads forming the line. The axle to be used as a standard is carefully defined in all its dimensions, but as

yet nothing has been ruled by the Association as to the quality of the metal of which it shall be made. In this respect axles differ as much as bad differs from best; and only the best have any claim to be used upon a railroad. As a general rule, an axle made from scrap will not endure, before breaking, one-half the number of blows, each being sufficient to bend the axle, that one of the same size made from rolled bars will stand; and these superior axles will be more likely to carry safely the increased loads lately imposed upon cars than those which are less tough; but, unfortunately, the better ones cost the more. A railroad manager who is buying new cars experiences a great temptation to use the poorer axles, when he finds that the difference in cost, upon the number of axles required, would pay for several additional cars; but if he will reflect that the average life of a good axle, as determined by past experience, is about fifteen years under freight cars, and consider the number of torsions and shocks to which an axle must be subjected in that period, and the chances which he takes with an inferior axle that it will break under some of these strains and wreck a car, perhaps a train, perhaps a life, it surely "must give him pause."

The wrecks of freight trains, caused by bad axles under the cars of a certain freight line, cost not less than $20,000 to one company in the line,

in one winter; it happened, too, that they were the only axles broken upon the road during that winter; the class of axles which had been broken was hastily replaced under all the cars, and the accidents ceased.

It has been found convenient and satisfactory to use the same standard of size for axles under passenger coaches and tenders of engines as under the freight cars; the strains to which they are exposed in the fast trains makes it advisable to change them frequently, which can be done without loss when the different classes of equipment use the same; the axles may be used for about a year, or run, say 50,000 miles in the faster service, then be replaced by others and allowed to finish their term under freight cars. All axles and wheels should be dated and numbered, which, with the date when they are put under a car and the number of the car and when shifted to another car, should be all recorded in a book kept for that purpose. It is very much to be desired that the mileage of each individual car should be correctly known; but, as that can not be under the present general system of reporting mileage upon foreign roads, only an approximation can be arrived at,—perhaps near enough to determine the life of axles, if the kind of service in which the car has been engaged is taken into account; for cars in some kinds of traffic run four or five times as many miles in a given period as others in another sort of

traffic, upon the same road. Experience has made it quite certain that proper care in the purchase, testing and rejection of axles, will almost eliminate from the list of accidents such as are due to the breaking of them in service. The homogeneousness of steel and its superior strength would give it decided claims to preference over iron as a material for axles, were it not for faults probably due to improper manipulation in manufacture; up to this date there is not the same certainty that every axle in a lot will be as tough as the one taken at hazard for proving, if the lot is of steel, as if it is a lot of rolled iron axles. Breakages occur, which show that some of the lot are brittle, while others may be extremely tough. The journals of iron axles are very apt to be seamed with minute flaws, due to the imperfect union of the pieces of which they are made; which flaws, although so small as to be almost microscopic, do nevertheless act as a sensible roughness unfavorably upon the brass bearing; the journals of steel axles, on the contrary, are crystalline and without a flaw. It is just to state that some great American roads prefer the steel axles, finding them, on the whole, more satisfactory than iron ones; and that in England and in Europe they are regarded with much favor.

Until within a few years the only car wheels used in this country were made of cast iron; there are a few of other varieties used now upon

passenger cars and locomotives, where the greatest safety is wished for, yet the immense majority of wheels is of cast iron. A recent report by Mr. M. N. Forney to the Master Car-Builders' Association has shown that there is a very great diversity, in important particulars, among wheels which have been supposed to be substantially uniform; that none of them are adapted to the rails upon which they run, and that as to the form of rails and wheels there ought to be a definite agreement among engineers, car-builders and wheel-makers, to secure better results; which can be readily had for both rails and wheels by slight changes in the forms of the surfaces of both. Now that the cars from each road run over so many other roads, in through lines or with through freight, the reform becomes important to every road, and it can afford to adopt a compromise not quite satisfactory, rather than to suffer from the evils which Mr. Forney has so ably pointed out. How much damage may result, from a want of correspondence between the rails and the wheels, was conclusively shown by a costly experiment inflicted some years ago upon a railroad by its engineer, who, perhaps rightly, conceived that a rail with a much broader head than the one in use would be very desirable, and he laid down in one season a great many miles of such a rail. Probably, if he could have run only new wheels over his new track it would have

worn to his satisfaction; but as the wheels were in fact nearly all worn to a groove more or less deep, corresponding with the narrower heads of the older rails, they bore upon the new rails at the edges of these grooves only, and soon broke down the heads of the rails to a rough conformity with the prevailing width. Any sudden and wide departure from common forms, in either rails or wheels, would prove costly, as this one did, but a judicious modification would result in general benefit.

The durability of wheels has been vastly increased, perhaps doubled on the average during the past ten or twelve years, chiefly by reason of exact records of their performances, which were kept by a few roads; owing to the defective method of reporting mileage before alluded to, this exact record could only extend to locomotives and passenger cars, and to the few freight cars which did not run off their own road. Doubtless the effect of complete accounting would have been even more favorable to the railways. Manufacturers are now ready to guarantee an average wear of 60,000 miles. The manufacture by several large roads of a part of their own wheels, for comparison with those purchased and for experiment, also contributed toward the favorable results which have been attained. The chilled cast-iron wheels are rarely exactly round; when bored for the axle, they are centered in a

chuck which divides the eccentricity as much as possible; yet it is very desirable, with the enormous loads now thrown upon them, that they shall be perfectly round. The manufacturers of machines for grinding chilled wheels affirm that the wear of them is increased by grinding, because they are thereby made very smooth and round; others believe that the removal of the outside of the chill for this purpose is a loss; it does not admit of doubt that the damage to rails and the strain upon the axles must be very much reduced by making them round before they are put into use. If the specifications upon which wheels are bought were to be more exacting as to roundness, it is possible that an improvement would be accomplished. It is one great recommendation of all varieties of steel-tired wheels that they are, or may be, and should be, round.

There is nothing which so nearly approaches a "fortuitous concourse of atoms" as an ordinary freight car truck. How it holds together, how it does duty so long, are questions which every mechanic must reflect upon with amazement. It is not strange that every terminal and division yard is full of cripples, and that every truck in every car, except those fresh from the shop, is lacking something. Every master car-builder could improve it, if he were to try; and would improve it, if not held back by a consideration of first cost; a careful accounting would certainly

prove that it is better to pay more in first cost than to pay so much for constantly repeated small repairs, as is now necessary.

The two great inherent dangers to freight trains, after that of breaking apart from defective couplings, have been from broken axles and from falling brakes; either of which accidents was formerly sure to wreck all of the train in the rear of the first unfortunate car. The axles now generally pass through loops upon the trucks, which hold up the ends of a broken axle and steer it along the track, possibly until the trainmen discover something to be wrong; the brake-beams are also surrounded by loops, or arranged to be caught in some manner, if the main attachment breaks. These are judicious, efficient, and not costly devices, which should be used by all roads, but are not.

There was once good reason for the attachment of safety chains to the corners of all trucks, to keep them from slewing round and running a derailed car away, at right angles with the track; whereas, if held by chains, the derailed cars would follow along parallel with and near the track. But derailments were more frequent then and the cars were fewer than they are now. The chances then were that any car would suffer many derailments during its life: the chances now are very good that any car may escape the experience. It is more economical now to provide for keeping

on the track than to fit all the cars for running off; but passenger cars should have safety chains attached to the trucks, because the risk to human life, in case of a run-off, would be by them much diminished.

Uniformity in dimensions of parts and their interchangeability have been before referred to and recommended. They can not be too strongly insisted upon in respect of cars, and in no other mechanical department is it easier to secure this uniformity—even to the timbers of the various classes, if attention is given to the matter in designing the equipment. It will require study and fertility in the designer; but such a result has been attained. This uniformity, when once arrived at, will admit of almost any repairs of a car being cheaply made at any place where it may stand long enough, for the parts can be prepared, completely ready for use, at the shops of the railway, and forwarded to where the car is, without any necessity for measuring or fitting. There are roads upon which one may notice different forms of brake shoes on the passenger cars, freight cars and engines, even though the wheels are of the same dimensions; and, following through the details of the equipment, it will be found that there are hundreds of patterns in use where a score would suffice, and consequently an immense quantity of castings and other materials must be kept on hand, in order to be ready for making repairs.

There is no economical reform more important than to reduce this diversity to the lowest term consistent with the use of the rolling-stock. Much of this variety may be due to the equipment having been bought of several makers, each of whom has used his own patterns; it would have been perfectly feasible for the company to have required all cars to conform in all particulars to a sample car, built at its own shop or at one of the manufactories.

It will be best to keep an inspector at the manufactory which is building cars for a railway company; for it will be more satisfactory to all concerned to have improper materials rejected at the shop; and they can be discovered or tested more readily before they have been built into a car than afterward.

The interchange of through cars is frequently interfered with by the captiousness of the inspectors of the exchanging companies, each trying to be smarter than the other; and they will sometimes create serious delays of freight, in spite of the liberal provisions for the interchange which have been made by the master car-builders. It has been found very satisfactory to make the inspector at such a point, with a sufficient number of his men, the joint employés of the two or more companies interested; for then he can not differ with any one as to the responsibility for any car, and the business proceeds without delay.

At one place of interchange, where express freight was delayed by the inspectors requiring many cars to be transferred, it was arranged that the inspectors' men must make the transfer of the freight; the result was, as may be supposed, a large reduction in the number of cars transferred. Of course, it was feared that some neglect might follow the change, which imposed an unpleasant duty upon the inspectors, and precautions against it were taken, but they proved unnecessary.

Great sums have been spent for lubricating oils, upon the supposition that some mysterious composition was known to the manufacturers, which would make overloaded journals or defective brasses run cool. It has been proven by innumerable experiments that if the journals are smooth, not overloaded and not twisted by the truck, they will run cool if thoroughly wet with water, or with the poorest oil; but they must be kept wet—they must not run dry.

The passenger trains of a certain road were run for a long time with paraffine oil as the only lubricant. Of course it is admitted that sperm and castor oils will carry a heavier burden upon a journal, without heating, than other oils; but it is confidently asserted that with the loads that are safe in railroad practice, a cheap lubricant is as good as a costly one; the attention should be fixed upon the best means of insuring that the journal is well covered with it. As the boxes are

made, the oil is below the journal, and requires to be lifted up to it, which is generally effected by a packing of cotton waste; this often settles away from the journal, under the constant jarring of the truck. It is therefore prudent to require it to be hooked up against the journal at each inspecting station, and if a little fresh oil is poured on top of the packing at the same time, it will add to the certainty that the journal will be thoroughly lubricated. This treatment will reduce the number of hot journals wherever they are now troublesome.

A very great increase in the loads carried by cars of all kinds has taken place during the last ten years, or since the great improvement in tracks which followed the introduction of steel rails and stiff joints. It is not determined yet what may be the limit of safety. It is in favor of extreme loads that the number of parts is the same in a car which carries only ten tons as in one which carries thirty tons. Some of the parts require to be stronger in the heavier loaded car than in the lighter, but others, as for instance the roof, the brakes, the doors, do not. Indeed, some roads have not increased the weight of the wheels, although probably it would be advisable to do so. It is also in favor of the heavy loads that they do not greatly affect the draught of a train upon light grades: an engine will haul about as many heavily loaded cars as it will of lighter ones, upon a level;

the axle friction is not measurably increased, while the other greater resistances remain the same, or nearly so. The trusses, the trucks, the springs and the draught irons need to be strengthened, of course; but they increase in strength more rapidly than in weight, so that the weight of a car to carry 10 tons has been increased by only about one-fifth of the additional load, in order to make it fit to carry 30 tons. This better ratio of dead load to paying load makes it possible, as it has long been desirable, for the railroad companies to spend more upon couplings and brakes than they have done, and improvement in these parts upon freight trains is what now seems most needed.

The advantages of a continuous train brake would be so numerous, as almost to demand a separate chapter; among the most important of these would be the removal of the brakemen from their unsafe position on top of the freight trains; rendering it feasible to reduce the height of overhead crossings of railroads by more than six feet, and the cost of such crossings by one half.

CHAPTER XI.

THE MOVEMENT OF FREIGHT.

To Make all Cars Available—Prompt Loading and Unloading—Reporting Foreign Car Mileage—Scales and Cranes—Charging Separate Items—Avoid Switching—Long Trains—Freight Blockades.

The first requisite is a supply of cars, which is now often seriously interfered with by the very arrangements which the great lines have made to insure a supply of them; that is, by the assignment to each of several fast freight lines of a certain portion of their equipment, which can not be diverted to any other service than that of the line. It not unfrequently happens that the market for a certain grain, for instance, is suddenly better at one port than at the others, and orders for shipments to that port come to all stations upon the road, at the same moment; there are as many cars, probably, upon the road, as would be required to move the whole quantity as fast as it could be loaded; but only a very small part of them are at

liberty to be sent to the port in question; the freight must be delayed until cars of the proper "line" can be brought up empty to receive the freight; meanwhile the other cars stand still, waiting for orders. It is well enough to advertise a fast freight line by painting its name on the side of the car, and to use it for the freight of that line when it has business for the car; but a railway should retain the right to use any car which it owns, in any direction which its circumstances may require. This was not so important when the first freight lines were established as it has since become; but any other mode of using cars is now the occasion for an excessive movement of empty cars from place to place, in order to find appropriate loads.

When cars are in great demand upon a large system of roads, they can only be judiciously distributed by one person, who commands a complete view of the equipment available at all parts of the system, and the wants of all. Such a view may be had by properly arranged telegraphic reports from each station to its division headquarters, and from all the divisions in a condensed form, to the central office. By the use of blanks in which every kind of a car in each line is designated by a different letter of the alphabet, the numbers of all kinds at each station, and the number required to be loaded at each, may be indicated by a few

symbols; and the report may be ready at an early hour, to permit the distribution to be made, by orders from the central office to division headquarters, and from them to stations.

An examination of the reports of the great railways will show results something like this: number of tons moved per car in a year, from 500 to 600, or about 1½ tons per day; or say 10 days for each car-load of 15 tons; yet, as the average car-load has probably not reached that weight on any road, the journeys are somewhat more frequent than this would indicate. The average movement per car per day is found to be, upon active roads, for the year about 36 miles, varying with the several classes of cars from 12 miles to 80; the most rapid movement taking place in stock cars; next in line cars, and after that in local cars, which do not leave the road. The delays to local cars, especially to those which handle coarse materials, as lime, coal and lumber, are notorious and shameful; they result in great loss of traffic to the roads, because the equipment is not generally sufficient for the demand, and in injury to shippers and consignees, who are not, in consequence, promptly served; evidently the remedy is not in providing more cars, but in compelling them to be promptly loaded and unloaded. So far the supposed necessities of competition have prevented any general adoption of a charge for the delay of cars by failure of consignees to unload;

or when such a charge has been adopted, it has not been forced long enough to have any permanent effect; but it has been frequently proved that a moderate charge, say 50 cents a day for all delays over 24 hours, sufficed to insure quick unloading, when it has been strictly enforced; for business men are not indifferent to their interests, and will exert themselves to avoid any unnecessary tax. Experience has demonstrated, however, that as the freight departments of most railways are organized, as if for the sole purpose of obtaining traffic without regard to revenue, it will not be possible to collect this tax through the ordinary agencies. The superintendent's department will be the most likely to see it laid on without fear or favor, for it is that one which finds itself imposed upon by the delays of shippers and consignees. It ought not to need much argument to convince all departments, that it would be better to lose the traffic by which the cars are delayed, if thereby the cars can make more frequent trips with other traffic, which is awaiting means of transport.

The delay of cars when on foreign roads has been one of the sorest grievances of which the railways have had to complain to each other, for which no adequate remedy has been found. It has been ably treated of in papers by Mr. W. P. Shinn, before the American Society of Civil Engineers, and discussed by persons of experience; those who wish to study the subject in detail are

referred to this discussion. Probably there is no better remedy, in the present condition of roads and of traffic, than would be afforded by the simple expedient of reporting the mileage and actual position of each car upon every road to its owners. This would often enable the owners to provide loads homeward, instead of having the car wait idly for a load to turn up, or for the convenience of the other roads to return it empty. Nothing seems more reasonable than that a road should demand such information as to the whereabouts of its cars; the experiment of making such reports has been tried and found to be easy, valuable, and not too costly.

Akin to the loss from the delays of cars is that unknown but immense deficiency in revenue from not weighing the loads which they carry—a loss which is not felt, because it is not known until weighing is resorted to, but which may as reasonably be neglected in the transactions between a grocer and his customers as between a railway and shippers. The cost of track-scales has often been pleaded in extenuation of a neglect to provide them; but where the traffic amounts to ten cars per day, experience shows that the gain to revenue may be reckoned upon to repay the cost of scales in a year. It is not necessary to have track-scales at all stations, because cars may be weighed at junctions and termini; it is insisted that the weight carried should always be accurately known

and charged for. The only party who suffers by a car-load rate is the railway company.

There are few stations in the older parts of the country at which the business would not be increased by the erection of a good crane or derrick, for many shipments which are almost impossible, or are undertaken with great hesitation where there is none, would be rendered easy if such a convenience were at hand; the saving of delays in loading and unloading from its use would also be considerable; the neglect to provide cranes at the larger stations is not excusable from the fact that it has not become customary, for there are always masses of stone, iron and machinery awaiting shipment or unloading at such places, which can not be handled economically without the aid of a hoisting machine. If thought best, no doubt a slight charge would be cheerfully borne by patrons for the use of it, yet the benefits to be derived by the company from its employment would be a sufficient return upon its cost.

It is to be regretted that charges upon freights are not divided, so as to show how much is for transportation, how much for handling, and what part is for the use of the stations or terminals. It can scarcely be doubted that such a division would be of advantage to the railway company, for the justice of the aggregate of small charges would be more readily appreciated than is a gross sum per hundred, or even than a rate per ton per

mile. These last methods of calculating rates must be very deceptive even to experienced transportation men, because they must be applied for various distances, to different articles destined to points at which facilities and expenses vary widely. At any station, it is probable that the cost of handling one class of freight will be per ton five times as great as that of another class; and that there will be other classes of which the terminal cost will lie all the way between these extremes.

Although these differences are not shown in the tariffs nor explained to shippers, it is very important that they shall be accurately known to those who make the rates, and duly considered by them. Among the few terminal charges which are now collected as separate items, the most important are those for *switching:* that is, for placing cars to be loaded or unloaded on private sidings, or on the sidings of other lines; at great stations this is a source of large revenue, if properly attended to. It is often, in our railway practice, left to the option of the agent at the station whether to make the charge or not; and sometimes there is no check upon his collections, and he reports to the treasurer such a sum as he pleases on account of switching. Such methods need reformation.

On long roads, the frequent breaking up of trains at the division termini and reassorting of the cars is a source of great expense, to reduce

which it is worth while to expend much labor and to endure some delay, especially to freights which are not of a perishable character. Each time that a car is shunted it runs some risk of injury, especially to its draught irons and brakes; perhaps one-third or one-quarter of the repairs of freight cars is due to damage in shunting. The mileage of switching engines is not known; it is usually estimated at six miles per hour, at which rate the aggregate is about half as much as the whole mileage of engines upon freight trains. The amount of violent exercise to which the cars are subject, in consequence of this, can only be realized by those who are familiar with the operations of a terminal yard upon a dark and stormy night. Of course, if this switching is avoided, not only the damage to cars is less, but the number of engines and of yardmen may be correspondingly reduced. A great deal may be done to lessen the breaking up of trains, by making up solid trains for through and division points at termini and important junctions, and by starting trains out with the cars in the order in which they are to be left, if any are to be dropped on the way. It will require systematic effort, patience and the co-operation of many persons to accomplish great results in this, but success in it will benefit the railway company correspondingly.

The cost of hauling a train through a division is made up of items which do not vary with the

number of cars taken or the tons hauled, to an appreciable extent; only the quantity of fuel and water consumed by the engine are affected enough, by any difference in the load, to make that difference perceptible. It is, therefore, a ready means of reducing the cost of transportation to increase the loads taken by the engines, if they can be increased, as on many roads they can. The number of cars may often be augmented upon the whole length of a division, except at some limiting grade, at which it will be advisable to station a helping engine, if the traffic is sufficient to justify it, which may be easily determined by a calculation; or a part of the train may be left upon a siding at the foot of the grade, to be returned for by the engine when the other part of the train has been taken to the summit. Such additions to the work done will be resisted by the employés concerned, and even by officers, because of the trouble involved; the employés frequently object because the number of trips required and therefore the number of men employed are thereby reduced; yet, as these objections are not well founded, they always yield to a persistent determination. Where the nature of the country and the volume of traffic will admit of it, the best mode of overcoming the limiting grade is by a reconstruction of the line, reducing the grade. This has been done very profitably upon many of the older railways.

When the movement of freight is obstructed upon a great road, in consequence of some great storm or disaster, the accumulation of cars, if the traffic is at its height, may become almost appalling to those who are charged with the duty of forwarding them to destination. The blockade is sometimes rendered much worse than it need be by injudicious efforts to "rush things."

The amount of traffic which can be passed through a division yard in a given time is often the limiting consideration; and, generally, such yards will admit of useful work by only a certain number of switching engines. It will therefore be impossible to take care of more than a determined number of trains at once; to allow more than that number to enter the yard would result in hindering the operations of the yard-men and cause delay instead of hastening the movement. The chief duty of a superintendent, then, will be to keep all trains under control, so as to prevent a blockade at any point. The zeal of yard-men and of train dispatchers, at the termini, is apt to be quite sufficient to hasten the departure of trains in as rapid succession as the power at command will admit of. When the trains have reached the next division yard, their responsibility for them is ended. There must be some one in control of the whole movement, who will arrest it from either direction when it is too rapid. The worst blockades have resulted from overcrowding, in

consequence of a want of coolness or of firmness on the part of the superintendent or manager, who will be beset at such times not only by the troubles incident to the movement of trains, but by the clamors of the shippers and consignees, aided probably by the officers and employés of other departments. If he loses his head, or yields a hair beyond his deliberate judgment, he may be lost; he must keep cool and trust to the successful unraveling of the snarl to be his vindication. The attempt to move too much traffic in a given time is likely to involve also destruction of engines and cars; the employés, being hurried and overworked, use less than common prudence, when the circumstances really demand more than usual caution to avoid collisions.

The small obstacles to the prompt movement of freight are too many to be recited, and they will differ upon every line and at every point upon it. They can only be discovered by the patient investigation of every complaint, and they can generally be removed when their cause is understood. Instead of regarding complaints as an annoyance, the judicious manager will look upon them as a help to improve his administration. He may be quite certain that they are not nearly so numerous as would be for his advantage—for there are only a few persons who are active-minded enough to write down their griefs; a very large majority only curse the road or its manage-

ment for what they presume to be shameful indifference. It will be found that agents, who have been carefully instructed by circular, have not read the circular; that they lost their copy, or if they read it, they put a construction upon it which no other person, certainly not the author of it, could have entertained. Misunderstandings of this kind, wholly inconceivable until traced out, will account for a very large proportion of the miscarriages of freight. The "capacity of the human mind to resist information" is in nothing more thoroughly demonstrated than in this matter of forwarding freight.

CHAPTER XII.

THE MOVEMENT OF PASSENGERS.

TREATMENT OF PASSENGERS—DISCIPLINE OF TRAINMEN—INSPECTION OF COACHES—UNIFORMS—REFRESHMENTS—LOCAL TRAINS—PORTERS—BAGGAGE.

The passenger is a patron; he ought to be treated in such a manner that his patronage will be continued; it is for the interest of the railway company that he shall be courted, surrounded with conveniences and placated by attentions. The *passenger department* appreciates this, and in glowing terms, as well as in glowing colors, holds out all sorts of generous inducements to the public to patronize the *only line* which has the comfort of the passenger at heart. Unfortunately, the employés of the transportation department, upon whom is devolved the care of the traveler after the passenger department has sold him a ticket, are not so much impressed with their obligations toward this patron as they ought to be; it is their principal concern to "put him through," without

much regard to whether he shall return by this favorite route or not. To their eyes he is not a patron, but a parcel; if delivered at destination in an undamaged condition, the contract of the forwarder will be fulfilled.

This is the most natural attitude of the mind for men who have been reared as the conductors of our passenger trains have usually been. In a great majority of instances the conductor begins his railroad life as a brakeman; he enters the service as a rough, intrepid, sanguine fellow, who has conceived the idea that he would like to *railroad it* for a while. Upon a freight train he learns plenty of railroading, but his energies are absorbed in quite other duties than an exchange of civilities with travelers. By constant and manly devotion to these, during years of hardship, involving great dangers to life and limb, he experiences the training of an athlete, not of a courtier, while he learns to run trains safely according to the rules; and he is at length promoted to be a freight conductor. Some more years of hard life in this capacity finally secure for him the great reward of merit, and he becomes a passenger conductor.

Energy, promptness, vigilance and obedience to orders are the characteristics by which he has earned his promotion, and are those which will continue to influence his conduct; they are the most valuable qualifications which he can possess,

both for the advantage of the railway company and for the safety of the traveler; and until he has been for a long time in this new service, he will not appreciate fully the importance of minor things, unless he is endowed with uncommon quickness of apprehension.

The other trainmen have commonly had less opportunity than the conductor for instruction in the smaller, but important, details of caring for the passenger train and its occupants.

Now it is clearly not from ill-will, but from a want of training, that their deficiencies arise; the appropriate remedy for which is to supply the necessary education in the shortest and readiest way. It would be very well to organize a *school of the trainman*, as in the army they have the "school of the soldier;" failing this, the most evident substitute for it will be provided by sending competent *inspectōrs* constantly over the road upon the passenger trains, to instruct all the employés in the minutiæ of their business.

The foregoing remarks are intended, of course, as generalities; there are most gentlemanly and affable conductors, as well as admirable trainmen; the object of this disquisition is to suggest how others may be formed after their model.

The more accomplished conductors upon any road would be likely to be the most efficient and most acceptable inspectors who could be selected; they should have no authority except to teach;

but should report incorrigibles to the superintendent for "promotion to the freight." They will find that the men neglect many things for which plain rules are printed in the regulations; possibly the men have not read them, or have not remembered them. Among the things which they first need to teach, is attention to the temperature and ventilation of the coaches; the trainmen are passing continually into the fresh air and are naturally somewhat indifferent to the state of the air inside; but the comfort of the passenger depends as much upon this as upon any other one circumstance connected with a railroad excursion. Other needed lessons will be, not to pass through the coaches oftener than is necessary; to go through them quietly; not to slam the doors, nor allow others to slam them; not to bawl the names of stations while the doors are open, but to announce them in a clear, moderate tone, with the doors closed. Let the trainmen be instructed to assist ladies and infirm persons on and off the train, and to provide all passengers immediately with seats, not compelling them to make room for themselves. They should also be taught consideration for the poorer classes of voyagers, who need it more than the richer ones; especially for the foreigners, who do not understand our customs, and, often, not our language; even mercenary considerations should prompt this, for "bread cast upon the waters will return after many days."

The American traveler is distinguished by an inquiring mind, and, as if to furnish a complete antithesis, the least communicative of all creatures, it is said, is the American railroad man. This difference has been compromised, at a few great termini, by the establishment at each of a "bureau of information," an institution which can not be too highly recommended for imitation; but on the road it is very desirable that the trainmen, when asked for it, shall give the wayfarer such information as they can. It could usually do no harm to tell him the cause of a detention from which he is suffering. It would often do some good to impart particulars about an obscure junction at which the stranger must debark in the darkness. The French instruction books contain a rule which we can profitably copy, although we can not exactly translate it. It reads: "The employés must conduct themselves toward travelers as if they were *eager* (empressé) to oblige them."

The condition of coaches at starting, and of waiting rooms, also demands the inspector's attention; for the chilling dampness of soaked wooden floors, in the station and in the coach, is apt to curdle the blood of the passenger who takes an early train from a terminal station. Floors ought never to be soaked; they will be cleaner, more comfortable and more durable if washed with only a moderate quantity of water; and they can then be dry when required for use. On some roads the

distinction between the several classes of coaches is but little observed, because there are not enough of the inferior classes, so that the most expensively furnished coaches are frequently used for second class and for smokers, sometimes even for emigrants. Aside from the enormous wastefulness of providing plush-covered seats for such uses, it should be remembered that they do not part with the fragrance which has been so imparted to them; and the passenger who has paid for a first-class ticket will think, if he does not complain, that he has not been furnished with first-class accommodations if placed in a coach which has been so used, even if it is a new one. It would be better to provide a surplus of cars for the inferior classes, rather than of the superior kinds, for passengers will prefer to ride, upon a pinch, in those with hard seats to being placed in finer ones which have been befouled.

Upon every road which has tried putting its men into uniforms, the effect has been found to be extremely good; it leads at once to decorous behavior, and it is certainly very desirable that passengers shall be able to distinguish at once all the persons in the employ of the company from whom they are likely to require a service. Upon the larger roads all the employés should be uniformed or distinguished by some noticeable badge, in order that they may be recognized by officials. In times of trouble this is of great importance, for

in the throng which huddles about on such occasions, it is impossible, unless they are so indicated, to select men who should obey orders from those who are not subject to them.

It contributes much toward making passengers contented to afford them, at frequent intervals, the opportunity of getting something really good to eat and drink. The hunger and thirst of the richer class are reasonably well taken care of by the dining cars and buffets; but the greater number do not patronize these luxurious institutions, and the passengers at a station waiting for a belated train are not ministered unto by them. Railways generally establish a few main refreshment rooms, at which trains stop for passengers to eat a hasty lunch, but do not encourage the sale of refreshments at other stations; yet the comfort of many would be promoted by neat lunch counters at all considerable stations; they would also serve to maintain a competition in the quality of the food, which might improve the present standard.

The number of passengers carried will be increased by more frequent trains; whether the additional number will be sufficient to justify the expense of running them or not will depend upon the population to be accommodated, but the fact of an increase proves that more passengers will travel if the hours of the trains are convenient for them than if they are not. It is, therefore, a

matter for careful study how best to adapt a few local trains to the wants of the community; it will generally be found that those way trains which run nearest the middle of the day carry the most passengers. The apparent reason for this is, that people living at a distance from the line of the road have time to reach the station without rising at inconveniently early hours, and that they aggregate more than those who live in the villages upon the immediate borders of the railway, who take the earlier trains. The local accommodation trains and commuters' trains must be run very exactly on time, in order to give satisfaction or to do justice to the commuters; their business appointments will be arranged to suit the time of the trains, and even a slight delay may cause them a loss. There is often a temptation to managers to carry excursions or extra car-loads of people on these trains, causing them to be retarded, when it would be just and judicious to run a special train for the extra cars. When once the best time for a local or for a commuters' train has been arrived at and properly adjusted, the schedule should be maintained as nearly as possible without variation, because the household and business habits of the country which it serves become adapted to it, and a variation, however slight, causes a vexatious change in the arrangements of a great number of people. The only change which is ever tolerable is to

quicken the time of the train, leaving the country terminus later in the morning, but arriving at the city as before. The occasional through passenger can bear a change of schedule better than the daily patron; yet the old established through trains, which have been continued for years in succession, always carry more passengers than the faster expresses upon recent schedules, until these have been running for a long time; for tributary railroads with their connections, and all the stage lines from neighboring districts will have become gradually fitted to the old schedules, and it requires a long period of time to enable them generally to conform to a new one.

At many, indeed at most, stations, even the largest, there is a lamentable want of porters to assist in the conveyance of hand baggage from the train to the carriages, and from the carriage or waiting room to the train, so that the most delicate persons are compelled to grapple with their hand-bags and wraps and to struggle along as best they can. The self-dependent, healthy American citizen, and his wife and daughters, are accustomed to do this from early childhood, and do not mind it much until they have been *abroad;* after they have been so carefully attended as they are in the western countries of Europe, where the passenger business receives more consideration than it does with us, they miss the ready help which meets them there at the door of the railway coach.

Probably the railways which first imitate the foreign roads in providing these porters, and in insuring cheap means of conveyance, by cabs and railroad omnibuses, to and from the depots, will secure the larger share of the patronage of that now somewhat numerous class who have made a foreign tour. Wheeled chairs and stretchers for the helpless are needed at large stations, but are not always provided.

There is no present hope of reform in our baggage arrangements, probably; the system of carrying baggage free up to a certain excessive weight has prevailed so long that the more just plan of charging for all baggage would be revolutionary. A reform might be inaugurated, by a slight reduction in fares to persons without baggage, which would possibly reduce the heavy loads now carried. The change would be much more important for the railways than at first sight appears, because the competition between passenger agents leads to the carriage of immense quantities of sample trunks free, in order to secure the sale of tickets. A limitation should be placed upon the size and weight of trunks, by agreement of the passenger agents, for they are already so heavy that the force at small stations is not sufficient to put them aboard the passing trains.

CHAPTER XIII.

EMPLOYÉS.

PROMOTIONS—TREATMENT OF DERELICTS—SELECTION OF EMPLOYÉS—REWARDS AND PUNISHMENTS—PROVISIONS FOR COMFORT—ASSOCIATIONS.

Good men, who have become acquainted with their duties and who perform them with faithfulness, are the most important of all the appointments of a railroad. It is a long process to educate a fresh man to a new place or to a new business; all the experience which the old hand has acquired is of value to his employer, so long as he continues to do well or to intend to do well; although too long continuance in one round of duties is apt to make a good man dull, and it is therefore advisable to make some change occasionally for all employés, promoting them if an opportunity presents, which will encourage not only them, but their associates, who then see that patient merit attains reward, even though slowly. Frequently, with a little trouble, a vacancy may

be availed of to move several persons up one round of the ladder each, and conscientious managers find much pleasure in the larger number who can thus be made happy, at the same time that the service is benefited and strengthened. It is easier for indifferent managers to fill a place with the fewest number of changes.

The great advantage to the company of experienced men makes it a difficult matter, sometimes, to decide upon the most judicious course, when a disaster caused by the neglect or oversight of an employé calls for a judgment upon him. The *disciplinarian* would dismiss him from principle, believing that he had thereby taught a lesson to the remainder of the force; but it is doubtful whether the fear of dismissal has any effect upon the larger number of employés. Let the manager consider how it is with himself or with the other officers of the road; do they perform their duties because of fear, or because they have undertaken them and feel a manly pride in seeing them well done? There are sneaks, of course, among railroad employés as among officers, yet they are rare; the great majority are meaning to do their duty as they understand it.

The case of an erring employé should be tried upon its merits, with regard to the previous record of the employé, considered with reference to the interests of the company, and generally without regard to the other employés. Has this always

been a careful, dutiful man? Did his fault arise from ignorance, forgetfulness, indifference or laziness? If from ignorance or misjudgment, did he use the best wits he had and do as well as he knew how? If so, he does not deserve great condemnation, even though he may have caused great damage. If from forgetfulness, not habitual, but instantaneous, as has often happened to switchmen and conductors, dismissal is no remedy; the remedy has been applied by the accident; he will be a safer man ever after. If the fault was from indifference or laziness, it is sure proof of a worthless character—that is, worthless for railroad purposes. Good conductors and excellent enginemen have forgotten for a dangerous interval their telegraph orders, and caused disasters; when pardoned because of their long and perfect records, they proved safe men and the most devoted servants of the company for years after. It was not found that this leniency had a bad effect upon discipline as related to the other employés; on the contrary, these perceived the value which a good record might have for a man who fell into trouble.

All men must have some education in railroad operations before they will become experts, and in acquiring this they will make some mistakes likely to cause accidents and trouble; it would be a grave error on the part of the manager to discharge men who have had this education at his expense, to take on fresh men to be educated in the

same way. We can imagine something of the state of a road upon which all the men should be new to railroad business, or, even if experienced men, new to the road. By the frequent discharge of employés, for trivial mistakes, some roads maintain a permanent approximation to this condition : their accidents are not thereby diminished in number.

The standard of character among employés may always be raised by slow degrees, but surely, if proper care is exercised in the hiring of new men ; generally something can be learned about the character of every applicant ; a wandering man without a certificate from his last place is not a desirable acquisition; and even a certificate requires to be scanned closely. If a man is employed upon a certificate from another road, it is a safe precaution to write to the officers of that road for private assurances; for, in the first place, many officers give unwarranted certificates, which they will not support in private correspondence ; in the second place, there are men who make a business of furnishing certificates of character and recommendations for passes to any one who will pay for them, frequently stealing the genuine letter-heads and forging the office dating-stamp. The sons of industrious farmers in the vicinity of the road are usually glad to get employment, and are a healthy stock to recruit from, if judiciously selected.

Brakemen and firemen are two classes of men who require to be chosen with peculiar care, as it is from them that the conductors and enginemen are to be developed; and since they are really apprentices, with the largest pay that any apprentices receive in any trade, it is not worth while to throw away the valuable instruction they are to receive upon inferior characters. Upon brakemen a great responsibility is necessarily placed, from the first. A reliance upon them for faithful performance of their duties without good evidence of their responsibility would invite disaster. Firemen should be of a mechanical turn of mind, and ambitious to become enginemen; there are plenty of young men with these qualifications, and it is a waste to employ any others; they make the better firemen, of course, from their hope of advancement.

In filling vacancies, the best general policy is to promote deserving employés whenever there are such who are competent for the positions, and to fill up the ranks of apprentices in shops, stations and offices, as well as other minor appointments, from the families of old employés, so far as possible. The children of employés are in a sort of apprenticeship from their birth; they have opportunities for learning many details which others can only acquire after a considerable period of service; they are already attached to the road and its managers, if the management has been just;

and this attachment may be of great value to the company; it is an inducement to continuous and faithful service, if the employés understand that these chances for a start in life are reserved for their children.

It does not admit of doubt that good service may be more promoted by rewards than by punishments; yet fines imposed for carelessness are a legitimate and effectual penalty, if due care is taken not to impose them unjustly, and the men will recognize the fairness of paying them, if within their means, when by carelessness they have caused damage. Rewards, however, are more stimulating; premiums for savings on engines, for superiority in maintenance of track, and promotions of the most deserving, without favoritism, encourage a generous strife for excellence. Heroic actions, or one of uncommon merit, should be acknowledged by a letter to the deserving employé, and it is all the better if accompanied by a small present in money. Such tokens of approval have been dear to men always; the railroad employé likes to show them, as a soldier does his medals.

Discipline is only maintained by careful attention to small details. The experience of armies shows that men do not fail in the important things until they have become negligent as to the less considerable. A superintendent, supervisor or foreman must therefore be continually looking for the small defects if he hopes to avoid the

larger; nothing which is not exactly right should pass without remark; nor, if not immediately corrected, without a louder remark. It is probably not necessary to say that if the superior officer keeps his temper, under whatever provocation, his determination to require perfect obedience will be more manifest and more felt than if he falls into a passion; at the same time he will be more comfortable himself.

The condition of enginemen and firemen, of conductors and brakemen, is apt to be forlorn when they are away from home; some provision should be made for them to sleep and eat in comfort; and a sitting-room where they can pass the dreary hours of waiting, amused with games or the newspaper, is necessary, if it is not preferred that they shall haunt the taverns. These arrangements can be made self-supporting, but the company must take the initiative and furnish a suitable building which may be let to a landlord who will keep it upon terms dictated by the company, if that is thought best.

Employés' associations for any purposes, as for club-rooms, hospitals, insurance, lack the most important condition of success, which is a promise of permanence. Any employé or a considerable number of them, may leave the road at any time, and the society may fail suddenly from want of support, or the employé may cease to benefit by his contribution because of his own removal; it is,

therefore, important that the railroad company should be a subscriber to, or guarantor of, such associations as it would wish to encourage. So far as experience goes, it appears that the men are less interested in libraries and reading-rooms than in reasonable bodily comfort while living, and in benefits to their families in case of death or injury; a judicious manager can secure the hearty co-operation of the employés in any well-conceived undertaking which has these ends in view.

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