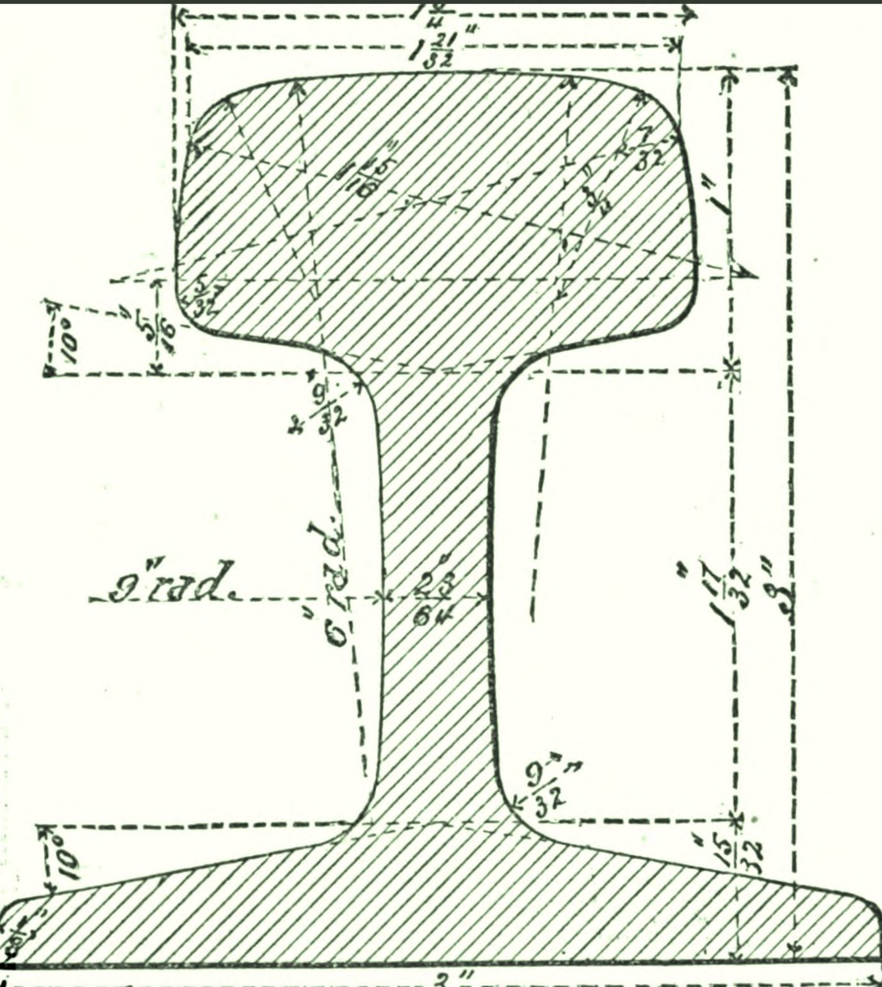

The Road-master's Assistant and Section-master's Guide

William S. Huntington, Charles Latimer

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THE ROAD-MASTER'S ASSISTANT.

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AND

SECTION-MASTER'S GUIDE:

A MANUAL OF REFERENCE FOR ALL HAVING TO DO WITH THE PERMANENT WAY OF AMERICAN RAILROADS; CONTAINING THE BEST RESULTS OF EXPERIENCE AND MINUTE DIRECTIONS FOR TRACK-LAYING, BALLASTING, AND KEEPING THE TRACK IN GOOD REPAIR.

BY

WILLIAM S. HUNTINGTON.

REVISED AND ENLARGED BY

CHARLES LATIMER,

CHIEF ENGINEER ATLANTIC & GREAT WESTERN RAILROAD.

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PREFACE.

THE object in offering this little volume to the railroad public is to correct, as far as possible, certain erroneous practices into which track-layers and section-men have fallen, which practices are fatal to the life of track and rolling stock.

With the introduction of the "T" rail in this country a certain method of laying track was adopted, and, with few exceptions, has been adhered to until the present day, and so with track repairs. It may be said that track-men "fell into a groove" thirty years ago, and are still following it, to the great detriment of railroad shareholders and of the public at large.

The enormous expense of track repairs and the liability to accident may be greatly reduced by a reform in the every-day practice of the track-layer and section-master; and the manner in which this may be accomplished is set forth in this work as clearly and briefly as possible. It would not be a difficult matter to fill a volume of several times the size of this on the subjects herein embraced, but the author believes that the information here given will be more acceptable in its present form—"in a nut-shell"—than if occupying unnecessary space for the purpose of making a *big book*. It is not forgotten that several books have been published, bearing on the same topics; but they are mainly of a technical nature, and not adapted to the wants or capacities of the average *track-man*, and are of little value to other than professional engineers.

The author has undertaken to make this a *practical book for practical men*, and the ideas herein presented are the result of upward of a quarter of a century's experience and extended observation in various capacities, on some of the *best* as well as some of the *worst* managed railroads in the country.

It is not designed to "upset" any *well-established theory*, nor is it expected to introduce ideas entirely new to every one who may read these pages; but it is confidently hoped that the great mass of track-men will here find suggestions that will be valuable to them, and far more so to their employers.

The author has, in the course of his experience, demonstrated the truth of all the statements made herein by actual experiment and practice, and may, therefore, commend them to his readers as more valuable than conclusions which are only "jumped at," or opinions formed without mature consideration.

W. S. H.

BYRON, MICH., April, 1871.

PREFACE TO THE REVISED EDITION.

To Mr. W. S. Huntington, a practical trackman, and a man of very keen perceptive faculties and sound, decided common sense, is due the credit of first presenting to the railroad fraternity a practical work upon track repairs, of which the present volume is the final outgrowth; and the owners and operators of railroads owe him a debt of gratitude at least for having raised the standard of railroad construction and repairs throughout the country. The invention or initiation of a system is the principal point; any one may follow him who is the pioneer, but all may not do better or as well. But railroading is a branch of one great work which is developing more rapidly than anything else, and it is almost as hard to keep up with it as to keep pace with the geography of our country and the population of its towns.

I do not pretend to have completely filled the gap where Mr. Huntington left off, but simply,

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at the solicitation of others, who did me the honor to ask me to revise and add to the work of my fellow-laborer Huntington, I have at leisure hours supplied, as I hope, some of the *desiderata*.

One of the most important things for me to do was to make the book general—that is, to apply to nearly all of the various gauges of the country. To this end I have prepared tables for the elevation of curves for the four gauges in most common use, also frog and switch tables for the same, with bills of timber, etc., as well as methods for putting in crossings and cross-over tracks. I have given more especial descriptions of the better kinds of switches, switch-stands, and ordinary and crossing frogs. I have selected the best systems of rules for the government of the track department from two roads. One set I prepared myself, with the advice and assistance of all the ability upon the road for which they were intended, and with the original rules as a ground-work. The other set was taken from a road where the able engineer followed the same plan, and selected from my rules as well as others the best he could find, producing a more comprehensive system than my own.

The "specification for a perfect track" of the Pennsylvania Railroad is a valuable guide, and is also given to show the experience and teach-ing of other earnest and zealous workers in this direction. These three will enable the organizer of any road to select the fittest for his use.

A special chapter is devoted to the subject of elevation on curves—a subject so much neglected, and yet one of the most vital to the safety, economy, and comfort of a road. A very excellent method for curving rails with a track-lever is also given, which I can heartily recommend. A special chapter has also been devoted to the question of the disadvantages of level crossings, which to some, perhaps, may seem irrelevant, but to others differently situated probably less so.

A variety of engravings has been introduced, illustrating the best patterns of rails, joints, frogs, and switches; also the best selections of track-tools, some of which are novel, yet proven. Others, however, of equal, and perhaps in some cases greater, merit have been reluctantly omitted. It is not to be understood that I commend those given as wholly superior to others.

In the preparation of this new edition I have utilized the brains of my friends whose names appear, and of some that do not appear, whose reward, like my own, is not so much expected in material form as in the hope of forwarding the cause of sound railroad practice. All have my warm thanks, as I am sure they will also have the reader's and student's; and I trust that some of them may be moved to take up the work where I cease, fill up the gaps left by my friend Huntington, to say nothing of my own, and present a more perfect work; at which none will more rejoice or be more ready to contribute than myself.

CHARLES LATIMER.

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CHAPTER I.

TRACK-LAYING.

CARELESS WORK—USUAL DEFECTS AND THEIR CONSEQUENCES—CHOICE OF CROSS-TIES; SHOULD BE OF UNIFORM SIZE —HOW TO LAY THEM, AND HOW NOT TO LAY THEM—SIDE TIES—"SIGHTING IN TIES"—MEASURING OFF FOR JOINT TIES—LAYING TIES ON BRIDGES, ETC.—THE USE OF SHIMS—SELECTION OF TIES FOR JOINTS—PREPARATION OF ROAD-BED—INSTRUCTIONS FOR TRACK-LAYING—USE OF COMPASS, LEVEL, AND SQUARE.

TO ensure the durability and safety of a railroad great care in track-laying in the original construction of the road is essential. Unfortunately, in our country we are prone to sacrifice everything to rapidity, even at the risk of great expense in the application of remedies to evils which ought never to have existed. In order that a road may be completed in a given time, a system of false economies is thus inaugurated which proves a dead weight to the road, and from which it most frequently never recovers. It is taken for granted that any serious defects will be corrected when the road has once been tested. This is a most fallacious idea; for there is, in fact, no remedy for some of the defects of poor track-laying. It is true that by ballasting, putting the track in good surface and line, by clearing out ditches and water-courses, the road may be fitted for use for a time; but if the ties are improperly laid, if crooked iron be laid on a straight line, or if the iron is not sufficiently curved, there is no remedy but to tear up the track and relay it. This is a result not at all provided for in the budget of expenses, and is therefore not entertained for a moment. The road is kept up by ruinous repairs, until finally, after a very much shorter period of time than if the original work had been thoroughly done, the ties are decayed, the iron worn, and the road will prematurely require extensive renewals, and probably a receiver.

CROSS-TIES.

An important matter in connection with track-laying, too often overlooked by railroad managers, is the selection of cross-ties. These should be of uniform length, breadth, and thickness. If they are not so supplied, they should be assorted before they are laid, so that all the ties in a set or a length of iron will be of the same size. If they vary in length the rail on one side of the track gets an uneven support and will settle out of surface, while that on the other will remain in good surface, making a disagreeable track to run over. If they vary in thickness it causes trouble in frosty weather, as the action of frost is not uniform, but varies as the ties vary in the depth they enter the ballast. Much mischief has been done by frost breaking away under the thinner ties while it remained solid under the thicker ones as trains were passing over them. The action of water settling under cross-ties where they vary in thickness often occasions a serious disturbance in the surface of track by washing out the gravel from under the thick ties, while it is not disturbed under the thin ones; thus rendering it difficult to keep the track in good surface. If the ties vary in width, and are laid the same distance apart from centre to centre, the rails get an uneven support, to the great damage of track and rolling stock. Any one standing by the side of such a track while a locomotive is passing slowly will observe that the drivers spring the rail most where the narrow ties are. In passing from a couple of wide ties over a few narrow ones placed adjoining them, the narrow ties settle into the ballast deeper than the wide ones, and the drivers seem to be running down hill. On the other hand, when passing from the narrow to the wider ties they appear as if running up hill; thus rising and falling as the ties are wide or narrow. If the rails were made of a material which would retain its shape after they were sprung out of surface by a locomotive, they would present an appearance similar to the waves of the ocean in a gentle breeze. Running over such a track is far more expensive than when ties are of uniform width and laid equal distances apart.

With ties of uniform length, breadth, and thickness it is possible to lay a track that a locomotive will run on as smoothly as a ball on a billiard-table, which is certainly very desirable.

Laying ties is not an operation that requires much mechanical skill; and probably most track-layers would consider any hints on the subject superfluous. Yet there are matters of great importance connected with the operation that are frequently overlooked, and it is proposed to point out here some of the most serious faults that are committed.

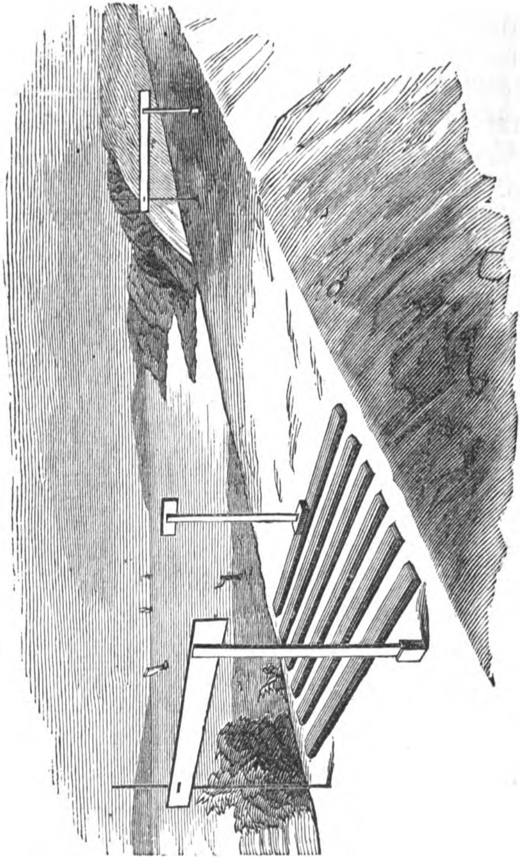
Track-layers do not generally take sufficient pains to lay ties at right angles to the rails; thus the ends are brought nearer together on one side of the track than on the other, resembling the letter A. At the next space, perhaps, the letter is reversed. This gives a good support to a portion of the rail on one side, while the rail on the opposite side has no support; and as these conditions are reversed in the next space, a disagreeable rocking motion is given to the trains, which occasions unnecessary wear to track and rolling stock.* Ties should be laid at right angles with the rail, with a view to giving the rail a continuous uniform support through its entire length.

Joint-ties should be of equal width and laid the same distances from the end of the rail. It will be observed that the ends of rails, at all joints having joint-ties properly laid, will be in good order; while those having one joint-tie nearer than the other to the end of the rail will be battered and broomed, being subjected to a pounding from every wheel that passes. By paying proper attention to laying joint-ties the iron will last much longer than when laid in a careless manner, and it would be a great saving to railroad companies if the managers would see that more care is exercised in this respect than is generally given.

"SIGHTING IN TIES."

Almost every one has a "way of his own" of doing certain kinds of work, and every one considers his method the best. It is the practice of some engineers to set grade-stakes 20 feet apart for laying ties. This is unnecessary labor for the engineers, and, moreover, it is inconve-

* In addition to this the track cannot be kept in perfect gauge when ties are laid diagonally.—C. L.



SIGHTING IN TIES.

nient for those who lay the ties. The men who lay the leading ties must handle a straight-edge 21 feet in length—a difficult proceeding, especially in windy weather. It is a slow and tedious operation to place each end of a straight-edge on the grade-stakes. A more ready method of laying the "leading ties" is to "sight them in" by the use of "target-boards." These boards are shown in the annexed cut. They are constructed by taking a board 8 or 10 inches in width and the length of the ties to be laid. Near one end a leg, 3½ or 4 feet in length, made of a strip of board, is fastened. At the same distance from the other end is a clasp and thumb-screw. An iron rod passes through the clasp and is driven into the ground far enough to support the board steadily. Two boards like Fig. 1 are required, which should be painted white, with a black stripe half an inch wide on the upper edge.

With this arrangement it is only necessary to set one grade-stake opposite each centre-stake, 100 feet apart. Place the leg of the target-board on the grade-stake; then drive the rod into the ground sufficiently to hold the board steadily. If on a straight line, level the board, and secure it in place by the thumb-screw. If on a curve, first level the board, then elevate the required distance by the ¼ inch, ½, or inch marks on the rod. Place another board like this at the next grade-stake, and you are now ready to proceed. The target is made by mortising a standard into a block. A cross-piece at the top of the standard is painted like the target-board. Place this upon the tie after it is in place. Of course, if the top of the target, when placed on the tie, coincides with the two boards, the tie is right. A sprightly lad, ten or twelve years old, can, after a little practice, sight with great accuracy and rapidity.

By this process the leading ties can be laid near enough together, so that a short straight-edge may be used to lay the intermediates. When sufficient leading ties have been laid between the target-boards, the rear board may be moved ahead, "jumping" the other board like playing checkers. The distance between the leg and the rod of the target-board should be equal to the gauge of the track. On curves the grade-stakes should be set on the inner side.

This method relieves the engineers of an immense amount of unnecessary labor, and track-layers who have tried the plan prefer it to any other.

MEASURING OFF FOR JOINT-TIES, ETC.

This should be done with great care, and, if nicely done, will not only save much labor and trouble in track-laying, but will tend greatly to prolong the life of rails and reduce the expense of track repairs. The cross-ties must be properly and evenly spaced, sixteen ties to a 30-foot rail, with 10 inches between the edges of the bearing surfaces at joints, and intermediate ties evenly spaced a distance of not over two feet from centre to centre. When it is necessary to move the joint-tie, the intermediate ties should also be moved, to make them equal distances apart. This will not only prevent the wear of the rails at the joint, but will save much expense in track repairs.

The ties should not be laid far in advance of the rails, as it is convenient, in measuring for joints, to go back occasionally and measure from the end of the rails and correct the measurement, which will obviate the necessity of moving ties after being once laid. The measuring pole or rod should be as long as the target-rail. The length of shorter rails may be marked on the pole. The joint-stakes should be made square and straight. Set the stake ahead of the end of the pole (or the marks, if for short iron) just the distance that is allowed for expansion, and by driving the stakes perpendicularly and firm the measurement will be correct. By exercising a little care to place the stakes in line, the measuring will be more accurate than when driven zigzag. Rails should be of uniform length, except a few shorter ones for curves. In laying track on curves it is necessary to use a short one for the inner rail occasionally, to keep the joint even with the centre of the opposite rail, or to maintain even joints. In such cases the measuring-pole must be "set back" as much as is necessary. The man in charge of laying the iron should keep watch and notify the "marker" when the iron has run ahead far enough to need the short rails. The marker can thus act understandingly. The ends of the ties on the outside on double track, and on one side on single track, should be lined up parallel with the rails.

LAYING TIES ON BRIDGES, TRESTLE-WORK, ETC.

There are some splendid railroad bridges in this country, built at an enormous expense, which are greatly injured because the ties on them are improperly laid. When cross-ties are used on bridges, they should be laid by a mechanic, with great nicety, as this is essential to the life of the bridge. In adzing them down to a uniform thickness great care should be taken that there is not the slightest variation; for, although it is usual to use sawed ties on bridges, they will be found to vary considerably in thickness. It is not uncommon to find track laid on bridges where the ties have not been properly fitted, and shims used to level up with. The shims are often made of soft wood, in which case they are worthless, or they work out of place, thus leaving the rail with only a bearing on every third or fourth tie. This should never be allowed, as it causes great strain and vibration and injures the structure. Cross-ties should be securely fastened, so that they cannot slip or jar out of place. Frequently three or four ties may be found out of place, and so close as to touch each other, while the rail has no support for several feet. Of course such things would not be looked for on some of our first-class roads; but they are far too common in this country, both for the good of the railroad corporations and the public.

Under no circumstances should the ties be notched, but, should they be twisted, they must be made true with the adze, so that the rails may have an even bearing.

The ties on bridges, as well as the bridges, should be under the charge of the bridge-men. No ties should be laid on any bridge so thin as to permit the spike to go through into the stringer; the stringers, except those on the outside, should not be marked or marred with a spike. On all bridges long ties should be used, not less than 12 feet, and they should be 5 inches by 8 inches, broadside downwards, notched carefully over each tie, not over 3 inches apart, and bolted every 6 feet, so as to avoid jarring in case a train crosses the bridge off the rails. In order to avoid, if possible, the destruction of the bridge, a guard-timber should be notched over the ties 1 foot outside the rail, and bolted every 5 feet to the outside stringer.

JOINTS.

In the preceding instructions, written some years ago, it has been assumed that the joints are laid upon ties, and the remarks are universally correct for a track laid with the old-fashioned chair; but at this time no road of importance uses the chair, except to wear out old material. The chair has given way to the ordinary fish-plate, and this has been supplanted in many instances by numerous devices, such as the angle-bar, the Trimble, the Fisher & Norris, the Dilworth & Porter, the Arthur, and many other patent joints, which I will treat of in a separate chapter.

The opinions of engineers differ upon the question of the position of the joint with the fish-plate, and many experienced engineers and track-men maintain that the suspension-joint is the proper place. I have given this subject careful attention, and maintain that with the ordinary fish-plate the joint on the tie is the proper position; and as overwhelming evidence of the correctness of this I claim that the broken fish-plates with the suspension-joint are far more frequent than in the joint on the tie. But I also assert that no fish-plate fastening that I have ever seen has proved strong enough for the steel rails now in use, and therefore the wisest engineers are seeking for a joint which shall have all the requisites of economy and strength.

In this chapter nothing is said of preparing the roadway for the ties. When this is done, much of the use of level and sight-board recommended in the chapter and universally practised is needless. The proper and only way to secure a thoroughly good track is, before a tie is laid, and just before track-laying is begun, to have a small gang of experienced graders ahead of the tie-layers, with an engineer of experience and good sense, who shall give the grade about every 100 feet and the elevation of the curves. The graders can thus make the road-bed as smooth as a floor, and, however much it may cost, the expense is a mere trifle compared with that of the plan generally practised; for by the ordinary plan the rails are bent or damaged by the construction locomotive through the almost universal carelessness of either the engineer or contractor. These graders should have sight-boards, and no half-way levelling should be permitted. The result will amply pay. Of course a difficulty will ensue, provided the ties have not been hewn to a uniform thickness; but this should be attended to, and when a tie varies it should be adzed, so as to have a perfect surface. A few hundred dollars spent in this preparatory work will often save the expenditure of many thousands, especially if a track be laid in the beginning of winter.

THE USE OF COMPASS, LEVEL, AND SQUARE.

The use of the track-level on railroads is indispensable to obtain a good track.

I am sorry to say that many railroad men fancy that the eye serves the same purpose as a good instrument. Managers will do well to change the ideas of such men, and, failing in this, to get others of better sense. The trackmen who use the level most carefully will show the least wear and tear of track and rolling stock to the tonnage and speed, and *vice versa*.

Let every section-foreman be supplied with a good track-level, each road-master with a spare one and a light test-level and gauge combined, for his own use as inspector. Under no circumstances should he permit the track to be put up without the use of the instrument.

Whenever a section-foreman does not use his level, and shows intractable pig-headedness upon this point, put him at some work more suited to his capacity.

The good mason prides himself upon the use of the three tools of his craft—the compass, the level, the square. These tools—the compass being represented by the transit—are equally essential to the good track-man, and it should be his pride to apply them constantly in the perfecting of his work.

The compass, or transit, is the instrument for tracing the line. A perfect alignment of track is as important as a perfect level. The level, it is well understood, is used for the purpose of getting the two rails of the track at the same height or level, and to elevate the outer rail of curves, so that the centrifugal force may as nearly as possible be balanced or counteracted. The square is the gauge—a gauge that is not a square is not a perfect gauge. The Huntington gauge is a square, and by it the rails are laid and maintained perfectly parallel.

He who neglects the use of these three instruments can never be a good trackman and must always remain a comparatively unprofitable servant.

TRACK-LAYING GANG.

To lay track at an average rate of half a mile a day, the grading being well done, the ties distributed ahead, and the iron and other supplies delivered by a construction train promptly, a gang of thirty-one men and a horse are required, the men divided about as follows:

1 foreman.
4 men spacing ties.
6 men on iron car.
8 men spiking.
4 men holding up end of ties.
4 men bolting splices.
1 boy distributing spikes.
1 boy on iron car.
1 boy carrying water.
1 horse hauling iron car.

These will require the following tools:

1 iron car with rollers.
1 1-in. rope for same.
6 picks.
24 shovels.
2 adzes.
12 spike-hammers.
2 claw-bars.
12 steel lining-bars.
6 wrenches.
1 sledge, 12 lbs.
12 cold-chisels.
3 pick-handles.
6 spike-hammer handles.
4 rail-tongs.
2 rail-forks.
4 gauges.

1 double-clamp gauge for iron car.
1 tie-pole, 30 ft. long.
1 tie-line, 1/4 in., 1,000 ft. long.
12 expansion-shims.
2 water-pails.
2 dippers.
2 tool-boxes.
1 set harness.

The number of men and teams required to distribute the ties depends so much upon the manner in which they are delivered that no fixed rule can be given.

CHAPTER II.

LAYING THE RAILS.

DAMAGES BY ROUGH HANDLING—CURVING IRON—COCKED JOINTS, AND HOW TO REMEDY THEM—EXPANSION OF IRON—USUAL PROVISION AGAINST IT—CAUTION NECESSARY IN REPLACING REPAIRED RAILS—THE FOUR-BOLTED FISH-JOINTS—HOOP-IRON SHIMS—SUSPENSION-JOINTS—CREEPING TRACK.

EVERY year a large amount of money is wasted throughout the country by bad handling of railroad iron. It is often bent by being carelessly thrown from cars and laid without being straightened, or it is thrown to one side as useless. Steel rails should be unloaded more carefully even than iron. They should be slid off the car on skids, or else dropped square in a soft place, each rail being moved to give room for the next, no one falling on another.

CURVING IRON.

It is customary, with most track-layers, to curve iron by dropping it as it is drawn from the iron cars, when laying it. This is a bad practice, as it is either curved too much or not enough; or, as is generally the case, it is not curved at all, but only gets an elbow in the middle of the rail, while from the middle to the ends it remains perfectly straight. Sometimes, on slight curves, the iron is curved after spiking by throwing the curve into it with lining-bars. This makes a very handsome track for a short time; but the iron will soon regain its former shape and become straight. Straight iron wears rapidly on curves, and it is difficult to keep in line. Iron should never be laid on curves until it is properly curved; and, if no curving-machine is at hand, it can be very nicely done with the old-fashioned apparatus—viz., a chain, lever and sledge, a couple of ties, and a fishing-line.

EXPANSION OF IRON.

Many serious accidents are caused in this country in the summer months by the expansion of iron. These accidents are not confined to what are called "one-horse roads," but frequently occur on some of the best-managed roads in the country. In the month of July, 1867, eight serious accidents occurred in one day, all caused by expansion of track-iron! Several lives were lost, and the damage amounted to an enormous sum. Probably there are few more fruitful sources of accident than expansion, although it is fair to presume that there is not a track-layer or a section-master in the country unacquainted with this property of iron. It is safe to say that, as a cause of disaster, it ranks next to collisions and misplaced switches. Accidents from expansion are always serious ones, usually resulting in a general smash-up, with loss of life. Yet these accidents may be prevented by allowing for expansion, especially when rails are laid in cold weather. In winter a distance of $\frac{3}{8}$ of an inch in latitudes of severe cold, and in summer $\frac{1}{16}$ of an inch, must be left between the ends of the rails to allow for expansion, with 30-foot rails.

It is customary to drive the rails to place with a sledge, and a chip of wood, or little sliver, is placed between the ends of the rails to keep them open a little for expansion. This is of no use, for a blow of the sledge will smash the chip, or compress it to the thickness of a sheet of paper. The length of iron and temperature of the weather should always be taken into consideration. Probably one cause of track-layers neglecting to make provision for expansion lies in the fact that, years ago, the iron was only about half the length of that now in use; and in laying the long iron now they only make the same provision that they did for short iron. A continuous line of track, five hundred miles in length, will expand one-fourth of a mile. Railroad managers would do well to see that all track-men in their employ are posted in this matter; and, as different rules are needed in different parts of the country, the subject should be attended to by engineers, each in his own locality.

Care is also needed in replacing iron that has been repaired. In welding the ends of battered rails they are frequently left a trifle longer than they were before, and, when they are replaced in the track, they take up all the space, leaving no room for expansion. It is a common practice for repair-men, when replacing mended iron, to squeeze it in perfectly tight. In such cases they are sure to have trouble in hot weather. In most cases it is not economical to repair rails, but instead the battered ends of the rails should be cut off carefully with a saw, and the good pieces repunched and relaid in strings, thoroughly bolted up.

The iron car should always be provided with a shim-box on each side. The boxes should be divided into various compartments to hold shims of various thicknesses, not only to be used at different seasons of the year, but at different times of the day. The thicker ones should be used in the morning when it is cool, and at the close of the day, and thinner ones in the heat of the day. It is a good plan to take hoop or band iron, 1 inch or 1½ inches wide, and of various thicknesses, and cut into lengths of about 3 inches; then bend the pieces in the middle at right angles, so that they will form two sides of a square; select the proper thickness, and use them by placing one end between the rails and the other on the top of one rail at the joint. After the joint has been bolted and spiked the shims can be easily removed for future use. This is an important matter, and should receive more attention than is generally given to it.

Trouble is sometimes experienced on roads where it would seem that ample provision had been made for expansion. This is sometimes caused by sand, gravel, particles of iron, etc., getting into the space between the rails at the joint, where the chair prevents its working out. There is no remedy for this except to exercise care in ballasting, and to clean out the joints as well as possible after dressing off the track. Expansion may also be hindered by bolting the fish-bars so tight as to prevent the *slip* of the rail, causing it to buckle, which throws it out of line. This is not likely to occur where elastic washers or wood is used.

"Suspension joints" have been used considerably on some roads, and thus far have given good satisfaction. With these joints no chair is used, and the joint is made by placing two broad-faced ties near together, each tie being near the end of the rail, leaving about five inches of the ends of each rail with no support except the fish-bars. This leaves the joint suspended between two ties, ten inches apart, and all sand, gravel, etc., is allowed to fall through, leaving the joint always free.*

CREEPING TRACK.

Much damage has been done by expansion from improper treatment of "creeping track." The creeping of track occurs most frequently on roads with heavy traffic, and where grades are heavy and change often. The rails in creeping have a tendency to move towards the foot of the grade, bringing the ends of all the rails on the incline in contact, while at the summit there is sometimes an open space. This space is sometimes filled with a hard-wood plug or block, driven in tightly to prevent its working out. On some roads a "plug-chair" is used in place of the block. These chairs are of the ordinary form of cast chairs, with a tongue in the middle of the rail-seat, the tongue being in the form of a cross-section of the rail. The tongue, or plug, is cast with the chair, and chairs are cast having the plug of various thicknesses, varying from one to three or four inches, to fill a space of any width. Of course these chairs prevent the brooming of iron at the open spaces,

* It is not advisable to use a suspended joint unless the joint is stronger than the ordinary fish-plate.

and are also a great relief to rolling stock; but they prevent expansion, and their use should be abandoned. Fish-bars prevent creeping in a great measure, but there are thousands of miles of road in the country still using the old style of chairs, and the railroad community is greatly in need of some effective contrivance for keeping rails in their places longitudinally. The inventor who will produce it will, no doubt, be well rewarded.

[Since the above was written, which was several years ago, chairs have generally disappeared; at least, they are now seldom used for new roads and renewals. Many new patterns for joints, too, have been introduced. Some of these are mentioned in Chapter X., entitled "Patterns of Rails—Joints," which begins on page 91 of this book. In that chapter, moreover, reference is made to engravings of the "Samson," the "Fisher" (often called the "Fisher & Norris"), the "Dilworth & Porter," and some other of the forms of fish-joints now in common use, including the ordinary fish-joint.]

RAILS.

In one mile there are 5,280 feet, or 1,760 yards. To lay one mile of track requires:

704 fifteen-feet rails,
660 sixteen-feet rails,

587 eighteen-feet rails,
528 twenty-feet rails,
503 twenty-one-feet rails,
377 twenty eight-feet rails,
352 thirty-feet rails.

Rails weigh about ten pounds per yard for each square inch of sectional area. For example: The cross-section of a 56-lb. rail is $5\frac{6}{10}$ square inches.

Sectional Area in square inches.	Weight per yard in pounds.	Tons per mile (2,000 lbs.)	Tons per mile (2,240 lbs.)
4	40	70.4	62.85
5	50	88.0	78.57
$5\frac{6}{10}$	56	98.5	88.00
6	60	105.6	94.28
7	70	123.2	110.00
8	80	140.8	125.71
9	90	158.4	141.42
10	100	176.0	157.14

For any weight of rail: Multiply the weight in pounds per yard by eleven (11), and divide the result by seven (7). The answer will be the number of "long" tons (2,240 lbs.) per mile.

CROSS-TIES.

The number of cross-ties per mile, when they are placed 2 feet apart from centre to centre, is 2,641; at 2¼ feet apart, 2,348; at 2½ feet, 2,113; at 2¾ feet, 1,921; and at 3 feet apart, 1,761.

X. Explan[illegible]
Weight [illegible]
mile (1760 × [illegible]
[illegible] - $\frac{3520}{2240} = \frac{11}{7}$

CHAPTER III.

ABOUT SPIKES.

WASTEFUL HANDLING—DRIVING SPIKES—HOW THEY ARE SPOILED—THE RIGHT METHOD—THE GAUGE: ITS MISUSE—OSCILLATION OF RAILROAD CARS: BAD SINKING ONE CAUSE—OTHER CAUSES—SPIKING ON BRIDGES—WASTE OF RAIL-PLATES.

THE driving of spikes is an operation which is usually performed in a slovenly manner, and a great deal of money is wasted in consequence. Kegs of spikes are thrown from the car into ditches, culverts, cattle-guards, etc., the kegs are broken open, and a portion of their contents lost in the mud or covered with gravel and never seen again, unless they should accidentally be dug up, years afterwards, by repairmen. If a little more care was exercised in this respect it would be well, not only with regard to spikes, but with bolts, nuts, washers, chairs, fish-bars, etc., which frequently share the same fate. But it is the manner of *driving* spikes that chiefly needs improving; it may be changed greatly to the advantage of all concerned.

Spiking, like all work connected with track-laying in construction, is usually done with a *rush*, and, consequently, poorly done. The spikes are often driven under the rail; that is, they are set leaning, so that the point either goes with a *slant* under the rail, or, in the other direction, from it. It is wrong in either case, as the spike can never afterward be drawn for track repairs without bending it so as to render it unfit for future use; for an attempt to straighten it will break it. Spikes should be driven as nearly perpendicular as possible. Tall spikers usually set the spike leaning from them; probably for convenience of driving. The practice is a bad one, as it brings the head of the spike down on the rail edgewise, which weakens it; moreover, the spike is in a worse position for drawing than when driven in the other direction above mentioned. In drawing a spike driven with the top leaning from the spiker, the head is almost sure to break off; or, if it does not, it will be bent to one side, so as to render it entirely worthless. For proof of this, notice the kegs and barrels full of bent and broken spikes, and the loose piles of the same article around every car-house, shop, or depot, or in the scrap-house, to say nothing of the great numbers of them that are lost in the gravel. Most of these spikes might have been used again, if they had been properly driven.

Spiking joints is often carelessly done, although with some kinds of chairs now in use much care is necessary to secure a true joint, so as not to subject the ends of the rails to pounding and battering, which soon renders them unfit for use.

Many heads are broken off the spikes, when driving them in a hurry, by striking the last blow too forcibly. When the spike is nearly driven home, a light blow should be given, so as just to bring the head to the rail without cracking or straining it. In frosty weather bushels of spike-heads may be picked up on some roads which have been needlessly broken by carelessness in striking. In spiking the gauge side care should be taken to place the gauge at right angles with the rail. It is not uncommon to find tracks to vary in width from ½ to ¾ of an inch, and sometimes even more. One cause of this variation lies in not placing the gauge properly. On straight lines it is not difficult to get a true gauge, if ordinary pains are taken; but on curves and frogs, etc., it requires considerable care to place the gauge properly, as the eye is liable to be misled by surrounding objects. But the greatest difficulty in this respect is generally encountered on curves, by reason of the inner rail "running ahead," as before mentioned. Spikers are in the habit of placing the gauge diagonally across the track at the joint on both sides of the track; and when one joint is 15 or 20 inches in advance of that on the opposite side it has the effect to alter the width of the track very much. This variation in the track is a serious evil, which may, in some measure, be remedied by proper care in spiking the gauge side.* There are other causes of the evil above mentioned, which together have the effect to make this variation far greater than is generally supposed. The gauge is sprung by driving the outside spike under the rail, so as to draw the rail in; or, perhaps, the inner spike is started first, which draws the rail out a trifle too much; and, after the spikes are once driven, it is left as it is, right or wrong, not being considered of any importance, as it is but a trifle too wide or narrow, as the case may be. The oscillation of railroad-cars is, in a measure, due to variation in gauge. The question, "Why do railroad-cars oscillate?" has lately been discussed in the scientific and mechanical papers, and has been ascribed by some, who have given the matter considerable attention, to the bevel of car-wheels. There is no doubt that conical wheels are, to a certain extent, the cause of oscillation of cars when running on a track in good line, and with a true and uniform gauge. In the discussion here alluded to the oscillation of railroad cars is described as something ex-

* The proper remedy is in the use of the gauge of Mr. Huntington, which will prevent these mistakes.—C. L.

tremely disagreeable, and with a good deal of truth. There are, however, a few roads in the country where cars are comparatively free from this nuisance. It is customary to allow ¼ to ½ of an inch for play between the flange of the wheel and the rail; or, in other words, there is a difference of from one-half to one inch between wheel and track-gauge. The compromise wheel, of course, has much more, running on the 4 feet 10 inch gauge, and consequently there is more oscillation. This is necessary, for obvious reasons, and with this space for play it is impossible to prevent oscillation entirely. There is, however, nothing particularly damaging from this cause to track or rolling stock, when track is laid to a true gauge, while a gentle, regular, swinging motion of a passenger coach is not a disagreeable sensation to passengers. It is the sudden jerking and twitching from side to side that nervous people so dislike, which tends to the rapid wear of track and rolling stock, and is not unfrequently the cause of accidents.

As the rail is a guide to the wheels, the line side may be in perfect condition; yet, if the gauge side varies, it will be seen to present a snaky appearance, full of kinks, and, as the flange of the wheel is as likely to follow the gauge side as the other, the disagreeable oscillations will still occur. If track is ½ or ¾ of an inch too wide, then, of course, the trucks have an excessive side motion, producing what is called "gauge concussion." Another cause of concussion and oscillation may be found in the surface of track, even when the gauge is tolerably correct. It is a fact not generally known that a locomotive or car wheel will generally follow the highest rail on straight line, when one side of the track has settled more than another. For instance, if a rail, or the length of several rails, on the right side of the track has settled so as to be lower than on the left, the flange on the wheel will follow the *left* side; but suppose this condition of the track to be reversed for a few lengths of iron beyond, then the flange will follow the *right* rail, and so on, continually changing from side to side, causing both oscillation and concussion. These difficulties are not so serious on curves as on straight line, unless the track is out of line, and in that case they are far more disagreeable on curves.

There is but little track in this country with straight line perfectly level, for various reasons above mentioned — viz.: improperly-selected sleepers, improper manner of laying them, etc., etc. The track settling out of surface, and the incline of the ties (the cross-section of the track) continually changing from side to side, the trains which pass over such track at high velocities (the flanges of wheels striving to follow the higher rails) are, in consequence, subjected to sudden and powerful lateral motion. This motion, on track kept in good repair, is not always productive of any serious evils; but, as before said, it greatly increases the wear of rails and rolling stock.

SPIKING ON BRIDGES, CULVERTS, ETC.

A great deal of valuable timber is destroyed and track rendered unsafe on bridges, culverts, etc., by using common spikes, which act as so many wedges to split the stringers or rail-plates. When the track-layer is not furnished with bridge-spikes he should provide them himself by having the blacksmith sharpen a sufficient quantity of common spikes, so as to reverse the points. This will prevent the splitting of rail-plates, or checking them, which lets in water, causing them soon to decay. There are many bridges the stringers of which are so decayed that the spikes can be pulled out with the fingers. The main body of the timber may be perfectly sound, while a line along the base of the rail, on either side, and under the rail, may be so far decayed that the spikes will work out by the jar of passing trains. On some roads it is not uncommon to see track-men picking up the spikes and driving them in a new place; or, if this has been done so many times that *there is no new place*, they make one by plugging a hole, or filling it with sand, in the soundest place they can find.

Thousands of rail-plates are now lying by the roadside, rotting, which might safely have done duty for years longer had they received proper treatment. Such timber as is used for this purpose is expensive; and no railroad company can well afford such wanton destruction of property. Of course these timbers should not remain in the track one minute after they become unsafe; but, with proper usage, they will do service much longer than with such usage as they too often receive. Rail-plates should be securely fastened to prevent spreading.

CHAPTER IV.

CATTLE-GUARDS, CULVERTS, AND TURN-OUTS.

CATTLE-GUARDS OFTEN MERE TRAPS—THEIR PROPER CONSTRUCTION—LAYING IRON OVER CATTLE-GUARDS, CULVERTS, AND ROAD-CROSSINGS—LAYING TURN-OUTS—LOCATING FROGS—TABLES FOR PUTTING IN FROGS AND SWITCHES—CURVING IRON GUARD-RAILS—MEASURING DISTANCES BY THE HAMMER—ADJUSTMENT OF GUARD-RAILS—TIE-RODS—A FEW WORDS OF HOME AND FOREIGN ROADS.

CATTLE-GUARDS are sometimes constructed by digging a narrow, shallow pit and covering it with slats. This is certainly not the best form of cattle-guard. Some more ingenious device should be employed, as there is danger of killing stock in one at road-crossings. Frightened animals become entangled in the slats, and are held until crushed by the train, which is not unfrequently thrown from the track. Railroad companies have sometimes suffered by traps of this sort, but they continue their use. The most effective cattle-guard is a deep pit left entirely open, without even cross-sleepers. These pits should be strongly walled up, either with masonry or timber (the former is preferable, but it is difficult to obtain material in some sections), and the track laid on stringers in a substantial manner—not cobbled up on ties or fence-posts, as is frequently the case. Nothing gives our railroads a more poverty-stricken, slovenly appearance than a shabby and unsafe manner of building cattle-guards and culverts.

In laying iron on cattle-guards, open culverts, etc., care should be taken that the joints do not come on the end of the stringer outside the face of the wall or abutment. If the joint is near the end of the stringer, it is likely to injure the masonry by rocking when trains are passing. It is far preferable, therefore, to bring the joint near the middle of the timber. This can be easily arranged by laying a few lengths of short iron just before reaching the culvert or cattle-guard; or, if there is no short iron at hand, it is better to cut a length for that purpose, as the pieces need not be wasted; they will be wanted for guard-rails or something else of the kind. The same care should be exercised in regard to road-crossings, except that the joints should be brought outside the planking. This cannot always be done, owing to the length of track that must be planked; but there are many crossings that may be laid with no track-joint in the planking. This can easily be done by the track-layer, while it will save a great deal of trouble to the section-master and expense to the company. The principal objection to a joint in a road-crossing, where it is covered with plank, is that it is frequently necessary to disturb the crossing for track repairs. To do this the planking must be taken up; this often results in the splitting of the planks, so that new ones must be furnished or the crossing is not left in a safe condition. Besides, it often happens that frost remains under the planks, in which case it requires a vast amount of hard labor with the pick to accomplish the necessary repairs. The reason is this: the joint-tie is more likely to settle than any other part, and water will remain a long time under the crossing after it has entirely left other portions of the track; so that the joint in the crossing needs frequent raising to keep it in surface, while if it was outside the planking it would be easily accessible for repairs when needed. Every section-master has experienced more or less trouble with joints in road-crossings; and, as this trouble is costly, it would be well for those in charge of track-laying to give it special attention.

LAYING TURN-OUTS.

It requires considerable skill and judgment to lay a good turn-out. There are many track-layers of great experience who are not successful in this branch of their work; and again, many men skillful on turn-outs are not rapid and successful in track-laying. However, the latter make the best track-layers in time, though, probably, for a while they will exercise unnecessary care until they gain the general experience which will enable them to avoid wasting time in the plainer work.

The principal difficulties encountered by track-layers of limited experience are in getting the frogs the proper distance from the switch, and the right distance apart when more than one frog is to be laid.

In placing a frog the track-layer wants to know *how far from the heel of the switch-rail to place the point of the frog.* This distance depends upon the gauge, the angle of the frog, and the "throw" of the switch-rail: Frogs are usually made six inches across the head, and with four inches of opening at the mouth. With these dimensions the following tables will give the distances in feet and decimals from the "toe" or "head" of the switch to the point of the frog—the throw of the switch being five inches, except for the three-feet gauge, for which it is three inches.

When a double turn-out is to be laid from the main track, on a straight line, one to each side of the main track, it is not a difficult affair, provided the frogs are of the right size and length in relation to each other. Of course the two long frogs generally should be of equal length, and placed opposite each other in the main track. When these two frogs have been put in place, it is easy to ascertain the proper location of the short or centre frog by the following tables:

Tables for Putting in Frogs and Switches.

GAUGE, 6 FEET ; THROW, 5 INCHES.

Proportion of frog.	Frog angle.	Angle of curvature of lead.	Radius of curve, feet.	Middle ordinate, inches.	Length of switch rail, feet.	Distance from head-block to point of frog.	Crotch-frog.	
							Proportion.	Distance from head-block to point of frog, ft.
1 to 4	14° 15′	29° 24′	197.1	17⅞	12.8	35.2	1 to 2.9	22.4
1 " 5	11° 25′	18° 54′	304.5	17⅞	15.9	44.1	1 " 3.6	27.6
1 " 6	9° 32′	13° 10′	436.1	17⅞	19.0	53.0	1 " 4.3	32.9
1 " 7	8° 10′	9° 42′	591.5	17⅞	22.1	61.9	1 " 5.0	38.0
1 " 8	7° 09′	7° 24′	775.0	17⅞	25.3	70.7	1 " 5.7	43.3
1 " 9	6° 21′	5° 54′	971.8	17⅞	28.4	79.6	1 " 6.4	48.6
1 "10	5° 44′	4° 44′	1211.0	17⅞	31.7	88.3	1 " 7.0	52.5
1 "11	5° 12′	3° 55	1463.2	17⅞	34.8	97.2	1 " 7.7	57.8

GAUGE, 4 FEET 8½ INCHES ; THROW, 5 INCHES.

Proportion of frog.	Frog angle.	Angle of curvature of lead.	Radius of curve, feet.	Middle ordinate, inches.	Length of switch rail, feet.	Distance from head-block to point of frog.	Crotch-frog.	
							Proportion.	Distance from head-block to point of frog, ft.
1 to 4	14° 15′	37° 34′	155.9	14	11.4	26.2	1 to 2.9	16.2
1 " 5	11° 25′	24° 06′	239.6	14	14.1	32.9	1 " 3.6	20.0
1 " 6	9° 32′	16° 40′	345.0	14	16.9	39.5	1 " 4.3	23 7
1 " 7	8° 10′	12° 19′	431.3	14	18.9	46.9	1 " 5 0	28.3
1 " 8	7° 09′	9° 28′	606.0	14	22.4	52 8	1 " 5.7	31.3
1 " 9	6° 21′	7° 30′	764.5	14	25.2	59 4	1 " 6.4	35 1
1 "10	5° 44′	6° 04′	949.1	14	28.1	65.9	1 " 7.0	37.9
1 "11	5° 12′	5° 14′	1096.0	14	30.1	73.3	1 " 7.7	42.5

GAUGE, 5 FEET; THROW, 5 INCHES.

Proportion of frog.	Frog angle.	Angle of curvature of lead.	Radius of curve, feet.	Middle ordinate, inches.	Length of switch rail, feet.	Distance from head-block to point of frog.	Crotch-frog.	
							Proportion.	Distance from head-block to point of frog, ft.
1 to 4	14° 15′	35° 20′	165.0	14⅞	11.6	28.4	1 to 2.9	17.8
1 " 5	11° 25′	22° 42′	254.5	14⅞	14.6	35.4	1 " 3.6	21.7
1 " 6	9° 32′	15° 44′	365.4	14⅞	17.4	42.6	1 " 4.3	25.8
1 " 7	8° 10′	10° 08′	566.2	14⅞	21.7	48.3	1 " 5.0	28.6
1 " 8	7° 09′	8° 54′	642 0	14⅞	23.0	57.0	1 " 5.7	34.2
1 " 9	6° 21′	7° 04′	811.4	14⅞	25.9	64.1	1 " 6.4	38.2
1 " 10	5° 44′	5° 42′	1005.7	14⅞	28.9	71.1	1 " 7.0	41.3
1 " 11	5° 12′	4° 44′	1210.9	14⅞	31.7	78.3	1 " 7.7	45.4

GAUGE, 3 FEET; THROW, 3 INCHES.

Proportion of frog.	Frog angle.	Angle of curvature of lead.	Radius of curve, feet.	Middle ordinate, inches.	Length of switch rail, feet.	Distance from head-block to point of frog.	Crotch-frog.	
							Proportion.	Distance from head-block to point of frog, ft.
1 to 4	14° 15′	58° 48′	102	8¾	7.1	16.9	1 to 2.9	10.5
1 " 5	11° 25′	37° 48′	154	8¾	8.8	21.2	1 " 3.6	13.0
1 " 6	9° 32′	26° 20′	220	8¾	10.5	25.5	1 " 4.3	15.4
1 " 7	8° 10′	19° 24′	296.8	8¾	12.1	29.9	1 " 5 0	17.9
1 " 8	7° 09′	14° 48′	388.2	8¾	13.9	34.1	1 " 5.7	20.4
1 " 9	6° 21′	11° 48′	486.5	8¾	15.6	38 4	1 " 6.4	22.9
1 " 10	5° 44′	9° 28′	606.0	8¾	17.4	42.4	1 " 7.0	24.7
1 " 11	5° 12′	7° 50′	732.0	8¾	19.1	46.9	1 " 7.7	27.2
1 " 12	4° 46′	6° 37′	866.3	8¾	20 7	51.3	1 " 8.4	29.9
1 " 13	4° 24′	5° 38′	1016.0	8¾	22.5	55.5	1 " 9.1	32.4
1 " 14	4° 06′	4° 52′	1177.0	8¾	24.3	59.7	1 " 9.8	34.3

NOTE.—These tables are for turn-outs from straight lines. The distances in turn-outs from curves remain also the same; the curves of the turn-outs and ordinates only vary.

They are arranged for stub-toe switches, or those where the head-block is at the toe, or further end, of the switch-rails or moving bars. Where the head-block is at the heel, or nearest end, as in a split or point switch, the distance from head-block to point of frog is obtained by taking the sum of the figures in the columns headed "Length of

More care is necessary in placing cast frogs than rail-frogs, as the latter can be made to yield somewhat in lining up, so as to conform to the different tracks; while the cast frogs require to be very nicely adjusted at first, or they are sure to cause trouble in lining.

Next in importance to the proper location of frogs is the curving of iron. This should be nicely done on all curves (as stated on a previous page), but it is especially important that it be well done among frogs. The amount of curve the iron should receive can be readily ascertained at the time the lines are drawn for placing the frogs.

The guard-rail, placed opposite the frog, is frequently too short and the bend at the ends too abrupt. When guard-rails are made of common track rail they should be of good length, and the bend much further from the end than is usual. A short guard-rail, with the ends bent at nearly right angles, is an abomination.

switch-rail" and "Distance from head-block," etc., as found in the tables. The switch-rail in the latter case need not conform to that given in the table.

The table for a gauge of 4 ft. 8½ in. can be used for either of the gauges of 4 ft. 9¼ in. and 4 ft. 10 in., by adding for the former 1 ft. to the figures in the column of "Distance from head-block to point of frog"; for the latter, 2 ft. This will give nearly the exact distance for the proportion of frogs ordinarily used.

The above tables are calculated by the formulæ—

$D = 2gm$. $S = \sqrt{(R + T)^2 - R^2}$, where

D = Distance from head-block to point of frog.

g = gauge. m = proportion of frog.

s = length of switch-rail. T = throw of switch-rail.

R = radius of lead.

Whenever the throw is different from that stated, the tables, of course, will have to be altered.

It is impossible to keep it in place, as it is hacked and gouged by the flanges of wheels coming in contact with the ends and cutting out pieces of iron, and the fastenings (which are not always of a substantial character) soon give way, resulting in more or less damage.

To place a guard-rail correctly, it is a good plan to measure two inches from the end of the gauge and make a mark there. Then place the opposite end of the gauge at the point of the frog, and spike the guard-rail to this mark, always measuring from the point of the frog and not from the rail opposite. This will answer as a general rule, yet there are some peculiar cases to which it would not apply so well; if there is anything wrong in the adjustment, its cause may be ascertained by watching closely as trains are passing slowly over the frog. Sometimes the flangeway of frogs contains large quantities of chips and shavings that have been cut from the locomotive flanges while passing through the frog. This indicates something wrong and should be attended to at once. The cause can easily be discovered by close examination, and its removal in season may prevent accident.

Tie-rods on split switch-rails should be secured in place by bolting them to the flanges or base of the rail. They are usually made to clasp the rail loosely—are driven on from the ends of the rails and left. In a short time they become loose, rattling and clattering in a disagreeable manner as trains pass over them. They soon slip out of place, leaving a long portion of the switch-rails with nothing to prevent spreading, which sometimes happens in consequence.

Other faults might be shown in the every-day practice of track-layers; but it is deemed sufficient to have called attention to the more important points generally overlooked by them, and by stockholders and directors, who, above all others, are interested in the matter. It is now (1870) about forty years since we commenced building railroads in this country, and in that time we have built and put in operation upwards of 50,000 miles of road. Some of these roads are a credit to the builders and to the country, yet it must be admitted (however reluctantly) that our roads are not, as a whole, as substantially built as roads are in Europe. The main excuse offered for this is the want of capital. It is, however, a false economy to build railroads in this shiftless manner and undertake to keep them open for traffic. The heavy expense of maintaining the permanent way in this country, as compared to that incurred on foreign roads, is ample proof of this. It would seem that our railroad men, as a class (to use a common expression), "fell into a groove" years ago in regard to certain practices, and the majority of them are there yet. A few, however, have left it, to their advantage and to the advantage of the public; and present indications are that we are on the eve of a general reform in the construction and maintenance of railroads throughout the country.

CHAPTER V.

ON BALLASTING TRACK.

Best Ballast—Dumping Gravel: It should never be done till Road-bed is Ready—Boulders, Roots, etc., should not be carted with Gravel—Raising Track—Tamping—Dressing off Tracks—What to do when Material is Scarce—Sags.

BALLAST.

Railroads are forced to content themselves with the ballast obtainable on their line of road until they become rich enough to pay for a better. Some roads must employ the natural soil. If of clay, the only salvation lies in a perfect system of drainage; if of sand, by filling to the top of ties and shouldering out at least a foot and a half to keep the track in line; if of prairie soil—black sand and loam—fill to top and slope to end of ties. With gravel use the same course. The best ballast is that which has the greatest elasticity and durability. I believe that mill (furnace) cinder broken fine has no superior. Besides being elastic, it is dry, clean, free from dust, contains no nourishment for vegetation, and permits water to pass off readily. Its freedom from weeds is a very great economy, a large proportion of the track work in summer being thus avoided; while in winter the road-bed is warmer and clears itself of snow. I therefore recommend its use whenever obtainable. Engine cinders from the yards, used like sand (filling to the top of the tie and shouldering out a foot or two), have the same good properties to recommend them, but are less durable than furnace cinder, slag, gravel, or stone. Stone broken evenly, not larger than a cube that will pass through a two-and-a-half-inch ring, and gravel, cannot fail to make a perfect road-bed, if properly used; but gravel is less durable than cinders, because more liable to be washed out. It is useless to prescribe the depth of ballast—economy must decide the question. The more the better; but there should be at least a foot, to provide against heaving of track from frost. No ballast can be effective without proper drainage. When the foundation and ballast are broken stone, sand, and gravel, draining is provided for by the nature of the prepared track-bed, but in all other cases careful ditching is the great requisite for keeping a good track.

Gravel should never be dumped until the road-bed is in good condition to receive it without danger of its sliding down embankments, or being dumped into mud and mixed up with clay and slush so as to render it worthless as ballast.

Before dumping ballast the road should be closely examined, and all spikes, bolts, nuts, washers, rails, chairs, ties, etc., etc., picked up. Track-layers should be particularly careful not to leave such property scattered about in ditches; if it is not saved before ballasting, it is very likely to be lost. This subject has been spoken of before, but frequent cautioning on all matters connected with the saving of property can do no harm.

In some gravel-pits there are a great many boulders, roots, stumps, etc. It is common to load these with the gravel, merely to get them out of the way of the workmen in the pit, and it often happens that this trash is dumped in a cut where there is much trouble to get rid of it. So much of the rubbish as cannot be put into the track (and none of it should be) is left in the ditch, where it must either be removed or allowed to remain and clog the water-course. Boulders, and all stones too large to be used as ballast, should be thrown to one side when the train is out of the pit. They will be found very useful for wash-outs, but they are not good for ballast when mixed with gravel.

Raising track for ballasting is not always conducted with needful care, especially when raising it to a considerable height. Frequently a joint is raised on one side of the track at a time; if cast chairs are used, it is very sure to break off the lips, also to rack and twist the joints and put the whole track into disorder. This should be avoided as much as possible; with a little care, track may be raised to any height required for ballasting without doing any damage.

When the track is raised, and before filling with gravel, all ties should be put in their proper places, held snugly up to the rail, and the spikes carefully driven home; otherwise gravel and small stones will work under between the rail and the tie. When ties are out of place, and the track is filled with gravel, they are likely to remain so, much to the damage of the track, as has been shown.

It is customary to tamp the ties their entire length; but it is found to be bad practice to tamp as hard midway between the rails as at the ends of the ties and on the inner side of the rails. All track newly raised will settle more or less, and if the middle of the track is tamped hard it will cause it to rock and work out of line, as ballast will wash out from under the ends of ties when it remains hard and full in the centre. Such track will rock from side to side in a very disagreeable manner, and is sometimes dangerous, as ties are frequently broken from this cause.*

* A first-class lifting track jack is a great labor-saving machine.

It is best always to leave the gravel a little slack in the centre; not sufficiently so, however, to make a cavity for water to settle into, but so that the principal bearing will be mainly under the rails, or as near them as possible. With this manner of tamping the stability of the track will be found much greater than when tamped hard in the middle.

Filling up and dressing off track are usually done without rule, hardly any two men having the same way of doing them. It is sometimes difficult to follow a given rule in dressing off, or to adopt any particular mode of filling up, owing to the lack of ballast. At the first raising it is not advisable to take much pains in finishing off, as the track will settle so as to require considerable surfacing in a short time, so that any extra finish it may have received will be spoiled and so much labor lost. The second time of going over it is the proper time to finish in good style. This is usually done by the section-men; and it would be better to have section-men do all the ballasting, as they are likely to take more pains with it than those who never expect to see the track again after the ballasting is done.

If there is an over-supply of ballast, which is sometimes the case, all that cannot be used to advantage should be scraped into piles out of the way, and saved for future use. It should never be allowed to lie in heaps and ridges along the ends of the ties, preventing the escape of water, as is frequently done. It is not advisable to fill the track too full, on account of ballast being plenty, as it causes trouble when repairing in winter, especially in shimming, which operation will be discussed hereafter.

In filling track on curves it is not well to slope the ballast from the middle of the track each way, because, the outside of the track being elevated, it would cause water to settle under the track. It is better to fill the track so that the slope will commence at or near the ends of the ties on the outer side of the curves, so as to carry the water across the track toward the inner side. The slope on the upper and outer side must be shorter and more inclined, so as to carry the water from the ends of the ties, or perhaps a little to the outside of them, into the ditch. In short, the main object in view, in filling up and dressing off track, should be, in all cases, to prevent the settling of water under the ties.

Much damage is done by allowing trains to run over track before it is well tamped up. When track is raised considerably, and only the joint-ties, and perhaps one or two intermediates, partly tamped, a train running over it will bend the iron surface-wise, so that it is impossible to straighten it again without heating it; there will be kinks in it after all is done when it has once been badly bent on the surface. With good management no train need pass over track until it is well tamped. It is an easy matter, at least, to have the track ready for all regular trains, and it is better to stop working or irregular trains than to allow them to run over track before it is really prepared for them. To some this caution may seem unnecessary, but there is much bad track made by the spoiling of the iron while ballasting.

Some hints have been given on filling track when plenty of gravel is at hand. What follows will point out how the work should be done when there is a scarcity of that material. It is said that a good cook can prepare a very palatable meal with almost nothing to make it of, whereas a poor cook will nearly breed a famine when there is plenty to eat. So with track-men: some will put a piece of road in good order, and keep it so with small allowance of ballast, which is "the needful"; while others, with abundance, will make but a sorry show. The practice with most track-men, when but a small quantity of gravel can be had, to put it all under the ties, leaving nothing to fill between them, is erroneous. For, however small the quantity of ballast, the track should not be raised so high as to require all the gravel under the ties, but a portion should be reserved to fill between the ties and at the ends. Let us examine a piece of track with little or no material between the ties, where the road-bed and the ballast are of a light, sandy nature. Some of the ties will, of course, have a solid bearing, while others will hang loosely by the spikes, having no bearing at all except when the rail is deflected by a passing train; as soon as the rail is relieved of its load it springs back to surface, taking with it the ties holding by the spikes. With this cavity under the ties the sand is forced out from under them by compressed air escaping as the tie is suddenly forced into its bearing. Each tie not sustained is thus continually working its way into the road-bed, while those having a solid bearing are not so affected. Any one having doubts of the truth of this statement may be convinced of its correctness by sitting close to the track when a train is passing. He will notice that a jet of sand escapes from under every loose tie, forced out by the rush of air caused by the sudden settling of the tie into the cavity, literally *pumping* the ballast from under the track. There is no way of obviating this when the road-bed is not wide enough to prevent the ends of the ties projecting over the slope, which is often the case on unfinished roads and not unfrequently on roads considered finished. When the road-bed is of ample width, fill the track (as before stated) between and at the ends of the ties, so as to exclude air and water as much as possible. Mud or clay, from the ditches at the side of the track, is preferable to air for ballast; for if track is well filled with even a poor material it will keep in order much longer than with an insufficient quantity of good gravel, with none between the ties.

The track is often raised too high for the amount of ballast at hand, owing to the desire of the track-men to put the track on true grade, leaving no sags. This is very desirable, but it is far better to leave sags and have ballast enough to fill the track properly than to make a true grade and leave the track naked. Of course a short sag looks bad, and we can hardly blame a track-man for taking it up, even with scarcity of ballast; but stability should not be sacrificed to appearances. How often do we see a piece of track at the foot of a steep grade, on a high embankment, *piked up* as far as possible, with all available material put under it, and the ends of the ties projecting over the slope of the embankment, squirting ballast as every train passes, and requiring the constant attention of the section-men to keep it in anything like a safe condition; when, by leaving a slight sag, it might be kept in tolerable running order with half the labor that is required in its present misplaced elevation. It is not well to be too particular in bringing track up to a true grade on new roads, as the road-bed will settle, and on heavy fills it will require raising several times before it will remain up to grade. It is impossible to keep track in line when it all lies above the ballast, with nothing to steady it and keep it in place.

CHAPTER VI.

ELEVATION OF CURVES.

SUBJECT OF ELEVATION OF THE OUTER RAIL LITTLE UNDERSTOOD—IMPORTANT TO DETERMINE THE RATE OF SPEED FOR WHICH THE ELEVATION SHOULD BE CALCULATED—NO INVARIABLE RULE CAN BE ADOPTED—DEGREE OF CURVES.

THE subject of the elevation of the outer rail on the railroads of the United States is one little understood, and there is less uniformity in the systems employed than in those of any other work connected with track. Ask ninety-nine men out of a hundred—managers, superintendents, engineers, road-masters, and section-foremen—for their rules for the elevation of curves on their roads, and the majority will reply that they have no rule. I affirm that many have not only no rule, but that the subject has never been considered by them at all. The superintendents in charge of track leave it to the road-masters, the road-masters to the track-foremen, so that on nearly every road in the country there is as much variety in the elevation of curves as there are sections on any of the roads. It is not unusual to find on first-class roads an elevation of the outer rail of one and one-half inches to the degree of a curve—that is, to a radius of 5,730 feet; and in that proportion for greater curves, sometimes with and sometimes without uniformity—in lighter curves even two or three inches on a one-degree curve. It is a shame to our American roads—that is, to many of them—that the level is entirely ignored upon them. In consequence of this comes the oscillation so disagreeable to passengers and damaging to both rolling stock and track to an incalculable extent. After determining upon a uniform system of elevation, it becomes a matter of importance to decide upon the speed for which the elevation should be calculated. To do this wisely we must take into consideration the speed of the various trains running over the road. As a rule, we have freight trains limited to a speed of 15 miles per hour, and we have passenger trains at a rate of from 35 to 40 miles per hour, or an average of 31 or 32 miles per hour, including stops, and sometimes, when behind time, at a rate of from 50 to 60 miles per hour. With such disparity of speed, and with but one track, it becomes of vital importance to decide upon the question of elevation in its bearings upon the points both of economy and safety. Upon a road having heavy grades and curves the question is a more serious one than on lines of level grades and similar curves. As the freight trains are from three to five times as numerous as the passenger trains, it is important that the elevation of the outer rail should be calculated somewhat in consideration of their speed. If the elevation is made for the full measure of the highest speed of passenger trains, which run only one-fourth as often as the freights, may we not have it so great that the freights will be in danger of running off on the inside of the curve? Again, since the elevation of the outer rail has a tendency to retard the progress of the train, may we not by using too much elevation cause such a diminution in the power of the engine as to shorten up the train and haul fewer cars? This is not only theoretically but practically the case; and should the elevations be made for 45 miles per hour, instead of 35, it would probably cause a dropping of a car in each train, and result in the loss of at least one train per day. Over each division this would imply a loss of at least $65 per train per day; for four divisions $260 per day, or $100,000 per annum. It is, therefore, essential to consider whether it is not wise to equalize the elevations of the outer rail so as to consider economy and safety for the freight trains also. To this end I have made an average in the elevation, so as to avoid, as far as possible, the danger from too great an elevation for the low speed of freight trains and the too slight elevation for passenger trains. This average I have found to be three-quarters of an inch for broad-gauge (6 ft.) and half an inch for standard-gauge

(4 ft. 8½ in.) roads for each degree, for 35 miles per hour; that is, allowing a speed of fifty miles per hour for passenger trains and fifteen for freight trains.

The tables given in this book (pages 177 to 180) for the elevation of curves cover most of the gauges in use in this country.

To lay down an invariable rule as to how many inches or fractions of an inch should be used to a degree of curve or to a given radius is manifestly impossible. A good, practical, tested rule for gauges of 4 ft. 8½ in. or 4 ft. 9¼ in. on all the main thoroughfares of the country, with single or double track, is half an inch to the degree; for a 6-feet gauge, three-quarters of an inch—this for an average of 35 miles per hour. It is plain that if one track of a two or two of a four-track railroad were set apart for passenger traffic, and the other track or tracks set apart for freight business, a uniform rule could be adopted, provided that a uniform speed was also prescribed for each class of trains on their respective tracks. The New York Central and Hudson River Railroad, for instance, could elevate the curves of one or two tracks for passenger traffic and the others for freight. The question then to determine would be, How fast shall the passenger trains run? This decided, there would be no trouble, unless in case of damage to the passenger tracks, when it would be found that the freight tracks would be unsuited to a high rate of speed; and the reverse might occur, and the freight train would have to be reduced one or two cars on account of elevation. Nothing but keen judgment and close observation can determine the elevations so as to bring about the most economical result consistent with safety.

DEGREE OF CURVES.

It may be desirable for a track-man to find the degree or radius of a curve. Stretch taut a fifty-feet tape-line on the inner side of the rail, and measure the perpendicular distance (which is the "middle ordinate") from the centre of the tape-line to the inner edge of the rail. The radius and degree of the curve corresponding to this middle ordinate may then be found in the following table:

Degree.	Radius in feet.	Middle ordinate in inches.	Degree.	Radius in feet.	Middle ordinate in inches.
30′	11,460	.22	11°	522	7.20
1°	5,730	.66	12°	478	7.87
2°	2,865	1.32	13°	442	8.51
3°	1,910	1.97	14°	410	9.17
4°	1,433	2.63	15°	383	9.80
5°	1,146	3.28	16°	359	10.49
6°	955	3.94	17°	338	11.11
7°	819	4.57	18°	320	11.78
8°	717	5.24	19°	303	12.41
9°	637	5.89	20°	288	13.06
10°	574	6.54			

Railroad curves are spoken of as being of a certain "degree of curvature" or of a certain "radius." The radii corresponding to the various degrees ordinarily met with may be found in preceding tables. To ascertain the radius corresponding to any degree: Divide 5,730 (the radius of a 1° curve) by the degree of the curve under consideration. For example:

Radius of a 5° curve$=\frac{5730}{5}=$1,146.

BENDING RAILS.

A table of middle ordinates for bending rails to be laid on curves will be found immediately after the tables for the elevation of the outer rail, on page 170.

CHAPTER VII.

TRACK REPAIRS.

METHODS UNCHANGED FOR A QUARTER OF A CENTURY—ROUTINE IDEAS—CHEAP SECTION-MASTERS NOT DESIRABLE—WORK ON A NEW ROAD—JOINT-TIES—LINING TRACK: IN FROSTY LOCALITIES—CLEARING OUT DITCHES AND CULVERTS: THEIR PROPER DIMENSIONS—KINKS IN RAILS—IMPORTANCE OF TRUE GAUGE—TRESTLE-WORK AND BRIDGES SHOULD BE PLANKED FOR FOOT PASSENGERS.

THE present age is one of improvement, and although on many roads the subject of track repairs may not have kept pace generally with other arts, yet the whole country is waking up to the importance of improvement in men, material, and discipline.

Many railroad managers are apt to pursue an unwise policy in the appointment of track men, and, influenced by a false economy, to employ men of little experience, as they can be had for less money. It is a practice with many companies to cut down the wages of section-masters at every favorable opportunity, so that all the keen, wide-awake men, who have seen service, will not "stand the pressure," but leave for better-paying situations; and, as there are plenty of incompetent men willing to take their places at the reduced wages, the managers consider that they are making money by the change. They argue that "any man who has worked on track repairs a little while can take care of a section, and we are not going to pay a man fifty or sixty dollars a month when we can get the work done for half that sum."

This is a great mistake. Half-price men are the most expensive that can be employed. The property in the care of a section-master has cost a great deal of money, and, if not properly cared for, wears out rapidly. A section-master who understands his business can save more money for the company than his wages amount to. Indeed, an incompetent foreman of a section will waste more than would pay a dozen good men. The best are not too good, and a really good one is cheap at any price, while a poor one is so expensive that no company can afford to employ him. There are many matters of importance connected with track repairs that are not generally understood, and it is for the interest of the railroad community to give the whole subject careful consideration; to see henceforth that track-repairing is put into the hands of none but capable men, who will improve its methods, and carry into their work a spirit of thoroughness and efficiency.

The first work of the section-master, on taking charge of a section on a new road, is to undo work that has been improperly done by the track-layers. If the track has been laid according to the suggestions in a former chapter, it will need but little overhauling; but there is generally more or less work of this kind to be done. Suppose the track to have been ballasted. The work now will be to take out sags and put the track in first-rate surface. Great care should be exercised in surfacing, and on straight line it should be perfectly level. It should be tamped as uniformly as possible, and, as before mentioned, a little slack in the middle. Now is the time to attend to this, as it is important to keep track level in its cross-section; and if hard-tamped in the middle, it is impossible to keep it so. The joint-tie should always be the last one tamped. This is contrary to the ordinary practice, but a little reflection will prove it to be the true way. It is an easy matter to raise a tie by tamping it with bars, in good ballast, and if the side-ties are tamped after the joint it will raise the joint-tie so that it will be loose, hanging by the spikes to the rail. If but one side-tie is tamped after the joint, it will cause a cocked joint, exposing the end of one rail, on each side of the track, to severe pounding by passing trains. By taking the joint-tie in hand last, it can be raised a trifle by hard-tamping; and the joint will then nave a solid support, and not bear too much on the side-ties. It is well known that the joint-tie is more likely to settle than any other; and miles of track can be found on some roads without a solid joint in the whole distance, owing to the ordinary practice of tamping the joint first. Of course these loose joint-ties cause iron to wear rapidly, and are also injurious to rolling stock.

LINING TRACK.

The importance of having track in good line must always be kept in view. Many suppose that after track is once well lined it needs no further attention; it is, however, constantly working out of line from various causes. Now, line is of as much importance as surface; for if a track is not in surface it is impossible to keep it in line. There is nothing more disagreeable to passengers and train-men than the sudden jerking of cars from side to side, caused by track being out of line; not only is it disagreeable, but the iron is badly worn in consequence, with a corresponding wear to cars, etc. When track is well ballasted it will remain in line much better than when insufficiently ballasted. When one side of the track has settled somewhat, it will work out of line by the sudden shocks imparted to the rails by the lateral motion of car-trucks, and outside-connected freight-engines, when laboring hard, disturb the line considerably. But the chief cause of track getting out of line is the raising of it when surfacing. Placing a bar under the end of the tie, when raising track, has a tendency to pull it toward the operator, although it be but a trifle. Perhaps the next joint will need raising on the opposite side, and thus one joint is pulled out of line a trifle in one direction, while at the next it is pulled in the opposite direction, leaving it zigzag. Track should always be put in line after surfacing, for the above reason. The line may not be greatly disturbed by one surfacing; yet as track-men are constantly going over the road picking up low joints, and as some joints require frequent raising, the track soon gets badly out of line and should be attended to. It is better to line after surfacing, and before filling in the ballast, as the track is easily moved then; and, when it is put in place and the ballast filled in afterward, it will the better keep in line. In frosty localities, where the ballast and road bed remain frozen for a considerable time, it is all-important to give track a thorough lining at, and to keep it in surface before, the commencement of cold weather; otherwise it must remain out of line for many months, during which time the iron will have worn considerably, and there will be a heavy addition to the expense of car repairs in consequence.

DITCHES, CULVERTS, ETC.

Section-men will find more or less gravel remaining in ditches, culverts, etc., after ballasting, frequently obstructing the passage of water. All this should be removed and all water-courses put in good order, as it is impossible to keep track in good surface when water is allowed to soak through the road-bed, as is frequently the case. In narrow cuts, where there is but a slight descent for the passage of water, a very little gravel or rubbish will cause water to penetrate the road-bed, and much labor is wasted in surfacing that might be saved by a very little labor in the ditches. It is a common thing to see a considerable gang of men employed day after day with tamping-bars, surfacing in some cut, while the ditches are half filled with water and rubbish; what little gravel there is in the track, mixed with wet clay, being made into mortar by the use of the tamping-bars. It will often be found that a large quantity of gravel has slid down the embankment and lodged in the mouth of a culvert, hidden by grass and weeds. In cases of high water, chips, small sticks, and all manner of floating trash, by settling in the gravel at the mouth of the culvert, soon form a place of lodgment for larger floating substances. In this way the culvert is completely dammed up and embankments are frequently injured, or completely washed away, when a little attention would have prevented any damage. A stone, a fragment of wood, or any other obstruction lying in a ditch or small culvert is not in itself any great injury to the road, but it will collect sufficient rubbish in a short time to occasion mischief. A block of wood falling from a locomotive tender and rolling into the ditch, a strip of board, fence stake, or other obstructive substance, lodging across the mouth of a culvert, has often been the cause of damage which has cost hundreds of dollars to repair. It is a good plan to clear all rubbish out of small streams for a considerable distance above the culvert; and not only from the bed of the stream, but for a considerable distance on either side, where there is any possibility of the overflowing of the banks. Small streams (very small ones) are more dangerous than large ones. A stream of tolerable size is usually provided with ample room for free passage at bridges, and the water in it runs with sufficient force to prevent any floating substance lodging so as to cause mischief. Of course all logs or trees lodging against piers or abutments should be cleared away, and this matter is generally attended to; while a few leaves and small sticks lodged in a small culvert, which are really more dangerous, are likely to remain unnoticed. Section-masters are too apt to think that attention to such matters is out of their line of duty, and, owing to their anxiety to have "the best riding section on the road," consider it to their disadvantage to have any labor performed except on the track; but it is clear that, in this view of their obligations, they lose sight of the interest of the company.

With respect to culverts, it may be well to say here that engineers are often at fault in estimating their proper dimensions. Culverts are often staked out in a dry season of the year, and the engineer is apt to be deceived as to the quantity of water that may flow into them at other seasons or in case of a freshet. In other cases the ground is frozen and covered with snow, and a ravine is crossed by an embankment, no culvert being considered necessary; then, as the ground thaws out, a considerable stream makes its appearance, which must force a passage, if one is not provided, through the embankment. It costs more to build a large culvert than a small, but when to the cost of the small one is added that of getting an engine and a train of cars out of the mud, repairs to engine, cars, track, etc., to say nothing of the hindrance to other trains, and possible loss of life, the increased prime cost of the larger culvert is more than counterbalanced. In case of doubt as to the size of culvert needed, it is best always to take the safe course and be sure that it is large enough. It is certain that an immense amount of property is destroyed and many lives lost every year from a lack of foresight, and yet accidents from it are generally looked upon as unavoidable, and no one is blamed.

As before stated, the section-master will find much to do in putting to rights what has been neglected by the track-layers. Perhaps a few rails have been laid with "kinks" in them, the result of bad handling. If any such are found, they should be removed and replaced by straight ones; or, if there is no iron to use in their place, they may be taken out and straightened with the chain, lever, and sledge (but much better with the jim-crow, figured on page 160). If they are so badly kinked as to require heating to straighten them, a fire may be built at a convenient place, and the rails heated on the spot, without taking them to the shop for that purpose. With this treatment iron will last much longer than if allowed to remain out of shape. Many joints will be found badly spiked, displaced, or twisted out of shape in ballasting, so that the ends of the rails do not meet in good line; and if these are allowed to remain the iron will soon be spoiled. The spikes should be drawn, and all such joints spiked over again. The joint-ties which are out of place, so that the meeting of the rails is over one side of the tie instead of over the centre, should be at once adjusted.

Although it requires considerable labor to do this, it pays.*

On inspecting track it will be often found that the gauge side will be too wide in some places and too narrow in others; if the deviation is not very slight, it is best to draw the spikes and spike to a true gauge. Some of the evils of this inaccuracy of gauge have been explained in a previous chapter; but as the matter is an important one and much overlooked, it is proper to call attention to it here for the good of the section-master and the interest of the company.

The section-master should thoroughly examine all trestle-work and bridges, and see that the hints here given to track-layers have been acted upon. However carefully the work may have been done, it is possible that some important matter may have been overlooked. The bridge carpenters may have neglected to secure the stringers, so as to prevent their moving out of place, leaving this work for the track-layers, who in turn may have overlooked the matter or left it for the section-men to attend to; as they are the last men on the ground, to them belongs the duty of making good the shortcomings of those who have gone before. Perhaps the cross-ties have not been secured so that they will not

* It is my experience that no contractor ever laid a track or ballasted it as it should be, and, therefore, my deliberate judgment is that the company always should lay its own track and ballast it, and that for this purpose none but the most careful and experienced men should ever be employed.—C. L.

jar out of place. This should be done in a substantial manner, and, on bridges where there is much crossing on foot, planks or boards should be nailed or spiked across the ties, so as to form a safe footway. It is impossible to prevent people crossing bridges, and, this being the case, it is better to make the passage safe, not only for the general convenience and safety, but for the convenience of track-men themselves. There are many bridges thrown over dangerous streams, with no way for pedestrians to cross except by stepping from timber to timber, where to fall through would be certain death, and, if caught by a train, escape would be impossible. Many of these bridges are so constructed that there is no room for a person to stand in safety while a train is passing, even were the fastenings secure, and even with plenty of room timid persons would incur imminent danger. In fact, hundreds of persons have met their death in this way; and as a notice at the end of the bridge prohibiting people from crossing amounts to nothing, it is best for the section-master to provide a safe foot-way, except on such bridges as require a guard night and day to prevent persons walking over.*

* Notices should always be erected at each end of dangerous bridges, warning the public. This will not only be performing a duty which will relieve responsibility, but possibly save the life of some ignorant person.—C. L.

CHAPTER VIII.

DRAWING SPIKES—SHIMMING.

WASTE IN SPIKE-DRAWING—CLAW-BARS—THE BULL'S-FOOT—SPIKE-DRAWING IN WINTER—LOSS BY CARELESSNESS—SHIMMING: ITS ADVANTAGES—OFTEN BADLY DONE—SHIMS OFTEN ILL-MADE AND OF BAD MATERIAL—CONSEQUENCES—SHIMMING IN FROSTY WEATHER—HOW TO MANAGE IT—TAMPING—THICK SHIMS SHOULD BE SPIKED TO TIES—MACHINE-MADE SHIMS—SHIMMING UNDER TIES, OR UPON CULVERTS, TRESTLE-WORK, ETC.—WHAT COMES OF SHIMS WORKING OUT—ROAD-CROSSINGS—WOOD-PILES.

DRAWING SPIKES.

THE various operations connected with track repairs necessitate the drawing of a great many spikes. A great many tons of spikes are yearly wasted by carelessness in drawing and by bad handling afterwards. As claw-bars are usually made, it is impossible to draw a spike without spoiling it for future use. The claws should be so shaped as to take no hold of the point of the head, otherwise the head is either broken entirely off or is bent so as to become unfit for use. When the claws are made properly all the force applied to the spike in drawing it will come in a line with the body of the spike, so that it can be drawn straight. Some spikes are of bad shape to draw in good condition for future use, but with a claw-bar of the proper form, and care in drawing, a great many spikes can be saved.

There are a good many kinds of claw-bars, some of which work well; and there are several kinds of patent bars for pulling spikes which are well spoken of, but for some reason they have not yet come into general use; and probably the old style of "bull's-foot" claw is as good as any, if properly made.* It is, however, a difficult job to make a good claw-bar; but as it is an implement which is in almost constant use, it should be rightly made and used. Even with a good claw-bar, when not handled rightly, spikes are often broken, bent, and twisted needlessly. A great many spikes are broken and destroyed by attempting to draw them in winter when the ties are frozen solid, and when they cannot be drawn by any claw-bar without breaking. This is one instance of a vast amount of labor performed by repair-men that results in no good to the track or profit to the company, but is rather an injury than a benefit, not only wasting time and labor, but destroying property in place of saving it or keeping it from wear. Some trackmen have a great desire to be busy, *especially about train-time*, and they frequently draw spikes

* The best form of claw-bar is given on page 159, together with other tools of the most approved patterns in use on the best-managed roads.—C. L.

for shimming when it is not necessary, as in severe cold weather, when not one spike in ten can be drawn without breaking. Of course those drawn must be replaced with new ones, which are expensive. But this is not all; for not only spikes, but chairs, bolts, etc., and often bars, hammers, and other tools, are broken by careless use in frosty weather, so that it would be better for the company to pay the men for sitting by the fire than to have this kind of work done at such times. Those who have not given the subject special attention would be surprised at the amount of money that can be saved by exercising more care in this seemingly unimportant matter. There are other ways of destroying this kind of property, and it is singular that such wasteful practices are allowed to such an extent as they are. It is frequently considered too much trouble to draw spikes, and they are driven into the tie out of the way, being hammered until the heads break off, when one more blow sinks it out of sight. This operation is sometimes performed to such an extent that a half-dozen or more spikes are jammed into a single tie, resulting in the loss of so many spikes and the injury of the tie. Sometimes a chisel-pointed crowbar is used to force spikes from the rail. By placing the bar perpendicularly and using the rail as a fulcrum, the spike is bent sufficiently to allow the removal of the rail, when shifting iron; when, afterwards, another rail is put in its place, the spikes are driven up to the rail and so left. Old hands frequently do this, and there are miles of track served in this manner, with only a portion of the spikes taking any hold of the rail. Track left in this condition is not safe. The matter is well worthy the attention of railroad managers; it is strange that it should be so generally overlooked.

SHIMMING THE TRACK.

In winter, when ballast is so frozen that track cannot be surfaced by tamping, it is done by *shimming*. This is often performed in a shiftless manner, and many serious accidents have happened in consequence. If shimming is well done, it is one of the nicest and most important operations connected with track repairs. It prevents wear of iron and rolling stock to a greater extent than any other operation consuming the same amount of labor.

Some section-men make shims out of blocks of wood that have fallen from the tender, or have been thrown overboard by firemen when too large for their use; sometimes they split off a piece from the end of a tie, make a wedge with a dull hatchet, drive it under the rail, and cobble it up in such a manner that it will roll and rack frightfully under a passing train. Track is sometimes raised on shims of considerable thickness, so that the spikes scarcely enter the tie, and after a few trains have passed the spikes will not touch the ~~rail~~, as every vi- tie ? bration of the rail forces the spike from it, where it remains. This is very unsafe. These shims frequently get loose and work out from under the rail, and a great deal of iron is ruined by being bent in the surface from this cause. Rails may often be found without support for several feet, the shims having worked out and the rail so bent that it cannot be straightened without heating. It is not uncommon to see track-men go along the road, pick up the shims that have worked out, and slip them under the rail, when, if the rail has been sufficiently sprung in the surface, they may hold it for a short time; but they will soon work out again, and then it may be necessary to hew off a little before they will go under the rail, owing to its being bent. In this manner track that has been raised on shims three inches thick will soon come down to half that thickness. This kind of work is practised to a far greater extent than is generally supposed, and there is hardly any road-master but can find some bad shimming on his road, if he closely examines it.

Much labor is wasted, when frost has left or is leaving the track at the close of the winter, in removing shims that should be left under the rail. Of course shimming is rendered necessary by track being thrown or heaved out of surface by the action of frost, and when the frost leaves it is necessary to remove the shims. In fact, this should be a busy time for section-men, where much shimming has been done, as it is often dangerous to let shims remain after the track has settled to its bearing when the frost is fairly out. It was formerly the practice on all roads to shim only when the track could not be tamped on account of frost; but now it is the custom on some roads to shim in summer, when it requires but slight raising to put the track in good surface. This is a bad plan and should never be practised on any road.

When a shim of considerable thickness is required, it should be spiked to the tie and other spikes driven through it, in the manner of spiking when no shim is used; otherwise the track may spread and cause mischief, especially on curves. Shims should be prepared by machinery, of hard wood, and of various thicknesses, bored for the spikes, and when used the tie should be adzed off smoothly, so that the shim may have a good bearing. Ties that have been in the track for a considerable time will be found to be grooved under the rail, and, unless the groove is adzed out, the shim will break, and the portion under the rail will settle into the groove and materially alter the surface of the track. When track-men are obliged to furnish their own shims they make them out of any material they get hold of, sometimes out of a pine board knocked off the fence, or a block cut from a cedar fence-post, or something else which is worthless for the purpose. It is for the interest of railroad companies to furnish shims ready for use and see that they are properly used.

Joints are often shimmed in winter when they do not really need it, for a joint may be considerably down and at the same time the ends of the rails lie perfectly solid in the chairs. In such cases it is better not to disturb it in frosty weather, as the iron is not subjected to unusual wear and the loss from breakage will overbalance any benefit that can be derived from shimming.

In regard to making shims by machinery, no expensive apparatus is necessary, as any ordinary car or repair shop is furnished with all needful appliances for making shims to good advantage, and one man can make more shims and better ones in a day, in an ordinary repair-shop, than a whole gang of section-men can hew and hack out in twice that time. Good hard timber can readily be sawed into shims of various thicknesses and packed into boxes to be sent where they are needed. Where many shims are used it will pay to rig a boring apparatus especially for that purpose. This can be done with very little expense in any shop by arranging two bits of the proper size in position to bore both holes at one operation. It is best to bore the blocks before sawing them into shims. New roads which have not got their shops in operation, or short lines which have no extensive shops affording facilities for making shims, will find it good economy to have them made at some private shop.

It might be thought that sufficient has been said about shimming, but there is room for a few further remarks on the subject, especially on shimming under ties, on open culverts, trestle-work, etc. Blocks, or shims, of several inches in thickness are frequently used in such places, and, as they are out of sight, they frequently work out, and remain out a long time before it is discovered. In all such places shims should be nailed or spiked to the stringer. It may be said that any one would know that; but whoever will get on a locomotive and ride over some roads will notice that the engine generally makes a lurch at every culvert or cattle-pass it comes to; this will be found, in many cases, to be owing to the shims being displaced under a portion of the ties. Enginemen on some roads can tell on a dark night exactly where they are, without taking notice of surrounding objects, by a certain rolling or pitching motion of the engine when passing over certain cattle-guards or culverts. The shims may after a time be replaced, but while they *are out* the rails become bent in the surface, and no amount of wedging or shimming will straighten them afterwards. There are roads of considerable length where it would be a difficult matter to find a straight rail on a cattle-guard or open culvert; and this is owing mainly to shims working out from under the ties, or from under the ends of rail-plates when no cross ties are used.

At other times the rail becomes bent by frost heaving the track at each end of the culvert, carrying the soil up and the ties or rail-plate with it, leaving the rails with no support for the width of the culvert or cattle-guard; the rails must then, of course, settle under the weight of passing trains until they reach their former bearing. Track is not unfrequently raised gradually several inches by the action of frost, leaving the iron the same distance above its bearing unless it is shimmed.

Planks at road-crossings are frequently raised by frost, so as to be caught by the pilot and cause more or less damage. Sometimes these planks are so raised that they become grooved and scraped by bolts hanging from the pilot or from brake beams, and no notice is taken of it until a plank becomes loose, and then comes mischief. These planks should be watched and kept in a safe condition by taking them up and picking away from between the ties the frozen ballast, which is usually the cause of the plank's being disturbed. It is obvious that if the ties rise with the plank there can be no danger; but when the planks are raised by the expansion or heaving of the ballast between the ties, so as to draw the spikes from the ties, or the spike-heads through the plank, it then becomes dangerous and should be attended to.

Wood-piles are sometimes tipped over upon the track by the action of frost in the spring of the year, as it is leaving the ground. In winter long piles of wood are often placed as near the track as possible, leaving barely room for the safe passage of trains; when a thaw commences it may go on more quickly on the side next the track, in which case the top of the pile is liable to be thrown so near the track as to be dangerous. When a wood-pile is seen to be settling towards the track it should not be *watched too long* before taking measures to prevent it from falling. Wood should not be piled nearer than six feet from the rail, nor should anything be built or placed nearer than this distance.

CHAPTER IX.

FROGS AND SWITCHES.

SELECTION OF FROGS AND SWITCHES—CROSSING-FROGS—BENT SWITCH-RODS—THE THROW OF SWITCHES—CONNECTING-RODS—FROGS: CAST STEEL PLATE AND RAIL FROGS—FASTENING GUARD-RAILS—SHORT GUARD-RAILS—USELESS TINKERING.

ONE of the first considerations in building a road is the selection of frogs and switches, for upon this may depend the life of many passengers and the salvation or destruction of much property. It therefore behooves the engineer to provide the operators of the road with nothing that does not merit the title of "first class."

I give my opinion upon both of these important matters without bias of any kind, but as the result of careful study and long experience.

As a general principle, I should say that no frog should be adopted which requires the cutting or scoring of the frog-timbers. This, as a general rule, would set aside all but rail-frogs. Nevertheless, I must say that of all the frogs

I have ever used and seen used on railroads the Mansfield frog bears the best reputation for wear and has no superior in elasticity.

No frog should be used, even if a rail-frog, the merit of which is to take the wheels over on their flanges by a lifting apparatus or incline in the throat. The principle is wrong and unsafe. Cast frogs, in these days, if possible, should be dispensed with.

I recommend as best the "steel-rail frog," with no plates underneath, but securely fastened by lugs and bolts, and guarded by rail-brace with reversible wing-rails, and "the spring-rail frog." The latter has the merit of lasting longer than any other kind of rail-frog, on account of the unbroken bearing the wheel has upon the point of frog and wing at the same time. Frog patents are numerous, but few have any value; the principle of nearly all has been known and used for many years, and their defects thoroughly shown.

The selection of switches is a vital matter. Many roads, some of the first in this country, still adhere to the old stub switch, claiming that it is the safest; while it is well known that a train cannot run through it without derailment.

The roads that use this switch universally are in the dark age of railroad management. In England the standard switch is the split or point switch, and there can be no question but that it is the first in value.

Captain Tyler, late Chief Inspector of Railways of England, would not count any road first class which did not use this switch, nor would he recommend that any road should be permitted to run unless equipped with it. I agree with him fully.

We have in this country a substitute for the point in what is called the "Tyler switch," but each one requires not less than 1,000 lbs. of castings. The difficulty of expense is, therefore, serious. It is a safety switch, and is thus far good; but the great difficulty of the stub switch is not removed, and that is the everlasting hammering at the point between the movable and fixed rails, to say nothing of the cost and weight. The Wharton switch has obtained a great celebrity in some parts of the country. The advantage in this switch lies in the fact that the rail is unbroken and the wheels are carried over the main track. This might be dangerous, however, at high speed going through siding. The cost, too, is greater than for points. Nevertheless, a very high authority, the Pennsylvania Railroad, has adopted this switch on its main line. The point or split switches have the combined advantages of economy and safety, and leave also an unbroken track at the points. No jar occurs to the train in passing over it, so that it has all the advantages of both the Tyler and Wharton switches, with none of their disadvantages. It is free to the use of all roads, and with the new improvements of the Tillinghast, Lorenz, and Armstrong springs, it stands unequalled. In putting them in it is of vital importance that the shoulder and split or point rail should have equal bearing upon an iron surface or plate. Should the shoulder rail be placed higher than the split rail, certain danger of derailment will result. There is another split switch which requires but one rail to be moved, while the other point is fixed in a casting upon which the flange of one set of wheels will ride in going into the siding. This is the only objection, while the advantages are great.

The next important matter is switch-stands. No switch-stand should be used on main line unless a light can be attached to it easily, and no switch on the main line of an important thoroughfare should be without a switch-light. There are many good forms of switch-stand; the main points are: levers with no lost motion, rapid locking as the latch moves, a good, visible target, painted red and white, and, above all, no poor iron used in the construction. The connecting-rod and connection rods should be of the best material, and should be made so that there is no lost motion to produce a foul switch. If the rods of stub switches, by being too full size, either allow lateral motion or permit base to become diagonal, the latter may be prevented by making a heavy shoulder upon one side, something like the plan of the Huntington gauge. The plans here presented, beginning on page 259, will illustrate the best frogs, switches, switch-stands, and targets.

CROSSING-FROGS.

Under the present system of railroad construction of this country many crossing-frogs are used, and it is ot the first importance to choose a proper device for this purpose. A failure in this respect may cost more in wheels than can be replaced with the salary of many road-masters. The most difficult to manage, and the most expensive to maintain, is the right-angle crossing; the easiest is the angle of the 1–11 frog, or say angle of 5° or 6°.

The right-angle crossing is the pest of the road-master, and I have never seen but one crossing-frog—viz.: the "Mansfield"—which comes near being what it should be. At this angle the use of india-rubber upon crossings of large degrees seems indispensable to economy in wheels as well as in crossings. In light angles the steel-rail crossing is all that can be desired. In right-angle crossings, if long timbers can conveniently be obtained, it is best to frame four timbers; but when that is inconvenient, and the angle is less than 30°, ties are preferable of particular lengths, as in diagram (page 261), so that the bearing surface may best remain uniform. The system of carrying wheels over crossings upon flanges is not to be commended; but if rubber is used with a lifter it may be employed to advantage.

In yards where much switching is done running off at switches is a frequent occurrence, and switch-rods are often so bent that the gauge of the switch is made much too narrow. If these rods are not straightened the ends of all the rails at the head of the switch will be exposed to rough usage, as the switch-rails will not meet in line with the others. It is best always to keep spare rods on hand, to be used in case of a run-off. The bent rods can then be taken to the shop and straightened for future use. Rods may be protected by placing a tie on each side of them, leaving just room enough between the ties for the rod to move freely. In case of a run-off, the ties will relieve the rods of the weight of the wheels and prevent bending.

The throw of switches should be nicely adjusted, so that the head of the switch will meet in perfect line with the ends of all connecting rails. It is not uncommon to see iron at switches exposed to the action of wheel-flanges cut and gouged to such an extent as to require removal before it has served out half its time.

Connecting-rods should be so constructed that they may be lengthened or shortened, as may be necessary, to adjust the throw of the switch, which would prevent unnecessary wear of rail and also of locomotive flanges.

Much injury is caused by putting a new frog with old iron; that is, iron that has been in use so long as to be worn down considerably lower than the frog. Or sometimes a rail of lower pattern is used next the frogs, which causes the frog to be severely pounded by every wheel that passes. There is scarcely anything more disagreeable in railroad practice than running a locomotive over the hard, square, unyielding end of a steel-plated frog that is from $\frac{1}{4}$ to $\frac{1}{2}$ an inch higher than the connecting rail; but if you call the attention of the track-man to it, he is very likely to tell you that "it will soon wear down to the rail, and then it will be all right." But when there is the slightest difference between the height of the frog and rail, shims of iron plates should be used to bring them to a level. A nick should be cut in the plate for the spike, to prevent its working out. If the rail is higher than the frog (which is rarely the case), it can be chipped off on the bottom so as to correspond with the height of the frog. It will pay to be very particular in doing this kind of work.

The fastenings to guard-rails should be of a more substantial character than they often are.

It is common to use cast fastenings on a great many roads, but there are guards on other roads with no fastenings but ordinary spikes, and a short guard-rail cannot be well secured by any number of these alone. In the absence of castings it is common to fit a piece of plank into the throat of the guard and spike it to the tie. This answers a good purpose, but not less than two should be used to each guard-rail, and the more the better—as many as there are ties to spike them to. One of these braces alone, if placed near the middle of a guard-rail, is worse than nothing; for there is, of course, more or less strain on the end of the guard-rail, as it is pressed by the flanges of wheels, and if only spikes are used at the end they will yield considerably. Now if there is an unyielding fastening in the middle, as is often the case, the shock takes effect in the opposite direction, at the other end of the guard; as trains pass in different directions the action is reversed, the guard-rail acting as a double lever, with the single plank or casting in the middle as a fulcrum. In this manner a guard-rail will soon be knocked loose, and not unfrequently thrown entirely out of the track; and the man who spiked it will wonder why it is that the brace he took so much pains to place in the centre did not prevent its getting loose, when it was in reality the cause of it.

The inefficiency of short guard-rails was mentioned in a previous chapter; but as they will, no doubt, be frequently met with by repair-men, I should advise them to take them up, throw them in the scrap-heap, and use good long ones instead, such as can be secured in place, and serve their purpose satisfactorily at all times.

The practice of putting a piece of plank or a car-stake between the frog and the guard-rail, for the purpose of securing the latter, is a bad one.* Guard-rails sometimes receive severe pounding, and the frog must receive a portion of the shock, which will in time loosen the spikes which hold it in place, unless it is well shouldered into the cross timbers that support it, which is not always the case. There is usually an immense amount of useless tinkering done among frogs and switches that serves only to pass away time which the company must pay for, and makes a great show of work while accomplishing nothing.

Carefully prepared rules for placing frogs in a cross-over track, where the two tracks are straight and parallel, will be found in the chapter of Rules and Tables at the end of the book, beginning page 171.

A great deal of work, too, is done on track repairs before it is needed, for the sake of being

* The practice of using makeshifts at all is wrong. Let everything be made and used for its legitimate purpose.

busy, at a useless waste of time and money. Of course there will occasionally be a slack time, or times when there is nothing particularly urgent on hand to do; it is at these times that the foreman of track repairs has to show his experience and judgment in placing his men where they can be best employed for the interest of the company.

CHAPTER X.

PATTERNS OF RAILS—JOINTS.

DIAGRAMS OF RAILS MOST IN USE—MODE OF BUILDING A PILE FOR ROLLING RAIL—WEIGHT OF RAILS TO BE IN PROPORTION TO TONNAGE—JOINTS—DIAGRAMS OF JOINT-FASTENINGS.

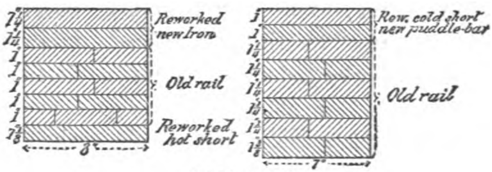
IT is the duty of a road-master not only to keep up his track, but to study the effect of the rolling-stock upon the rails, etc., that he may give an intelligent opinion upon the shape and weight of rails in use, and of the merits of everything pertaining to his department.

One of the first considerations is to get the material for a rail into the best shape for service. There is a great variety of opinions upon the shape of rails, and it requires no little judgment to select the best. It is difficult to change the pattern of a rail; iron once in the track must wear out there. A mistake in this matter on the part of a manager or engineer is more loss to the road than the salary of a dozen engineers or experts every year.

Some patterns of rails most approved are presented in the diagrams on pages 263 to 268, embracing rails serviceable for narrow (3 ft.) gauge to broad (6 ft.) gauge, with the heaviest machinery and rolling-stock used upon the heaviest grades and curves. These patterns are presented as the best models at present in use, but not urged as infallible; we must hope for continual progress.

Some authorities maintain that the old pear-shaped rail is the best form, and that too much has been sacrificed to making rails to suit the fish-plate. I differ from them, and maintain that the T-rail is the strongest and best. It has been found almost impossible since the first pear-shaped rail has been laid to keep a rail in line which is laid simply with a chair; a fish-plate is needed even when a base-chair is used. A T steel rail of 60 lbs. per yard may be made of sufficient strength to sustain the heaviest rolling-stock of our best roads upon heavy grades for a number of years. The Franklin Branch of the Atlantic & Great Western Railroad was laid from Meadville to Franklin upon a poor road-bed, with heavy curves but light grades and poor ballast, with an iron rail weighing 35 lbs. per yard. The heaviest locomotives (37 tons) of the road hauled successfully the largest trains over it during twenty months. The difficulties which caused the removal of this rail at this time were its turning over, owing to the narrow base (3½ in., with height the same). The iron was of very superior quality, and upon being broken showed a homogeneous texture.

The mode of building a pile for rolling rails is important. The engineer and road-master should pay attention to this matter. The following diagrams show the method of building the pile of what is called re-rolled iron:



RAIL PILE.

The re-rolled iron is not simply rail re-rolled, but new iron for head and base added to or mixed with a certain amount—about two-thirds—of old rails re-rolled into bars, 4 ft. × 7 in. × 1 in.

The place where a rail gives out is almost invariably in the head. Let the head be of proper material—firmly united cold-short iron, or with steel top—and the rail will be durable. Let it be of red-short iron, and in a few weeks it will be destroyed. Cold-short for the head, fibrous iron for the base, with the intermediate of old rails, is the usual combination.

The weight of rails should be in proportion to the tonnage passing over them, and more particularly to the weight of the rolling-stock. Locomotives weighing 70 tons (including tender), at present used upon roads of heavy grades, require a steel rail of not less than 60 lbs. per yard, with ties close together—not less than 2,700 to 3,000 per mile. A heavier rail is used both in England and on some of the roads of this country. It has been frequently remarked that the iron rails of our first railroads lasted much longer than those made in later years. Those who make this assertion do not take into consideration the facts that traffic has greatly increased, that rolling-stock is much heavier, and that the speed of trains is much increased. Then comes the additional fact that rails are made with less care, because railroad companies demand rails at a low price, because they cannot afford to pay for iron at all at a high price. The experience of the past ten years shows that no road can afford to use iron rails as at present generally made, and that steel rails of good manufacture will outlast the best iron rails at least from seven to ten fold.

JOINTS.

After selecting the best rail, the next point is to select a good joint. I am of the opinion that there is rarely money enough spent upon joints. The old-fashioned chair has long lost its repute as a first-class device. The fish-joint succeeded it about the year 1854, and many base-chairs have been substituted with varying success; and now it is admitted that the steel rail has been frequently sacrificed to weak and imperfect joints. The flange-iron, the reinforced fish-plate called the Samson joint, the Fisher joint, the Dilworth & Porter, the Arthur, have come into use, but it is probable that all these come short of what is required to make up a first-class joint for steel rails (as strong as the rail itself) upon roads of heavy grades and with heavy rolling-stock. A very satisfactory joint is the Dilworth & Porter combined with the fish-plate.

The angle splice is the best form of that kind of splice. There are three defects: first, the metal is not well disposed for strength; second, the strain of creeping comes upon the bolts; third, the vertical strain on the outer part of the flanges has a tendency to strain the bolts vertically. However, it has superior advantages over the simple fish-plate.

The diagrams on pages 264 to 271 represent some of the best joints at present (1877) in use in this country.

NUT-LOCKS.

There is an endless variety of nut-locks, and many of them of much merit, and yet, after an examination of nearly all, and of practical experience with many, I find nothing better than the wooden washer, made in two parts for each joint, that is, to go over two bolts about one inch thick. Outside of this washer put a washer of No. 16 iron and screw up tight, pressing into the wood. This gives elasticity and saves the threads of bolts. It is the cheapest kind of nut-lock.

CHAPTER XI.

RENEWING TIES—SHIFTING IRON.

THE WORK NOT SO SIMPLE AS IT LOOKS—NEEDS TO BE DONE INTELLIGENTLY—DIFFERENCE OF TIES—HOW TRACK IS AFFECTED BY CHANGING TIES—USES FOR OLD TIES—RAILS: WHEN ENDS ARE BROOMED—STEP-CHAIRS FOR LAYING REPAIRED IRON—ADJUSTING REPAIRED RAILS—SPIKE-DRAWING—PRESERVING THE GAUGE—UNCURVED IRON FOR CURVES.

WHEN ties have been selected and laid according to the directions given in a former chapter, it will be comparatively easy to replace old ties with new ones; otherwise it will be difficult to do it properly. I do not mean to be understood that it is a very difficult affair to take out a decayed tie and put a new and sound one in its place, as is done ordinarily; but to do it well requires considerable care and attention. The work is, however, too often entrusted to a squad of inexperienced men, with no one to act as foreman, under the delusion that any man, or gang of men, is capable of doing it. This is a mistake under which some of the best track-men in the country are laboring. It is not generally known by section-masters, or even road-masters, that a small tie has a heavier weight to sustain than a large one, and that therefore it requires some skill and intelligence to manage properly the apparently simple operation of renewing ties. It is easily understood that a small tie will settle into the ballast further under the same load than a large one, and that the rail will, in consequence, spring considerably more when supported by the former than in passing over the latter. Let us suppose that several small ties are placed next to several large ones, and that the small ones settle an inch more than the large ones (which is not an extravagant supposition); it is obvious that the small ties are subjected to a blow of six or eight tons, more or less, as the case may be, by the fall of one inch, greater than the larger ties have to sustain.

Of course the section-men, in renewing ties, should remove only such as are decayed. When ties vary much in size, as they usually do, it is only the small ones that require removal, as the large ones are capable of doing duty for a year, or perhaps several years, longer. If they have been assorted when first laid, and those of a uniform size laid together, of course each set of equal size will be so far decayed as to render it necessary to remove them all at one time, while the next or adjoining set (length of iron), if larger, may remain for a time longer.

In this way the rail will receive a uniform support, as well when the new ties are under it as it did with the old ones. If the ties have been laid promiscuously, without regard to size, in removing those which are decayed a tie will be taken out here and there; and as a new tie, well tamped, gives the rail a more solid foundation than an old one, it has a bad effect on rolling-stock, and on the track also, by presenting an uneven support. The condition of the track, in regard to its solidity, is subject to two changes under the operation of removing ties when it is done at random: first, by disturbing the road-bed under the ties newly laid, while it remains solid under others; next, after the second tamping of the new ties, necessary soon after they are put in, they become the most unyielding by reason of the greater solidity of the wood now resting on an equally solid bearing in the ballast. Any one riding on a locomotive over a track, after ties have been removed and replaced at random, will appear to travel over a very uneven surface, owing to a want of uniform support by the ties. Thus it will be seen that there is room for the exercise of as much care and attention in the simple operation of renewing ties as in laying them at first, in order that the track and the company may receive the full benefit of so expensive an operation.

Because a small tie has a heavier load to sustain than a large one, it follows that when several small ties are laid together they will, under some circumstances, settle an inch or more in excess of larger ones placed adjoining them. This may appear absurd to many railroad men, especially to those who have had the good-fortune always to have been employed on roads so well tied that there is barely room between the ties for tamping, having, in fact, almost a solid bed of timber with rails laid on of the heaviest pattern. Unfortunately for the railroad community, however, and the community at large, there are but few such roads in the country; and those whose experience has been on roads where ties are laid very scatteringly and with a light rail will have no difficulty in finding ample proof of the correctness of what has been said.

USES FOR OLD TIES.

Old ties have many uses:

1. *To patch temporarily broken fences.*
2. To make footings for washing embankments.
3. For temporary platforms for piling rails
4. Fuel for drying sand at sand stations.
5. Fuel for section-men.

In all cases the scrap spike should be carefully collected and sent to depots of scrap. Sawing up old ties for engine-wood is not profitable unless wood is worth $5 per cord.

After ties have been distributed to the uses above mentioned, if needed, the surplus should be burned at such times as to suit the movements of the trains, always after consultation with the superintendent.

After burning, all scrap spike must be carefully collected and sent to depot.

SHIFTING IRON.

When a rail gets badly broomed at the ends, it is taken to a shop and repaired by welding on a piece of bar-iron to level it up to its former shape. A great deal of iron remains sound and in good condition throughout its entire length after the ends have become battered so as to render them unfit for use. It is, therefore, a matter of economy to repair such rails, and put them to further use, rather than to put new iron in their place, as iron that is well repaired and properly replaced in the track will answer nearly as well as new iron for a long time. It requires considerable care, however, in replacing it in the track to make repaired iron pay. Sometimes the end of a rail that has been repaired is placed next to one that has not been worn or battered sufficiently to require removing. In such cases the ends of the repaired rails, being higher than the adjoining ones, are exposed to a severe pounding, and are soon spoiled, so that repaired iron does not always pay expenses.

The subject of repairing rails is an important one. With my own experience, and that of other engineers, it is best to put up a saw, cut the rails, and repunch the holes, where necessary.

In laying repaired iron what are known as step-chairs should be used. These may be made of any of the ordinary styles of cast chairs, but with the rail-seat on one side lower than that on the other, so that rails varying somewhat in height may be placed together and yet form a true and even joint, preventing all unnecessary wear or pounding of iron. The lips of step-chairs should be made low, and have both sides alike, so that they may be used either side out, or on either side of the track, as occasion may require. It is best, also, to provide chairs of various patterns, with reference to the height of the step, that, varying slightly, they may accommodate any variation in the height of rails. The expense of furnishing these chairs is but a trifle as compared to the saving they effect in the wear of iron, and it is economy to use them even when the variation in the height of the iron is very slight.

The various operations in repairing track render it frequently necessary to draw spikes from ties. Now, if in replacing iron the rails can occupy exactly the same place as those taken out, and leave the gauge correct, it is of great importance to plug the spike-holes with wooden spikes made at the car-shops; for, if the holes are left unplugged, the tie soon becomes full of holes, which fill with water. Thus the timber is softened under the rail and soon rots, while all other portions remain sound. It is best, therefore, to drive spikes in the old holes, after filling or plugging them up, unless there is some *good* reason for driving them in a new place, in which case the old holes should be tightly plugged to keep out water.

In putting new iron in the place of old it is generally the custom to draw the spikes only on one side of the rail. In some cases this may be done to good advantage, as it will save considerable labor, as well as the damage to ties and spikes which is the result of careless drawing. There is much variety of opinion upon the question of the propriety of pulling the outer or inner spikes in relaying iron; but it would seem that the advocates of the former method have the advantage, inasmuch as the new rails are sure to be truly spiked to gauge on the outer side, where the pressure comes, which seems to be the vital consideration, besides being more convenient. On the other hand, the great rapidity necessary in changing rails with heavy traffic causes the necessity of too rapid work, and spiking is sometimes not well done. Therefore the advocates of pulling inside spikes claim that they with more care and at leisure can spike to gauge on the outside afterwards. As old track is usually wide gauge, if the new rails are wider on the tread than the old ones, the gauge may occasionally be made correct, though the spikes are drawn on one side only. But it is not worth while to be too particular about saving labor in this work to the sacrifice of a true gauge, and it is important, therefore, as a rule, to draw all the spikes not close to the rails. Several miles of track might have been seen, not long ago, on what is considered a first-class road, where the laying of new iron had reduced the gauge half an inch. The rails, in consequence, were wearing out rapidly, and could last but a short time under those conditions. In the same way, the use of iron of some other pattern, with a broader base, might render a gauge half an inch or more too wide; and yet, judging from the practice of some track-men, they are not aware that track-iron is made of more than one size or pattern, but believe that all rails are alike.

In renewing iron, as in laying new track, curving is often neglected. A car-load of iron is run, perhaps, hundreds of miles from where it was loaded, to the spot where the iron is to be used, when it is distributed from the car and laid, without regard to curving or straightening. If the iron is to be laid on a straight line, this plan is well enough, care being taken to straighten such rails as have been kinked in handling; but if it is to be laid on a sharp curve, it is better to unload it carefully at the end of the curve, and then it can be properly curved and laid from the iron-car or a hand-car, as in laying new track.

In relaying iron that has been taken from the track and repaired it frequently happens that some which has been in use on a curve is relaid on a straight line. In such cases the curve should be well taken out of it before laying it. At other times it is found convenient to lay on curves iron which has previously been used on a straight line, and this is often done without curving it. This matter does not generally receive the attention its importance demands. Iron is taken out for repairs and sent to a shop, which may be many miles away, and when it is ready for use again it is likely to be sent to some other part of the line, far away from where it was taken out. As there is no remedy for this, all iron coming from the rail-shops should be closely examined before laying it, to see that it is in proper shape. The operations of removing, repairing, and relaying iron are, altogether, expensive, and, if not well done, will not pay. From the report of the New York State Engineer for year ending September, 1869, it appears that the cost for repairs of iron in road-bed in that State, during the year, was $4,717,907.54; and no doubt a large proportion of this cost might have been saved by proper care and attention in laying the track, and by giving it proper care and attention afterwards.

The cost of maintaining the permanent way is one of the greatest obstacles to the profitable working of *any* railroad; but, as before said, this expense, on some roads, is more than double what it need be, were proper measures taken to prevent all *unnecessary* wear to track-iron.

CHAPTER XII.

SNOW AND ICE.

SNOW-PLOUGHS INSUFFICIENT—JEALOUSY OF MASTER-MECHANICS A HINDRANCE TO THEIR IMPROVEMENT—OTHER REASONS —CLEARING THE FLANGE-WAY—SOME METHODS OF DOING THIS.

IN some sections of the country the expense of removing snow and ice from railroad tracks is enormous, and, as the work is usually done by section-men and often charged to the account of track repairs, it may be proper to offer some hints on the subject.

The clearing of snow from railroad track has not received sufficient attention from managers, and track-men are in a great measure powerless in this matter without the co-operation of the superintendent and master-mechanic. The last-named official is usually on hand, in case of a severe storm, with a huge snow-plough, constructed in his shop, after his plan. This commonly requires the united efforts of from three to six locomotives to move it through enormous drifts of snow, or through the deep cuts that are filled with it; and when once the monster, with wings extended, has passed over the line, it returns to be made much of by every mechanic who had the least part in its construction, and to increase the self-complacency of its designer. There is hardly any first-class railroad in snowy parts of the country but is provided with some kind of "big snow-plough," and, as a general thing, it is useful for removing heavy drifts of deep snow; but it is apt to leave large quantities in the flange-way, which soon become packed and frozen into solid ice, offering a great obstruction to trains. What is thus left to pack down in the flange-way is usually neglected by the master-mechanic and those under his charge, and track-men are left to their own resources to remove it.

When the first railroad was built in this country, it was asked: "Can we run it in winter, on account of snow?" It was a question not easily answered then, but after a few years' experience it was demonstrated that, with proper appliances, snow would not seriously interfere with railroad traffic, or, at least, that the difficulty was not an insurmountable one. Years later very good snow-ploughs were put in operation on some roads; but even the best of them were not adopted on roads other than those for which they were built, and there is not to this day any *standard* snow-plough in use. The reason assigned is the great reluctance of master-mechanics generally to adopt each other's improvements. However this may be, it is certain that no thoroughly efficient snow-plough has ever come into general use, and of all improvements of a mechanical nature pertaining to railroads the snow-plough may be said to be in the rear. There seem to be at least two good reasons for this: one as stated above, and the other that the article is needed only a portion of the year; so it is somewhat in the condition of the roof of a certain man's house—when it was fair weather it needed no repairs, and when it rained he could not repair it. So with building a snow-plough: in hot summer weather, or in pleasant weather in autumn, it is forgotten; when every one is up to his ears in snow it is too late to commence building one, as winter will soon be over and it will not be needed. This is the excuse on some roads, year after year, for not building a first-class snow-plough; and winter after winter their trains are lost in some severe storm and not heard from for days at a time. When the snow is all gone in the spring, the managers conclude they have had an unusually hard winter and probably will never see the like again; that it is at least doubtful if a snow-plough will be needed the following winter, and so none is built. This is the practice of many companies year after year.

But a more particular consideration of the snow-plough belongs to another chapter. The matter in hand is the work of clearing track of snow and ice, in which track-men are especially interested.

When the flange-way of the track becomes filled with hard snow, which soon forms into ice, it offers great resistance to passing trains, and the wood or coal pile is correspondingly diminished. This important matter is often neglected by track-men, who, as a general thing, imagine that if the surface of the rail is clear, and passenger trains make time, and if freights are not very much behind, the track is all right. They do not consider that the passenger engine which has passed them with such apparent ease is using a large amount of fuel in excess of the ordinary quantity, or they do not notice that the freight trains are running with several cars less than their usual number, on account of the flange being full of snow and ice. It is no excuse for to-day that the flanges were cleared out yesterday; for, when there is snow on the ground, it is constantly sifting along and drifting into the flange-way, where it is soon packed into ice by passing trains. Some roads in the country have an apparatus attached to the front of the locomotive or under a car for clearing flanges as the train passes along. This is a relief to track-men, and, if the contrivance works well, it is equally beneficial to train-men and profitable to the company. It is, however, difficult to operate such appliances successfully, on account of the liability of the scraper to catch on chairs, frogs, crossing-planks, etc. There is in use on some roads a very efficient contrivance that can be raised on approaching crossings, etc., but, owing to the difficulty of raising it at the proper time, it has not come into general use. In most cases track-men cannot make better use of their time in winter than in clearing the flanges, and by doing this thoroughly they may save the company a handsome sum out of current expenses.

CHAPTER XIII.

ON FIRE AND WATER AS ENEMIES—ALSO ON PRESERVING FENCES.

WASHING AWAY OF EMBANKMENTS—INSTANCE OF NEGLECT AND ITS CONSEQUENCES—VIGILANCE NEEDED AT THE SEASON OF FRESHETS—DUTY OF SECTION-MASTERS—POWER OF WATER NOT FULLY REALIZED BY SECTION-MEN—ACTION OF WATER IN DEEP CUTTINGS—SURFACE DITCHES—HAND-CAR PRACTICE — FIRES: BURNING WASTE; BRIDGE-BURNING AND ITS CAUSES—BREAKS IN FENCES MAY BE HIDDEN BY WEEDS—FALLING TREES—DANGER OF LEAVING FENCES BROKEN—TOOL-HOUSES.

IN many sections of the country the nature of the soil is such that a sudden fall of rain will frequently wash away the embankments; and many a frightful accident has occurred in consequence of a rainfall which the section-master has not regarded as at all dangerous. But in no case are vigilance and promptness more needed. Even in the night-time, if a section-master is awakened by a sudden and severe storm, it is best for him to bestir himself and look over his track before any train is due. The writer once cautioned a section-master to look closely to an embankment composed mostly of sand, in which a drenching rain had made a small channel and which it was rapidly undermining. By reason of his giving no heed to the warning a whole train was wrecked, with a loss of several lives and several thousand dollars' damage to property. This is not mentioned as a solitary instance, for occurrences of this kind are frequent at some seasons of the year. Within a few years a station building on a New England road was washed entirely from its foundation and an excavation one hundred feet in depth was made on the site of the building. This was done in less than an hour's time. Such an occurrence, though an extreme case, may, nevertheless, serve as a warning.

CARE OF ROAD-BED IN FRESHETS.

Attentive readers of the daily papers cannot fail to notice the frequent occurrence of frightful accidents at certain seasons of the year, caused by the sudden washing away or undermining of embankments. It will be seen, however, that these do not take place so often in the spring and fall of the year, when freshets and storms prevail, because at such periods all hands are on the watch. Section-masters are more vigilant; engineers run their trains with greater caution; brakemen, instead of taking the most comfortable vacant seat they can find, sit astride the brake-wheel, ready for action at the first signal of danger. It is in midsummer, when the rough spring weather is over and the usual spring freshets have passed, that some of the worst accidents on record have happened. These are attributable to the sudden and severe storms which are frequently experienced in this country, crossing it from the Pacific to the Atlantic. It is not pleasant for a railroad man to take a hand-car or go on foot over several miles of track in a severe storm; but every section-master should bear in mind that at such times his services are most valuable to the company. It is his duty to make examinations, especially of those portions of road-bed which he may have reason to believe most liable to damage by the storm; for, of course, there are places on every railroad that are more likely to be affected by storms than others. It is to be regretted that the average section-master is not aware of the power of water and does not realize the damage that may be done in a short time by even a small quantity of water, when conditions favor its action. Miners in California use water to tear down mountains; and, if properly applied, a very small quantity accomplishes great results. Of course they use artificial means to bring the water to bear with its greatest force; but nature has her means too, which are ample, in given circumstances, to invest water with terrible powers of destruction.

For example: in heavy cuttings serious accidents have occurred by the undermining of boulders and huge rocks, by the action of a very small quantity of water, in a short time.

There is a road in this country which occupies an enviable position on the list of first-class roads, and yet has had its full share of disaster; and the action of water in deep cuttings has been to it the greatest cause of danger and damage. All roads in mountainous districts are more or less troubled in the same way, yet some companies, by taking proper preventive measures, have suffered comparatively little.

Surface-ditches are probably the best safeguards against the danger under remark, and it is strange that they are not more generally used for that purpose. A surface-ditch is one that is dug on the top of a slope, but at a sufficient distance from its edge to prevent the water in it from breaking through and rushing down the slope. It is not expensive, the protection it gives to track is considerable, and track-men should see that one is dug in all places where it may be needed.

HAND-CAR PRACTICE—FIRES.

Section-men, in passing over the road with a hand-car, going daily to or from work, should carefully observe the condition of fences, etc., especially in view of the danger of fire. Careless firemen frequently throw overboard handfuls of dirty waste, which at any time may be ignited by a spark from a passing locomotive. Fire may be carried thence into the dry grass by the roadside, afterwards into the fence, and soon to the hay-stacks, buildings, wood-piles, etc. There are certain times in the year when such accidents are more likely to occur than at others, and much property is destroyed in that way which, with proper attention, might have been preserved. I do not undertake to say that all fires of this nature may be prevented; but it is notorious that track-men frequently pass handfuls of burning waste, or a stump that has caught fire from a spark, without deeming it worthy of notice. Now, when a gang of track-men engaged at work discover a smoke on a line, they should at once attend to it. It should be a rule at all times never to neglect the least indication that a fire has caught on the line. On more than one occasion expensive bridges have been destroyed owing to a neglect to stop the hand-car and remove a live coal of fire dropped by a locomotive, or to put out a fire caused by a spark from a smoke-stack lodging in a decayed spot of timber. It is well known that a bridge may be perfectly safe in regard to the soundness of its timbers, and yet have a small knot partly decayed, or "punky," as it is termed. This does not impair the strength of the timber to any great extent, but it is extremely combustible and may be ignited by a single spark; and when the fire has once caught, it may remain for days unnoticed. Then, all at once, when the wind is right, the entire structure may be consumed in a few moments. It will thus be seen that bridge-burning does not necessarily show neglect on the part of track-men; for, as above stated, fire may remain a long time in the timber without being discovered, and at last spread too rapidly to be checked. All these are exceptional cases.

It is a good plan for the track-men to examine bridges in dry weather every time they cross. On some bridges that have cost large sums and are in exposed places watchmen are employed night and day. Yet, even with this precaution, many expensive bridges have been destroyed by fire. Small bridges and stringers on culverts, etc., need watching as much as larger structures, as not unfrequently a coal or spark may drop on a stringer or rail-plate and so burn it as to cause a train to fall through. Some of the worst wrecks on record have been taken out of culverts where a stringer has been nearly burned through. Fire and water are admirable servants to railroad men, but if not watched narrowly they are apt to prove their worst enemies.

FENCES.

It is of the utmost importance that track-men should note well the condition of fences. In some places these are so overrun with weeds and underbrush that a serious break may be hidden from a careless eye. In fact, this matter is too often overlooked. In other cases a rail will be knocked off the fence, or a break be made by a fallen tree. It not unfrequently happens that such damages go from day to day unrepaired, giving cattle an opportunity to get on the track. Now, when cattle are pastured alongside of a railroad, they are tempted by the good growth of grass across the fence, and are generally more apt than the track-men to notice a break in the fence. Surely, it is far better to stop a hand-car and repair a fence than to subject a company to damages for killing stock, with the additional expense, occasionally, of a wrecked train.

In a word, men, when passing over the road with a hand-car, should be prompt to remedy every defect they discover. It should be a rule never to postpone any work of repairs that can be done on the instant.

TOOL-HOUSES.

Sufficient attention is not given to the matter of tool-houses. Their position should always be outside of the switches, to enable section-men to pass out in the morning to their work when there are trains at the station.

No tool-house should be less than twelve feet from the nearest *track*-rail. This space is required that hand-cars may be taken off and left where there is no danger from passing trains when the door of the tool-house is open. The house should be at least 12 ft. by 16 ft., the gable facing the track. The doors should be near one end of the house, to give room upon one side for tools, and to allow for inside labor and shelter in inclement weather.

CHAPTER XIV.

ON RAILROAD ACCIDENTS.

PREVENTABLE AND NON-PREVENTABLE ACCIDENTS — ILLUSTRATED NEWSPAPER CRITICS—A WORD TO NEWSPAPER MEN —WHAT ACCIDENTS MAY BE CLASSED AS UNAVOIDABLE—COLLISIONS: FROM BREAKING OF CAR-COUPLINGS; FROM MISUNDERSTANDING BY TRAIN-MEN; BETWEEN GRAVEL AND PASSENGER TRAINS—CHEAP AND IGNORANT FOREIGN LABOR —PROMPT USE OF LIGHTS—NARRATIVE OF A COLLISION—BROKEN (USUALLY CHEAP) AXLES — CRACKED WHEELS—BROKEN RAILS — WHO IS BLAMEWORTHY — MISPLACED SWITCHES—FALSE ECONOMY—CONCLUSION.

To say that all railroad accidents might be prevented would be to make a rash assertion; but to say that a large portion of them might be avoided would not be extravagant. When railroad accidents are classified, it is seen that there are some classes, all, or nearly all, of which might be prevented by means within the power of every railroad company.

There is one class at least which it would seem cannot be prevented by any human power or forethought. In the latter class may be reckoned, in the present state of our knowledge, such as are caused by sudden and severe storms, which tear away embankments or precipitate rocks and earth upon the track in deep cuttings or on mountain sides, or wrench even iron bridges from their foundations. This class of accidents has been incidentally mentioned when cautioning track-men to be vigilant in case of storms, and prevent accidents as far as possible by giving warning to trains in case of danger. There are, however, cases when it would seem that the utmost vigilance on the part of track-men would not prevent disaster. Many times men have been sent over the road to see that all was safe, just before a train was due; yet, during the short space of time between their passing a certain point and finding it safe and the time for the arrival of the train at that point, a violent storm has swept away the track and the train has been precipitated into an awful chasm.* Accidents of this kind are not infrequent, and there does not seem to be any way of preventing them, except by stationing men along the line in places where such accidents might occur to warn trains of danger. This has been, and continues to be, the practice on some roads; yet, notwithstanding the precaution, such accidents have still occurred. The illustrated newspapers have interested the public on many occasions with engravings of

* A furious gale had, in my opinion, more to do with the loss of the Ashtabula bridge than its inherent defects.—C. L.

these frightful disasters, taken from a sketch made on the spot by "our special artist." These illustrations are usually accompanied by very minute descriptions of the catastrophe, and generally wind up by assuming gross carelessness on the part of some one, and charging the officers of the road with neglect of their duties.

The daily papers of the country have of late, and indeed for years past, been very severe on the railroad managers in their accounts of what they usually term "the last railroad murder." In many cases such language is hardly too severe; for although it would not be fair to suppose that any railroad manager would deliberately subject himself to so serious a charge, yet the frequency of accidents on some roads makes it clear that there is far too little regard for human life or the interest of the road. On the other hand, it would be well for newspaper men to bear in mind that in railroad operations, as in every other business, accidents *will* happen in spite of every effort to prevent them; in such cases it serves no worthy purpose to occupy two or three columns in abusing the manager of a railroad. All such disasters as are caused by act of Providence, of course, cannot be prevented by any human agency, and no one should be blamed for them. Among these may be classed those caused by tornadoes, lightning, and by the sudden and awful rain-storms that sometimes visit various parts of the country and destroy hundreds of feet of embankment in a few moments. Fires may, under some circumstances, be properly put into this class of accidents; so may, in some measure, the breaking of wheels, axles, etc., which cannot always be avoided. Although these may have been selected with great care, and thoroughly tested in regard to their strength, they will at times give way without any apparent cause. There are other accidents of a kindred nature which may also be classed as unavoidable, such as the breaking of car-couplings, for instance. It is generally the custom to make car-couplings of sufficient strength to withstand a much heavier strain than they are ever expected to be subjected to. This is done as a measure of safety, and the idea is correct; but the constant friction to which the links are exposed will, after a time, wear and weaken them to such an extent that they frequently fail to bear the strain imposed upon them. Trains have parted while ascending a heavy grade, when, if there had been no brakemen on the detached cars, they would of course have run back down the incline; and sometimes a collision has occurred with a following train. These accidents have been rather more numerous than is generally supposed. Formerly they were more frequent than now, as it is a general rule on all roads to station a brakeman on the rear car to prevent them. This precaution does not always suffice, for the reason that there are often so many cars on the detached portion of the train that one brakeman cannot control them, and if the train following has been running a little closer to the train ahead than the orders allow, a collision is the result. This may be attributed to mere carelessness, and sometimes, at least, the charge would be fairly made. A rear brakeman, by leaving his post for a short time to have a friendly chat with his next brakeman, has been the immediate cause of such mischief. But it not unfrequently happens that a coupling-link works the pin out when the train is on a descending grade, and thus the train is divided. This cannot fairly be charged to carelessness; for no amount of care and attention would prevent the possibility of the pin working out, though it might prevent serious consequences ensuing. The breaking of links is in most cases due to their becoming much worn, bent, and twisted, and thereby rendered unsafe. Doubtless many accidents are caused by the use of links in this condition. As soon as a link shows the least sign of weakness it should be laid aside.*

* The very toughest and best iron should be selected for them, which is not always the case.—C. L.

These accidents, though occurring in many different ways, may be generally classed as avoidable. Yet it is at times extremely difficult to say who is to blame and how much. A misunderstanding between train-men and others interested in the running of trains is the most common cause of collision; and when this is made apparent, and all parties are found to have acted in good faith, it seems hard to censure anybody. Yet it would seem that either the rules of the road must be defective, or the persons employed to carry them out deficient in the necessary intelligence and carefulness.

At the present day such accidents are less frequent than formerly. There are obvious reasons for this, which will be apparent to any railroad man on giving the matter a little thought.

There is now and then an account in the newspapers of a frightful collision on some of the old roads; but this class of accidents is mostly confined to new roads, where no regular system of operating has yet been established, and where ballast trains, etc., which are very likely to be out of time, are either running or are directly in the way when regular trains are due. With few exceptions, the most frequent and destructive collisions have occurred on new roads, between gravel and regular trains, owing to the former blocking up the road. This is no "inscrutable dispensation," but the result of sheer carelessness. Any accident that is caused by ignorance or neglect is, of course, of the avoidable kind. If railroad superintendents would exercise more caution in the selection or appointment of men to responsible positions (and what position is not a responsible one?) there would be fewer collisions. It has become too much the custom of late, with railroad companies, to place men without experience to perform duties which, for the profitable management of the business, require a longer apprenticeship than they generally have. There are men of this sort in charge of working trains, on many roads, who can scarcely tell the time by a watch. This is a specimen of the "economy" before mentioned, and probably no one has practised this kind of economy for any length of time without furnishing ample evidence to condemn it, and to show the importance of putting none but intelligent, wide awake men in charge of working trains.

In regard to collisions commonly viewed as unavoidable, many have no doubt occurred in time of heavy fog, when, in a clear night, a light might have been seen a sufficient distance to prevent accident—such, for instance, as a hind train running into a preceding one which had broken down. Of course, if the leading train on meeting with an accident, were to send light back far enough, it would prevent coll sion, if the light could be seen at all; but when a following train runs rather close to the leading one there would hardly be time after a serious accident to send a light back far enough to prevent a collision. There are various ways in which a collision might occur during a fog which would be avoided in clear weather.

There is a well-managed road in one of the Middle States which was in operation for twenty years without having to record a single accident to trains or injury to passengers. Then came a terrible collision, partly in consequence of a misunderstanding and partly because of a thick fog which was prevailing at the time. It was usual, when an express train arrived at the terminal station, for another fast train to pull out and go over the road in an opposite direction. Four miles from the terminal station was another station, where, on certain occasions, if the train coming in was a little late, the two trains would meet. On the occasion referred to the train coming in was only a trifle late, so it was concluded to proceed to the next station. The conductor of the train going out had by some means got the idea that he was to meet the in-coming train at the station before mentioned, and the conductor of the last-mentioned train understood that he was to reach the terminal station as soon as possible. In consequence, the trains met with a fearful crash.

As the engineer of each train was making his best time to get to the station ahead of him before the other train came out, the trains were running at a high velocity, yet, strange as it may seem, the loss of life was but trifling, compared to that occasioned by similar accidents elsewhere; although both trains were completely wrecked, involving a severe loss to the company. In this case it was argued that the conductors of both trains were to blame; yet they were guided by exactly the rules which they had been practising for years with success. The main point in the argument for the defence was the fog. It is doubtful, under the circumstances, whether those trains could have been run even in a clear day, at the same velocity, without coming in contact. But putting aside this question, the instance is given to show that accidents of the kind *will* occur in spite of all precautions to prevent them.

It has been shown that there are certain accidents which happen in the common course of events, and for which no blame can be rightfully laid upon any one. There seems, however, to be an almost imperceptible line of division between such disasters and those that are the result of carelessness.

But admitting that there are many and various ways in which a railroad train may come to grief for which there is no apparent remedy, there are many cases where the ounce of prevention, which is better than a pound of cure, may be applied to good advantage.

On some roads broken axles seem to be a more prevalent disease than on others, and this is owing, doubtless, to the managers working on the pound-of-cure plan—that is, they wish to economize, and do so by purchasing cheap axles, which keep them in constant trouble by their frequent failures. The verdict, "caused by a broken axle," is often rendered of late, and this class of accidents is not diminishing, but continues to be alarmingly frequent.* Car-wheels have been greatly improved within a short time, and accidents from broken wheels appear to be less frequent than in the early days of railroading in this country; yet, in some instances, cracked wheels have been run a little too long, and have occasioned damage. Mischief has arisen from running a wheel which has had a piece broken out of its flange; and, indeed, it is not strange that accidents are frequent on some roads where little attention is paid to defective wheels and axles.

Some of the worst accidents have been caused by broken rails. In most cases this is the result of carelessness on the part of track-men. In others the managers are at fault for not provid-

* **My experience shows me that a large number of broken axles is caused by the crystallization resulting from the constant use of cold water for hot boxes and axles.—C. L.**

ing iron to replace that which has become dangerous by being battered and worn. Battered iron requires constant attention to keep it in a safe condition, and the least neglect on the part of any one connected with replacing or repairing rails may have serious consequences. The breaking of a sound rail is a rare occurrence. Most accidents happen on roads where the iron is known to be unsound; all such accidents can be avoided. It is true that, in frosty localities, rails sometimes break which were supposed to be safe, but even here it is usually the unsound rails which give way, and, as these can be easily detected by a practised eye, it follows that the accident that they give rise to might be prevented by proper caution.

RUNNING OFF AT SWITCHES.

Misplaced switches have been the cause of more accidents than anything else; several years ago these accidents were so frequent that timid persons, while on a train, were in constant fear of becoming victims of some frightful catastrophe. Switches and switch-tenders are improving in regard to safety, but serious accidents with which they are connected are still frequent. There is a kind of switch, known as Tyler's safety switch,* much used on many New England roads, that seems to be very effi-

* Described and illustrated on p. 61, vol. iii., *Railroad Gazette.*

cient, and it may be regarded as sure and safe at all times. This switch was patented, but, as the patent has expired, any railroad company that wishes to use it can do so without fear of prosecution. There is no doubt that the companies who have used this switch have saved thousands of dollars by it, and it is singular that it has not been more generally adopted. There are other switches that seem to be all that could well be desired to ensure safety, but neither have they come into extensive use; possibly because the inventors are poor and want a trifle for their patents. Running off at switches may in most cases be avoided by the exercise of ordinary care on the part of switchmen and engineers, so that any accident of this kind may generally be charged to carelessness.

The list of railroad accidents is a long one, and, although a great many on the list are not of a serious nature, it is impossible for even a slight accident to occur without more or less expense to the company; and many times these *slight* accidents are accompanied with the loss of life. Some of the most lamentable that ever happened in this country have taken place at drawbridges, owing to the neglect of the bridge-tender to change the signal when the draw was open. These disasters were so frequent a few years ago, and their results of so ruinous a character, that most of the companies operating roads where drawbridges are used have been driven to adopt signals specially for their prevention. There are signals so connected with the machinery of the draw that there can be no mistake as to whether it is open or not, and no running off at drawbridges is therefore likely to occur in future, where such preventive means exist, except as the result of derangement of the signal apparatus and neglect to put it in repair.

In explaining the causes of railroad accidents, perhaps the most comprehensive cause should not be overlooked—namely, the too great desire on the part of stockholders and managers to save money. This is the prime source from which most of the causes of railroad accidents arise. The way to remove them is to be found in a more liberal supply of necessary material, and in securing, even at some increase of cost, a greater efficiency on the part of employees.

There is no surer way to prevent accidents than to be always on the look-out for them, not forgetting that they almost always come from a direction where they are least expected. The opinion prevails with many that railroad travelling is more dangerous than any other mode, and yet reliable figures show that the percentage of travellers on railroads who are maimed or killed on their journey is far less than that of persons by the old-fashioned public coaches and private conveyances. It would be folly, of course, to rest content with such a comparison, and sit down complacently under removable evils. Accidents on railroads are yet far too numerous, and it is hoped that what has been said will help to draw attention to their causes and the remedies. The reformer's voice will only be effectually silenced when railroad men learn to work on the maxim—"*Eternal vigilance is the price of*—SAFETY."

We should probably be derelict in our duty if we did not call the attention of the railroad fraternity to the invention of the speed-recorder, a machine now coming into use upon many of the railroads of the country. This is an attachment to the axle of the caboose, which for every 5,000 revolutions gives one to a small cylinder in the car, upon which is placed a roll of paper marked longitudinally with distance and vertically with time squares, and upon which an arm carrying a pencil worked by a common clock marks a line upon the paper, which approaches more to the horizontal the faster the train moves. Every stop and every retrograde movement, as well as the speed, are accurately recorded, doing away with the book record often so abused. Such a machine I unhesitatingly pronounce, after three years' experience in observing its results, a great safeguard as well as an economizer to every road in the country which may use it.

CHAPTER XV.

RAILROAD AND HIGHWAY CROSSINGS.

RAILROAD-CROSSINGS—ABOLITION OF GRADE-CROSSINGS ADVOCATED—SAFETY AND ECONOMY EQUALLY DEMAND IT—ESTIMATE OF THE COST OF STOPS TO A MAIN TRUNK LINE AT A GRADE-CROSSING—IRRITATING ACTION OF THE GREAT CORPORATIONS WHEN LESSER LINES ARE PROJECTED—DEFECTIVE LEGISLATION—OUTLINES OF LAWS TO CHECK THE EVIL—CROSSINGS ABOVE OR BELOW PROPOSED—CONDITIONS FOR CROSSING AT GRADE WHEN UNAVOIDABLE—WATCHFULNESS AT HIGHWAY CROSSINGS ESPECIALLY ENJOINED.

ONE of the ever-recurring sources of annoyance, vexation, and lawsuits is the railroad crossing at grade.

Although the subject is one more directly for the consideration of the management of the road, the responsibilities of the road-master are so much increased by crossings that I do not hesitate to give my ideas with regard to them here. The road-master cannot understand too thoroughly all that bears directly or indirectly upon his business.

There is no question but that the entire system of grade-crossings should be abolished. Advantage should be taken of every occasion—of which there are many—to rid roads of this sort of incubus. But, instead of this, each month adds to the number. The cost of a grade-crossing to a first-class road—that is, one with a heavy traffic—is not well understood. Ignorance and obstinacy are permitted to run new roads across great thoroughfares of travel and trade with the spirit of vandals. Law, as a remedy, is powerless, for legislation is defective, and the most unwarrantable injury, accompanied by enormous expenses, is entailed upon the existing road; while an under or an over crossing, which in most cases can be made at the same cost, and many times at less, would prove a greater mutual advantage.

It is plain to every one that no road, under any circumstances, should be permitted to cross another at grade upon a heavy incline or grade.

To fix the limit of the grade upon which a grade-crossing might be allowed would be difficult, and must depend upon the maximum grade operated on the road to be crossed; but, if I were fixing a maximum for a crossing, I should not make it more than 22 feet to the mile—the grade upon which a car will stand without being affected by gravity. The damage to the road crossed, in addition to that from the "stop," would be augmented if the number of cars on a train should be decreased by the "stop." Unfortunately, the law does not seem to provide a remedy for an unfair crossing in all States.

As an illustration of some of these evils, we will present a case occurring almost every day in some part of the country. A new railroad, with a necessarily limited traffic, is projected, surveyed, and located at grade across the main line of one of the trunk lines of the country, having, we may suppose, a business of 30 heavy trains passing each way—that is, 60 trains per day. The new construction is begun and grading completed to the line of the old road. There begins a struggle, resulting, in a majority of cases, in the defeat of the old road. In case the officers of the old road had been notified of the intended location, considerable expenditure would be necessary to discover whether the crossing could not be made either over or under the old road; and even after the engineer of the new line has been shown a line, either under or over, probably better than the one adopted, he rarely pays attention to it, trusting to former precedents and the slackness or inefficiency of the law to maintain his grade-crossing.

The cost to the old line by the forcing of this new crossing cannot be less than an average of 50 cents per train for each stop—a consequent expense of $30 per day, or, say, $9,000 per annum. Now, what offset is there to this? There can be none where the roads have hostile interests, and the interests of the old road demand resistance until a fair compensation is obtained. If business relations are friendly, an understanding is always possible. Again, per contra, it not unfrequently occurs that a newly-projected railroad, of vital importance to a large community, is trammelled in construction by a gigantic monopoly which claims to own the earth, air and waters above and below it, thus presenting an insuperable obstacle to the progress of the country. To meet this state of things come appeals to a sympathetic public, resulting finally in many cases in crude and hasty legislation, the tendency of which is towards insecurity of life and damage to vested interests. This factious opposition is by no means confined to the great monopolies. Projected crossings at grade, above or below grade, are signals for battle array on almost all roads. Some general legal enactments should be provided to prevent the disgraceful scenes repeated every year at these disputed points. I would suggest the following as outlines of laws to this purpose:

1. Any new road shall have the right to build over or under any other road, without let or hindrance, at any point outside of the depot grounds of said road, and even over or under depot grounds in certain cases, provided, further, that in no ordinary case should room be allowed for less than two or more than four tracks.

2. That any road may cross another at grade

at a proper place by giving bond to pay an annual sum equivalent to 50 cents for each train required by law to stop on account of the existence of said crossing.

It is important that a law should be provided, in order that a judge or commission may determine upon the necessity of the crossing at the particular point asked for, and of the appropriation of the property. Surely, if a good place could be found to cross another road where the interchange of business, grade, and alignment would all be satisfactory to both roads, it ought to be done.

The obligation to pay a certain fixed sum, based upon the amount of cost to which the first road is subjected by a grade-crossing, would ensure a more careful survey to avoid it, and this would be healthy. It would seem no more onerous that the road crossing another should make good the damage caused by the crossing, than that the first road should suffer the loss. In most cases that from opposition in business would be sufficient.

The chief difficulties of stops may be greatly diminished by a change in the target system now in use. I should propose to substitute a semaphore signal, to be worked automatically with the central signal, for the purpose of blocking, by means of gates, one or other of the tracks (as the case may demand) on both sides of the crossing, at the distance of half a mile from it. At crossings thus provided there need be no stops when the signal gives notice of open gates. Of course, in the contrary case, a full stop must be required, not nearer than 200 feet nor farther than 800 feet from crossing in Ohio. In fact, by eliminating the necessity for a stop, except under the above conditions, and by making a crossing-frog as easy to pass over as any other part of the track, the damage at grade becomes so reduced that there will remain comparatively small excuse for contention.

But, even with the difficulties reduced to a minimum, I still maintain that grade crossings should be avoided when possible.

It is not easy to decide in the matter of the pre-emption right claimed by a constructed line to a certain surveyed and located right of way, to the exclusion of all other lines, at grade; but it is clear that there can be no right to prevent an under or over crossing, with the proviso that all masonry or bridging shall be solidly constructed and properly maintained. It should be the rule that the last road pay all the expense of frogs, targets, cattle-guards, cross-fences, watch-houses, watchmen, and maintenance of the same. The law of Ohio requires that the expense of crossing shall be borne equally by the two roads. This law was obtained by a partial legislation.

The laws relating to crossings vary essentially in different States. A national law would much simplify matters, while tending to greater security of life and property. In point of economy the advantages would be incalculable. Railroad companies would not fail to find it immensely to their interest to make a united effort to bring about a uniform legislation throughout the country.

HIGHWAY-CROSSINGS.

The subject of highway-crossings is of but little less importance than that of railroad-crossings, and their number compared to the latter is legion. The same rule should be applied to them as in the case of railroad-crossings—always to go over or under, if possible. The danger to life, limb, and property at all highway-crossings at grade is very serious. Large sums are annually paid by railroad companies for accidents caused at these points. These moneys, with the cost of watchmen, make up a total which represents the interest on a sum to be counted by hundreds of thousands. It behoves railroad companies to look closely into this, and, when it is possible, to eliminate all grade highway-crossings as opportunity offers. The road-master should be watchful to this effect, and should recommend it whenever it may be done with economy.

One thing is much neglected—viz., the keeping of highway grade-crossings in good order. The public should never have cause to complain of the shortcomings of the railroad management. The public are patrons of the roads; a dangerous crossing causes much irritation. Road-masters should see that the public are kept in good-humor.

CHAPTER XVI.

A WORD TO SUPERINTENDENTS AND ROAD-MASTERS.

INEXPERIENCED SUPERINTENDENTS APT TO APPOINT INEFFICIENT ROAD-MASTERS—ROAD-MASTERS NEED A PRACTICAL KNOWLEDGE OF DETAILS IN REPAIRS—THEIR DUTIES OFTEN TOO MULTIFARIOUS—SECTION-MASTERS NEED MINUTE INSTRUCTIONS—RIDING IN "PALACE CARS"—ROAD-MASTERS AS LIKELY TO INJURE THE ROAD BY ZEAL FOR ECONOMY AS BY EXTRAVAGANCE.

THERE are many railroad superintendents who owe their appointments, not to their experience in any capacity as railroad men, but to a financial interest in the road, or through the favor of their stockholding friends. These gentlemen frequently make poor selections in the choice of men to act as road-masters. They very naturally suppose that any one who has been found capable of acting as engineer or engineer's assistant will make a good road-master, and to a certain extent this supposition is correct. There are, however, very few men whose experience has been limited to engineering who make good road-masters, because they have had no opportunity to observe the many important details of repairs, which they must leave to the section-masters. These, as a class, do not take as much interest in the matter as they should, and generally depend on the road-master for instructions; it is therefore important that those who act in the latter capacity should be men whose practical experience enables them to instruct section-masters in all matters in their line of duty. When railroad building was in its infancy, or rather in its "teens," there was a lack of experienced railroad men, and many companies were forced to employ incompetent and inexperienced persons. Now, however, the case is different, and notwithstanding there are so many miles of road now in course of construction in this country, the supply of good men in any capacity is greater than ever before. It is not difficult at the present day to procure a first class man as road-master; and as the superintendent has no more important assistant than that functionary, it is important that he should be very careful in making the appointment. It is also important, when a superintendent or engineer has secured a good road-master, that he should not burden him with too many responsibilities. He is frequently expected to act as conductor of a gravel or wood train, as wood agent, agent for the supply of bridge and fencing timber and lumber, besides a host of other duties, which he cannot perform without neglecting important matters on the track. A superintendent should never require a road-master to perform any service unconnected with track repairs, if it can be avoided. The business of road-master, if performed thoroughly, requires the constant attention of a wide-awake, energetic man, and it is not economy to require him to perform many duties outside of his department. A man who has had practical experience on track repairs, first as a common laborer, then as a second hand, and finally as section-master, and who has keen observation and business tact, will make a better road-master than one who is a professional engineer with no other qualifications. On the other hand, the engineer who has sought and obtained the practical experience will naturally make the most efficient road-master.

Road-masters are not generally careful enough to give full instruction to section-masters; whatever particular is thus overlooked by the former is apt to be left undone by the latter, much to the disadvantage of the company.

It is not, of course, always the fault of the road-master that the track is in a bad condition, because sometimes, when the ties are decayed and require removal, the superintendent will not furnish the necessary material for repairs in the way of new ties or iron, and the road-master is consequently restricted in the performance of his duty.

But perhaps no greater cause can be assigned for the bad condition of railroad track throughout the country than the desire on the part of the road-master to make his account as light as possible. It is not expected that a road-master will either freely use the company's money to build up his own reputation, or that he will practise economy to such an extent as to injure the road; but it is sometimes the case that he has full permission to order all the material he may think necessary, and he will now and then abuse this privilege. That is to say, he will order more new ties or iron than are really necessary, for the sake of establishing a reputation as a first-class road-master, which reputation is gained at the company's expense. There are others who take a different view of the matter, and, seeking to gain a name for economy, do not order as many ties or as much iron as are really necessary for the good of the company. These extreme practices have a common object in view—viz., to make the reputation of road-masters—while both are fatal to the interests of companies.

A section-master cannot be expected to keep track in good order without being supplied with the necessary material, and when that supply is furnished it should be the business of the road-master to see that such material is properly used. If he has any section-master who does not thoroughly understand how to use the material properly, he should give as much of his time as possible to the instruction of such men and the supervision of their work.

The engineer or superintendent who may have charge of the track will do well to gather his road-masters together and discuss with them every subject pertinent to their duties. A mutual interchange of knowledge and experience is of vast value. It begets faith, a feeling of common humanity, devotion to duty. This is economy; this is safety.

CHAPTER XVII.

ORGANIZATION.

BANKRUPTCY THE RESULT OF A LACK OF FUNDAMENTAL ORDER—DISCHARGE OF THE ENGINEER BEFORE THE ENTIRE COMPLETION OF THE ROAD A FATAL MISTAKE—INCOMPETENT SUPERINTENDENTS—HARMONY BETWEEN THE ENGINEER AND SUPERINTENDENT NECESSARY TO THE PROSPERITY OF A ROAD—NO "SUPERVISOR" TO COME BETWEEN THE CHIEF-ENGINEER AND THE ROAD-MASTERS—FOREMEN TO WORK WITH THEIR MEN—ENGINEERS SHOULD INSTRUCT THEIR ASSISTANTS.

THE subject of organization of the engineering department of a railroad has been very much neglected. Financial trouble and bankruptcy have been the almost universal results of this absence of fundamental order.

The moment that the track of a new road is laid, even before the switches and frogs are put in, the engineer is generally discharged, thus removing one who might, with his knowledge, save ten times his salary yearly; some mercantile friend is put in as superintendent; * he turns

* As a matter of course I cannot be supposed to refer to gentlemen filling this position whose fitness for it is undisputed, and who, in many cases, are scientific and practical engineers, who have obtained their advancement by their earnest work and devotion to the interests confided to their charge by the companies which have employed them through a series of years. I am sure that these will agree with me with regard to the class to which the superintendent above mentioned belongs.

over the completion of the sidings, the nice work of adjusting frogs and switches, to the so-called "practical man," who, as a general rule, is well pleased to fall under the authority of one who knows nothing of the business, and he, with his superior, falls into the usual habit of denouncing the engineer now set aside as an unnecessary personage on a completed road. The result is easily foreseen: the road-master is given a large territory to supervise, and, not having time for his duties, he rides repeatedly over the track in a Pullman palace car, from which he throws frequent paper pellets to the foremen, with whom he rarely converses. He knows no more of the laws governing the elevation of curves, the adjustment of frogs and switches, than his superintendent; consequently, the appliances of science are thrown away and the rule of the thumb substituted. The curves are elevated by the eye, each foreman for himself, ignorant even of the degree of the radius of the curve; the frogs are sighted in, and more money is lost in one year by oscillation of rolling-stock alone than would pay for a select corps of experts, to say nothing of a good engineer. There are a thousand ways, not now our province to detail, through which waste and misfortune are engendered by ignorance and jealousy in the management of a road; the object here is to point out a proper and sensible plan of organization of the engineering department of a road, and by that I mean all that pertains to that branch, and more particularly that which relates to track.

One fact is undeniable—viz., the best results are obtained from theory allied to practice; therefore he who understands principles and is so constituted as to apply them in practice is the man best fitted for any work, and especially railroad work. In addition to theory and practice of his profession, the managing engineer of a road needs still other qualities—industry, prudence, and the capacity to select and govern are eminently essential to him. Through the latter quality especially he is enabled to bring about that sympathy and harmony between himself and his employees of every grade without which no department can be satisfactorily administered.

No man should ever be discharged except for cause or on the reduction of force. It is a crime against human nature to remove one man to put another in his place from mere caprice and favoritism, and this crime must bring a retribution upon the head of the guilty.

The duties of a road are properly divided into two grand departments—transportation and engineering. To the former generally belongs everything in relation to the movement of trains, maintenance of cars and machinery, with the purchase of cars, fuel, the selection of landlords for eating-houses, and the general direction of all subordinates in the department.*

The engineering department takes in the track and everything relating to it, with the purchase of all material for the construction and maintenance of the same, the purchase, sale, or lease of all lands, construction of all water-stations and all buildings and docks, maintenance of buildings and other property, and all questions relating to engineering and contracts bearing upon engineering.

There are many questions of a delicate nature in which the line between the superintendent and the engineer is very faintly drawn. It is, therefore, proper and courteous to consult with the superintendent in all cases where the question bears upon transportation. Among them are also all leases and rents, and all new sidings. The superintendent should be a party to be consulted as to the expediency of leases of any land, construction of any new siding or new building, or, in fact, anything which would change, interrupt, or interfere with his mode of business. There is another strong reason for consultation—viz.," in a multitude of counsellors there is wisdom," and the head of a department who understands this best will not only have

* Some railroad companies have deemed it wise to put the locomotive and car departments under persons of technical as well as practical education.

the most harmony, but will always avoid what is called "hot water." The president is umpire in all questions arising in either department, and settles all questions where any conflict of opinion occurs. The two heads of departments should report directly to the president.

The organization of the engineering department will here be principally treated.

The accounts of the department should be kept in the office of the engineer, under his own supervision. The principal advantage in this is that he is able to make his own estimates without having to refer to the auditor's department, avoiding needless delays and occasional complications. It is of vital importance to have reliable accounts of yearly expenditures for constant reference; no intelligent economy can be practised without a thorough knowledge of the cost in the past, and a comparison of the same with the present outlay; the experience of other roads is a good guide, and is often found of great utility. Economy, in fact, takes the first place, for without it all knowledge, practical and scientific, is considered valueless on a railroad. Constant comparisons of accounts, with graphic illustrations of them, tend to economy.

Second in point of importance are *right-of-way and leases of land.* No road of more than one hundred miles in length can be successful in taking care of its lands, unless it employs one person, a civil engineer, to take charge of these branches of business; it requires close attention not only to obtain what the road is entitled to, but to keep possession of what it actually owns. The number of those who fancy they have a right "to squat" on railroad property is very great, and it requires not only the eyes of a vigilant engineer to preserve it, but those of every man of his and other departments.

No road having a chief engineer should have any other engineer or general road-master to come between him and the road-master.

Many companies form the road into "road-master divisions" of 100 miles or more. This is wrong; no man can take charge of 100 miles and manage his division properly without one or two assistants. It is therefore better at once to make the road into 50-mile divisions, and have but one man, a road-master, with the foremen responsible to him, and he in turn responsible to the engineer. This distance is long enough, as the road-master should walk over his division at least once a month.

A foreman should have five miles generally and in winter the force, with a foreman, should not exceed one man to the mile for three million tons traffic per month, and less if below that.

If steel rails be used entirely, a reduction of two fifths of the force is entirely practicable, with equal safety, by using hand-cars of light weight.*

Foremen should all work with their men; the practice of having one man to "boss" three or four, and not to work with them, is an error which is too prevalent, and the sooner railroad companies change this system the better it will be for all parties.

The road-masters should estimate and measure, with the wood and tie inspector, all ties and wood purchased.

All roads more than 400 miles in length should have a wood and tie inspector, and a man in charge of fences.

Roads of less than that length may have that work done by road-masters; but it is safest and best, in all cases where practicable, to have that responsibility upon separate individuals, with a joint service.

There should be likewise one man to have entire charge of the water-stations, the plumbers to be under him.

There should be one bridge foreman or super-

* The economy of light hand-cars is very great, especially in these days of steel rails. One-third less labor can be used when steel rails with light hand-cars are used. Hand-cars of the present pattern are too heavy, and require generally not less than four men to handle them, and even more upon some roads—for instance, on a broad-gauge (6 ft.) road, where they weighed until recently 1,000 lbs. The hand-cars for the latter class of roads should be reduced to 500 lbs., with friction rollers. It will then be easy to lengthen the sections, as well as to use a less number of hands, with much more comfort to the laboring man.—C. L.

intendent to 400 miles of road—this depending upon the number, importance, and character of the bridges—and a foreman and two carpenters for each 100 miles, to do the necessary repairs of the line.

Promptness in action and in correspondence of all kinds on a railroad is its safeguard.

No road can be effectually managed unless every work, in the office and out of it, is promptly and efficiently done.

No road can be economically managed unless foremen watch faithfully the wear of the different rails, and can give intelligent answers in relation to them.

The intelligent and prudent engineer will instruct his assistants; the prudent and intelligent road-master will seek to teach his foremen, the foreman his men, regardless of all question of preferment, and thus all will work together to the interests confided to them, consequently to the advancement of their own ultimate advantage. "Be sober, be vigilant."

CHAPTER XVIII.

TRACKMEN'S TOOLS.

VARIETY OF TRACK TOOLS—DIFFERENT WEIGHTS—DESCRIPTION OF SOME OF THE TOOLS ILLUSTRATED—THE CORD CLAMP—TRACK GAUGE AND LEVEL COMBINED—RAIL SAW—TRACK JACK—LIST OF TOOLS REQUIRED BY ROAD-GANG—ILLUSTRATIONS.

THE tools of a railroad are many and various. It would seem sufficient to present here some of the most important. Their weights, too, vary, and some track-men use and prefer light tools, while others choose the heavy. We have endeavored to take a happy mean in the weights. Tamping picks vary from 5 to 9 lbs., spike mauls from 4 to 13 lbs., etc. There are several new tools here presented. One of the most important and simplest is the cord-clamp for determining super-elevation on curves. The clamp is merely used for holding the cord to the rail, so that the track-man can go to the centre and get the middle ordinate, which gives at once the elevation necessary for the degree of curve, if the cord be of the proper length, viz., 53 feet for 6-feet gauge, 45 feet for 5-feet gauge, 43 feet for 4 feet 8½ in. gauge, and 37.5 feet for a 3-feet gauge.

The claw-bar is a *model bar*, and will draw a spike without bending it.

The Huntington track-gauge is certainly, without exception, the only track-gauge known that fulfils all of the requirements of what a gauge should be.

The track-gauge and level combined is a very light seasoned pine rod, 1 in. by 2½ in., and was gotten up especially for the road-masters to test their track in level and gauge while walking over the track daily; but it was found to be so handy and useful as well as cheap (cost but 75 cents) that the track-men everywhere called for them. By using the cord and clamp with this instrument it is an easy matter to test the gauge and level.

There are some other useful tools—the jim crow, for straightening rails, and a curving apparatus—which no road should be without.

In these days of close economy one of the most important tools is the rail-saw. Until lately we have been wasting money in repairing rails by the wholesale. Now the wiser course has obtained to repair but few rails, and cut up the others with a cold saw, repunch, and send out the pieces. A rail-saw is probably the best labor and material-saving machine upon a road. Next to it is a new track-jack, invented in Dayton, O., which saves a large number of roosters from sitting on the end of a long lever while raising track.

Good tools are of vast importance, and much money can be saved to a railroad company by watching with jealous care every improvement and adopting that which has been proven.

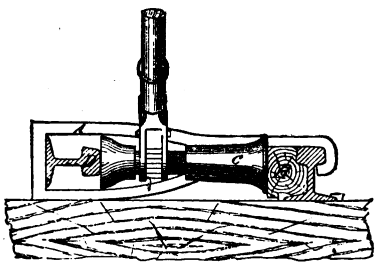
Engravings of some of the principal track tools are shown on the following pages.

LIST OF TOOLS REQUIRED BY A ROAD-GANG CONSISTING OF FOREMAN AND FIVE MEN.

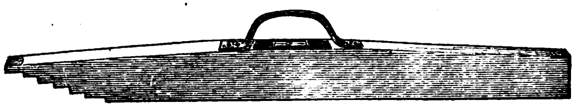
Adzes,	2	Hand Trucks,	1
" Handles,	2	" Cars,	1
Axe, Shimming,	1	Hatchets,	
" Chopping,	1	Lanterns, White,	2
" Helves,	1	" Red,	2
Brooms,	1	Line for measuring Elevation (see p. 159),	1
Brush Hook,	1	Nail Hammers,	1
Car Chains,	2	Oil-cans,	2
Chisels,		Padlocks,	2
Claw-bars,	3	Picks,	5
Cold Chisels,	12	" Handles,	5
Cord-clamps (see p. 159),	1	Post Augers,	
Crow-bars,	4	Punches,	2
Cross-cut Saws,	1	Rail Tongs, pairs,	1
Curving Hooks,	1	Raising Bar,	
Ditching Cars,		Rakes,	1
Drawing Knives,		Ratchet Drills,	1
Drills,		Screw Spike Wrenches,	
Files,		Scythes,	1
Flags,	2	Scythe Snaths,	1
Grindstones,	1	Scythe Stones,	1
Hand Barrows,		Shackle Bars,	
Hand-Saws,	1		

Shovels,	6	Tool Boxes,	
Sledges,	2	Torpedoes,	12
" Handles,	2	Track Jacks,	1
Snow Shovels,	4	" Levers,	1
Spades,		" Gauges,	1
Spike Hammers,	3	" Levels,	1
" " Handles,	3	Water Kegs,	
Squares,		" Pails,	1
Stone Hammers,		" Dippers,	1
Straightening Machine,	1	Wheel "	
Tamping Bars,	4	Wrenches,	4
" Picks,	5	" Monkey,	1
Tape-lines,	1		

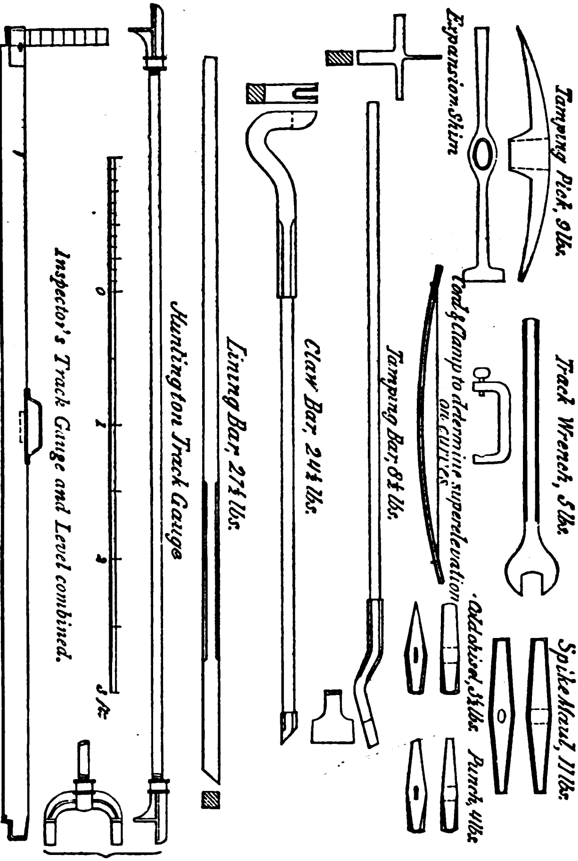
Besides the tools mentioned above, the road-master should have at his headquarters enough to meet any emergency that may occur by reason of a probable wash-out, slide, or other trouble, as well as to supply the ordinary demands of his foremen for new tools to replace those worn out.



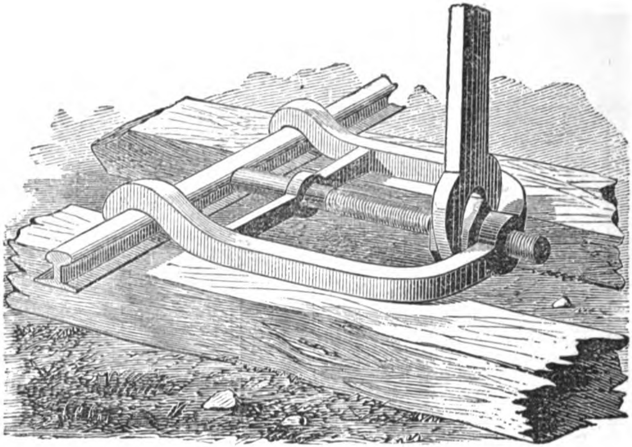
RATCHET SCREW-JACK, AS USED IN CURVING RAILS.



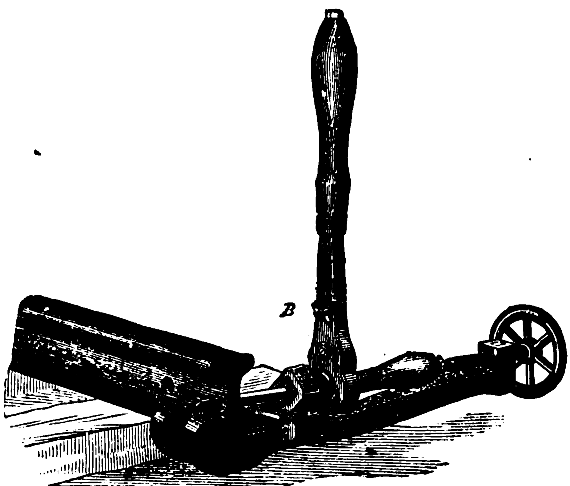
TRACK LEVEL.



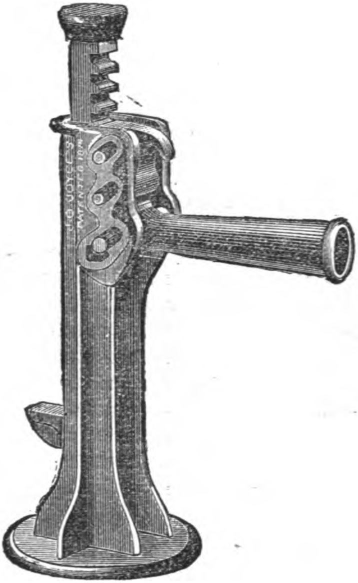
TRACKMEN'S TOOLS.



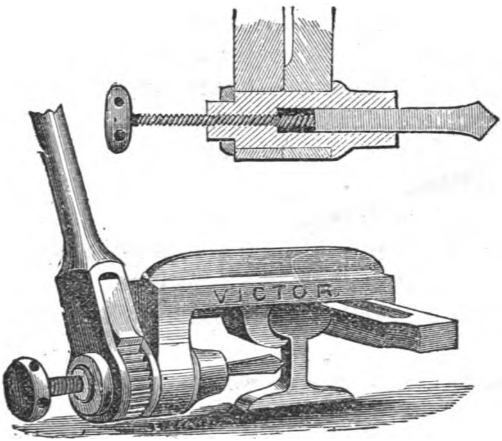
RAIL-BENDER, OR JIM CROW.



RATCHET-WRENCH AND DRILL, AS MADE BY WILLIAMS TOOL COMPANY



JOYCE'S LEVER TRACK-JACK.



LAKEY'S VICTOR TRACK-DRILL.

CHAPTER XIX.

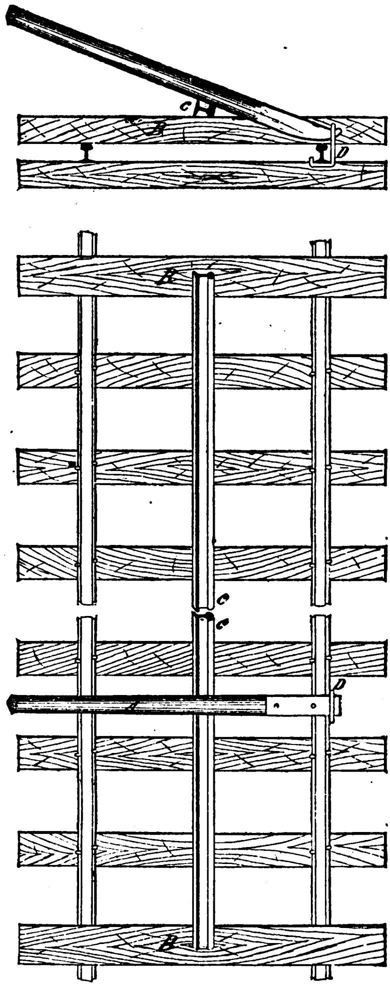
RULES AND TABLES.

Curving Rails with Lever and Curving Hook—Method of finding approximately the Degree of Curvature required to reach any desired object, Point of Curve being Known—Practical Method of Finding Proportion of Frog—Rules for Placing Frogs in Cross-over Track where the two Tracks are Straight and Parallel—Tables for Elevation of Outer Rail on Curves—Table for Determining Degree of Curvature and Elevation of Outer Rail, by Versed Sine of 43-foot Chords—Bills for Frogs and Switch Timbers.

CURVING RAILS.*

This is something not very well understood; at least there seems to be no regular system for doing it, and almost every track-man has a way of his own. Some drop the rails on blocks; others place a block under each end of the rail and have a gang of men stand on it to spring it down while one of them pounds it from end to end with a heavy sledge. The amount of damage done to rails in this way is very great, especially to steel rails. In many instances they are cracked or seriously weakened by

* The directions under this head have been prepared by Mr. M. J. McInarna, one of the road-masters of the Atlantic & Great Western Railroad.



CURVING RAIL WITH LEVER AND CURVING HOOK.

dropping or striking them, and the defect is not discovered until they are found broken in the track. Some track-men have an idea that if a steel rail breaks by striking it with a heavy sledge it is not fit to put in the track, and hence that curving by sledges is a safeguard. But this view is quite erroneous. A rail may lie in the track many years and not receive a shock as great as that caused by the blow of a sledge.

A better plan for curving rails is by the aid of the curving hook and lever, shown on the preceding page. A tie, *B* (see preceding page), is placed across the track under each end of the rail, *e*, which is to be curved. The hook, *D*, is then slipped under the main track rail between the two ties about six feet from the end of the rail to be curved, and the men pry down on it with the lever, *A*. This process can be repeated at any point on the rail, as may be required.

The hook, *C*, is made of 1½-in. round iron, eight inches long and six inches wide. The base is 4½ inches wide, to fit under the rail, and both ends are turned upwards 1½ inches. The lever, *A*, is a common track lever 10 feet long. The foreman should have a string to stretch taut from end to end and measure off from it the amount of curvature required. If he is a practical track-man, it is not necessary to measure every rail; he can tell nearly enough by the eye after curving two or three for any curve. The average time consumed per rail by this process is not more than three minutes. Each rail should be curved uniformly and free from kinks, so as to make a perfect curve without springing the rail into line by the spikes. The quarter-points should always be curved before the centre, for in many instances the centre curves at the same time with the quarter, thus saving so much time. The offset from the string at quarter-points is always three-quarters of the centre offset.

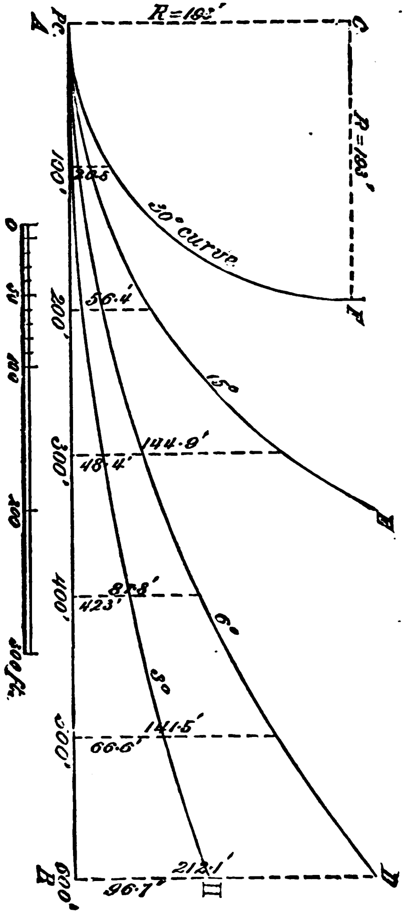
Some of the worst accidents on record have been caused by broken rails, and every man in charge of track should deem it his duty to use all means in his power to see that the work of curving and handling steel rails is performed in such manner as to reduce all chances of injury to a minimum. There is no doubt but that very many steel rails found broken in the track have been injured before they were laid, either by letting them fall on top of each other when unloading, or by striking and dropping them on blocks in the process of curving.

A METHOD OF OBTAINING APPROXIMATELY THE DEGREE OF CURVATURE REQUIRED TO REACH ANY DESIRED OBJECT, THE POINT OF CURVE BEING KNOWN.

The table on page 169 gives the perpendicular distances from points on the tangent 100, 200, 300, 400, and 500 feet from the point of curve, measured along the tangent, to opposite points on curves described with several different radii.

In the diagram the line A B represents a tangent, and the lines A H, A D, A E, and A F 3°, 6°, 15°, and 30° curves respectively. A B is divided into spaces 100 feet in length, and the perpendicular distances from the points on the tangent to the curves are marked, such as B H =96.7 feet; B D=212.1 feet.

For a practical illustration of the manner of using the table, suppose A B represents a rail on a straight main track, and, starting at a point as A, it is required to reach with a side track an object situated, say, at D; first it is necessary to find what curve to use, and then to lay out that curve. From the starting-point, A, measure along the rail to a point, B, opposite the desired object, D, then measure the perpendicular distance from the point on the rail to the object, or measure B D. At the top of the table look for the number that will correspond the nearest with the first measurement, or, what is the same thing, use the column headed with the nearest even 100 feet to that measurement. Then run the eye down the column and find the number nearest the second measurement; running along the line to the first column on the left, the corresponding degree of curvature is found, in the second column the radius. Thus in the ex-



A
P.C.
R=193'
C
R=193'
30° curve
F
15°
E
6°
3°
D
B
II
100'
200'
300'
400'
600'
56.4'
144.9'
48.4'
141.5'
66.6'
212.1'
96.7'
0
50
100
200
300 ft.

ample the first measurement will be 600 feet, the second 212.1 feet. The curve is therefore a 6°, radius 955 feet.

To lay off the curve, start at A and measure towards B, marking every 100 feet on the rail; then at each of these marks measure the corresponding perpendicular distances found in the table for the desired curve, and place a stake at the points so found; thus, in the example, at the first mark measure 5.2 feet; second, 21.2 feet; at the third 48.4 feet, etc. The line of the perpendicular can be obtained with sufficient accuracy by placing the Huntington gauge on the track and sighting along the handle. In this way points can be found sufficiently close together to lay out the curve, which of course is that of the outside rail.

If the main track is curved, the measurements may be taken on the prolongation of the tangent at the starting-point, if practicable; or if the degree of curve is known, they may be taken on the curve, and the perpendicular distances of the known curve and the desired curve may be added or subtracted, according as the side track runs outside or inside the curve. Due allowance must be made, however, for the difference of measuring along a curve and its tangent, and for the fact that the distances in the table are perpendicular to the tangent at the starting-point, not to the curve.

TABLE.

Degree of curvature.	Radius.	Perpendicular distances at 100 feet.	200 feet.	300 feet.	400 feet.	500 feet.
1	5,730	0.9	3.5	7.8	14.0	21.9
2	2,865	1.7	7.0	15.8	28.1	44.0
3	1,910	2.6	10.5	23.8	42.3	66.6
*4	1,433	3.5	14.1	31.8	57.0	90.5
†5	1,146	4.4	17.6	40.0	72.2	114.9
‡6	955	5.2	21.2	48.4	87.8	141.5
§7	819	6.1	24.8	56.9	104.4	170.1
8	717	7.0	28.5	65.8	122.1	203.1
9	637	7.9	32.2	75.1	141.2	242.3
‖10	574	8.8	36.0	84.7	162.4	292.1
11	522	9.7	39.9	94.4	186.6	372.1
¶12	478	10.6	43.9	105.9	216.3	
13	442	11.5	47.9	117.4	253.9	
14	410	12.4	52.1	130.5	320.0	
15	383	13.3	56.4	144.9		
16	359	14.2	60.9	161.8		
18	320	16.0	70.2	208.7		
20	238	18.0	80.6			
22	262	19.8	92.8			
24	241	21.7	106.6			
26	222	23.8	125.7			
28	207	25.8	153.7			
30	193	28.0				
32	181	30.1				
34	171	32.3				
36	162	34.5				

* Corresponds nearly with "AA" frog, 6 ft. gauge.
† Corresponds nearly with "AA" frog, 4 ft. 8½ in. gauge.
‡ Corresponds nearly with "A" frog, 6 ft. gauge.
§ Corresponds nearly with "A" frog, 6 ft. gauge.
‖ Corresponds nearly with "B" frog, 6 ft. gauge.
¶ Corresponds nearly with "B" frog, 4 ft. 8½ in. gauge.

The rule for calculating the above table, or any similar one, is as follows: From the square of the radius subtract the square of the distance from point of curve to foot of perpendicular, extract the square root of the remainder, and subtract the number so obtained from the radius; the result will give the perpendicular distance.

TABLE OF MIDDLE ORDINATES FOR BENDING RAILS TO BE LAID ON CURVES.

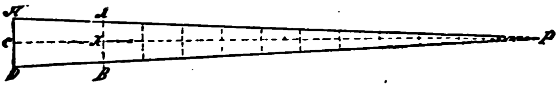
Deflect'n Angle.	Radius.	LENGTHS OF RAILS IN FEET.										
		30	28	26	24	22	20	18	16	14	12	10
Deg	Feet.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
.5	11 460	.120	.096	.072	.060	.048	.048	.036	.024	.024	.012	.012
1	5,730	.240	.192	.156	.132	.108	.096	.072	.060	.048	.036	.024
1.5	3,820	.348	.312	.252	.216	.192	.156	.120	.096	.072	.048	.036
2	2,865	.456	.408	.348	.300	.252	.204	.168	.132	.096	.072	.048
2.5	2,292	.588	.516	.444	.372	.324	.264	.216	.168	.120	.084	.060
3	1,910	.696	.612	.528	.444	.372	.312	.264	.204	.144	.108	.072
3.5	1,637	.840	.732	.624	.516	.444	.372	.300	.240	.180	.132	.096
4	1,433	.948	.828	.720	.600	.504	.420	.348	.276	.216	.156	.108
4.5	1,274	1.056	.924	.804	.672	.564	.468	.384	.312	.240	.180	.120
5	1,146	1.188	1.032	.888	.756	.636	.528	.420	.348	.264	.192	.132
5.5	1 042	1.296	1.128	.984	.840	.708	.576	.468	.384	.288	.216	.144
6	955.4	1.404	1.224	1.056	.912	.768	.624	.504	.408	.312	.228	.156
6.5	882	1.536	1.341	1.164	.984	.828	.684	.552	.444	.336	.252	.168
7	819	1.644	1.440	1.248	1 056	.888	.732	.588	.468	.360	.264	.180
7.5	764.5	1.752	1.524	1.332	1.128	.948	.780	.636	.504	.384	.288	.192
8	716.8	1.896	1.644	1.428	1.200	1.020	.840	.672	.540	.408	.300	.204
8.5	674 6	1.992	1.740	1.512	1.272	1.080	.888	.720	.576	.432	.324	.216
9	637.3	2.100	1.836	1.596	1.344	1.140	.936	.756	.600	.456	.348	.228
9.5	603.8	2.244	1.956	1.692	1.428	1.212	.996	.804	.648	.504	.372	.252
10	573.7	2.352	2.052	1.776	1.500	1.272	1.044	.852	.684	.540	.384	.264
11	521.7	2.592	2.256	1.956	1.668	1.404	1.152	.936	.756	.568	.432	.288
12	478.3	2.832	2.472	2.148	1.812	1.536	1.260	1.020	.828	.636	.468	.312
13	441.7	3.048	2 664	2.304	1.956	1.656	1.356	1.104	.900	.684	.504	.336
14	410.3	3.300	2.868	2.484	2.100	1.776	1.464	1.188	.960	.732	.540	.360
15	383.1	3.540	3.084	2.676	2.256	1.908	1.572	1.272	1.020	.780	.588	.396
16	359.3	3.756	3.276	2.832	2.400	2.040	1.668	1.356	1.092	.840	.624	.420
17	338.3	3.996	3.480	3.024	2.556	2.160	1.776	1.440	1.152	.888	.660	.444
18	319.6	4.212	3.672	3.180	2.700	2.280	1.872	1.524	1.224	.936	.696	.468
19	302.9	4.452	3.888	3.360	2.856	2.412	1.980	1.608	1.296	.984	.732	.492
20	287.9	4.704	4.092	3.552	3.000	2.544	2.088	1.692	1.368	1.044	.792	.528

NOTE.—This table is slightly modified in form from that prepared by Mr. John C. Trautwine for his "Civil Engineers' Pocket-Book."

PRACTICAL METHOD OF OBTAINING THE PROPORTION OF A FROG.

Take a stick, pencil, piece of paper, key, knife, or anything at hand of any length less than or equal to the distance across the head of the frog, *H D*, and measure across the tongue at any point at *H D* or between *c* and *P*, say *A B*, where the width may be equal to your measure, then see how many times that width is contained in the distance from *x* to *P:* this will give the proportion of the frog.

Example.—Take a pencil; you find it measures across the tongue exactly at *A B*, and you find that it measures eleven times from *x* to *P:* the frog is therefore a 1 to 11 frog.



If you have a tape or rule, measure across *H D*, and then measure from *c* to *P:* the latter divided by the former gives the proportion.

Example.—Measure $H D = 6$ inches, $C P = 66$ inches. $\frac{66}{6} = 11$. Proportion, 1 to 11.

RULES FOR PLACING FROGS IN A CROSS-OVER TRACK WHERE THE TWO TRACKS ARE STRAIGHT AND PARALLEL.

The following rules have been prepared by R. French, C.E.:

Suppose the cross-over is to be put in from the track A L to the track M G, figure No. 1, and the starting point to be at A, the position of the first frog C can be readily obtained from the tabulated form on page 174, and the only question is to find the position of the second frog D, which is given by the following rule:

RULE.—To find the distance that the point of second frog is to be placed in advance of the point of the first frog, *multiply the figure of the frog by the difference between the space between tracks and the gauge.*

Frogs are denominated by the following proportionals: 1 to 11, 1 to 10, 1 to 9, etc., meaning the ratio of the heel to the length of the frog; and the expression in the rule—"figure of the frog"—denotes the figures 11, 10, 9, etc., in each respective frog.

In the above rule, it is assumed that the track between the points of the two frogs is straight; and in every case this should be so, unless the space between the tracks is greater than thirty-five or forty feet, when it may be necessary to introduce two curves and a short tangent, or a reverse curve, so as to save track-room; but such cases occur very seldom, and when they do they ought to be put in by the aid of an instrument.

The application of the above rule is very easy, and can be used by any trackman having a moderate education. Suppose gauge is 6 feet, and the space between the tracks 8 feet, and two 1 to 9 frogs are employed. Then the difference between space and gauge is 2 feet, and 2 feet multiplied by the figure of the frog gives 18 feet, that the point of the second frog is to be placed in advance of the point of the first frog.

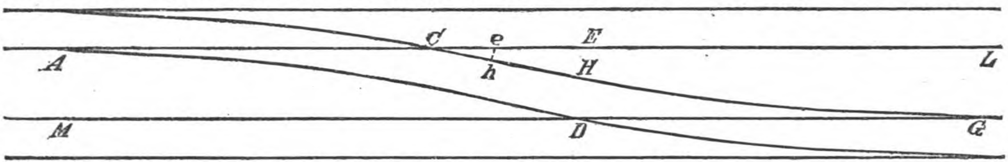
This distance must be measured along the rail, as in figure No. 1, from C to E, and then the point of the second frog will be at D, on rail M G, square across from E.

A very good method for finding the point D (opposite to E) is by means of the Huntington gauge, which will give the true direction of the perpendicular.

When the space exceeds 9 feet, it is well to use a frog having a large angle, such as 1 to 9 or 1 to 8, and when the space is 15 feet or over, a 1 to 6 frog may be used to advantage, so as to shorten the cross-over track. By carefully examining figure No. 1 the proof of the rule will be obvious.

As the tracks are parallel, and the track between the points of the two frogs is straight, the two frogs employed must have equal angles. The distance E H is the difference between space and gauge, and by comparing the two similar triangles, C E H and C *e h* (the latter of which represents the frog, 1 to 10, 1 to 11,

FIGURE No. 1.—TABLES GIVING DISTANCES BETWEEN FROGS IN A CROSS-OVER TRACK.



GAUGE, 6 FEET.								
Space between tracks.	FROGS.							
	1 to 11.	1 to 10.	1 to 9	1 to 8.	1 to 7.	1 to 6.	1 to 5.7.	1 to 5.
6 ft.	0′ 0″	0′ 0″	0′ 0″	0′ 0″	0′ 0″	0′ 0″	0′ 0″	0′ 0″
6½ "	5 6	5 0	4 6	4 0	3 6	3 0	2 10	2 6
7 "	11 0	10 0	9 0	8 0	7 0	6 0	5 8	5 0
7½ "	16 6	15 0	13 6	12 0	10 6	9 0	8 6	7 6
8 "	22 0	20 0	18 0	16 0	14 0	12 0	11 4	10 0
8½ "	27 6	25 0	22 6	20 0	17 6	15 0	14 3	12 6
9 "	33 0	30 0	27 0	24 0	21 0	18 0	17 1	15 0
9½ "	38 6	35 0	31 6	28 0	24 6	21 0	19 11	17 6
10 "	44 0	40 0	36 0	32 0	28 0	24 0	22 9	20 0
12 "	66 0	60 0	54 0	48 0	42 0	36 0	34 2	30 0
15 "	99 0	90 0	81 0	72 0	63 0	54 0	51 3	45 0

GAUGE, 4 FT. 9¼ IN.								
Space between tracks.	FROGS.							
	1 to 11.	1 to 10.	1 to 9.	1 to 8.	1 to 7.	1 to 6.	1 to 5.7.	1 to 5.
6 ft.	13′ 6″	12′ 3″	11′ 1″	9′ 10″	8′ 7″	7′ 4″	7′ 0″	6′ 2″
6½ "	19 0	17 3	15 7	13 10	12 1	10 4	9 10	8 8
7 "	24 6	22 3	20 1	17 10	15 7	13 4	12 8	11 2
7½ "	30 0	27 3	24 7	21 10	19 1	16 4	15 6	13 8
8 "	35 6	32 3	29 1	25 10	22 7	19 4	18 4	16 2
8½ "	41 0	37 3	33 7	29 10	26 1	22 4	21 3	18 8
9 "	46 6	42 3	38 1	33 10	29 7	25 4	24 1	21 2
9½ "	52 0	47 3	42 7	37 10	33 1	28 4	26 11	23 8
10 "	57 6	52 3	47 1	41 10	36 7	31 4	29 9	26 2
12 "	79 6	72 3	65 1	57 10	50 7	43 4	41 3	36 2
15 "	112 6	102 3	92 1	81 10	71 7	61 4	58 4	51 2

etc., as the case may be), it will be seen that the distance E G must necessarily be the same number of times E H as the number or figure of the frog—that is to say, 10 times, 11 times, etc.

When the two tracks which are to be connected by a cross-over are on a curve, the rule is precisely the same, only in that case the track from C to H, Fig. 1, instead of being straight, *must have the same curve as the main tracks.* This is necessary in any event if we are to use similar frogs in each track, which is always desirable, and it has the further advantage of making the rule general for all cases.

Doubtless it will be considered by some that there is no necessity of a rule for putting in a cross-over track; that a trackman's eye is accurate enough. It is true that trackmen can line very accurately with the eye; but no matter how good and well trained the eye may be, if there be not something definite to start from, there cannot be correct lining done. It is impossible to continue the line of a frog to any degree of accuracy when there is nothing to guide the eye but the line of a frog, which is only four or five feet, and that often not straight nor well defined. So it becomes imperative to employ a rule in putting in a cross-over. The knowledge of the position of the second frog before lining the first frog will expedite the work, as it determines where the frog-timbers of the second frog are to be laid.

TABLES FOR THE ELEVATION OF THE OUTER RAIL ON CURVES.

The following tables, calculated by A. Mordecai, C.E., are intended to serve for the principal gauges used in this country, namely, 3 ft., 4 ft. 8½ in., 5 ft., and 6 ft. The proper elevation is calculated for nine different speeds, from 15 to 60 miles an hour, and for curves from 30 minutes to 35 degrees radius, for each gauge:*

* NOTE.—These tables are calculated from the formula $e = \frac{G V^2}{1\frac{1}{4} R}$, where e = elevation of outer rail, G = gauge of track, V = velocity of train in miles per hour, R = radius. The elevation of ½ an inch to a degree for roads of 4 ft. 8½ in. gauge, and ¾ of an inch for those of 6-ft. gauge, has proved to be a reasonable and safe elevation for the roads in this country. This is about an average of 30 miles per hour upon the curves ordinarily used.

TABLE FOR THE ELEVATION OF THE OUTER RAIL ON CURVES.

GAUGE, 3 FT.

Degree of Curvature.	RATE OF SPEED IN MILES PER HOUR.								
	15	20	25	30	35	40	45	50	60
	In.	In.	In.	In.	In.	In.	In.	In.	In.
30′	1/16	1/16	1/8	3/16	1/4	5/16	7/16	1/2	3/4
1° 00′	1/16	3/16	1/4	3/8	1/2	1 3/16	13/16	1	1 1/2
1° 30′	1/8	1/4	3/8	9/16	3/4	1	1 1/4	1 9/16	2 1/4
2° 00′	3/16	5/16	1/2	3/4	1	1 5/16	1 11/16	2 1/16	3
2° 30′	1/4	3/8	5/8	15/16	1 5/16	1 9/16	2 1/8	2 5/8	3 3/4
3° 00′	5/16	1/2	3/4	1 1/8	1 1/2	2	2 1/2	3 1/8	4 1/2
3° 30′	3/8	9/16	15/16	1 5/16	1 3/4	2 5/16	2 15/16	3 5/8	5 1/4
4° 00′	3/8	11/16	1	1 1/2	2 1/16	2 9/16	2 3/8	4 3/16	6
4° 30′	7/16	3/4	1 3/16	1 11/16	2 5/16	3	3 13/16	4 11/16	6 3/4
5° 00′	1/2	13/16	1 5/16	1 7/8	2 9/16	3 5/16	4 1/4	5 1/4	7 1/2
6° 00′	9/16	1	1 9/16	2 1/4	3 1/16	4	5 1/16	6 1/4	9
7° 00′	5/8	1 3/16	1 13/16	2 5/8	3 9/16	4 11/16	5 11/16	7 5/16	10 9/16
8° 00′	3/4	1 5/16	2 1/16	3	4 1/16	5 5/16	6 3/4	8 3/8	12 1/16
9° 00′	13/16	1 1/2	2 5/16	3 3/8	4 9/16	6	7 3/8	9 3/4	13 9/16
10° 00′	15/16	1 11/16	2 5/8	3 3/4	5 1/8	6 11/16	8 7/16	10 7/16	15 1/8
12° 00′	1 1/8	2	3 1/8	4 1/2					
15° 00′	1 3/8	2 1/2	3 7/8	5 5/8					
18° 00′	1 11/16	3	4 11/16	6 3/4					
20° 00′	1 7/8	3 5/16	5 3/8	7 1/2					
25° 00′	2 7/16	4 5/16	6 13/16	9 3/4					
30° 00′	2 3/4	4 15/16	7 3/4	11 3/16					
35° 00′	3 1/4	5 3/4	9	13					

Table for the Elevation of the Outer Rail on Curves.

GAUGE, 4 FT. 8½ IN.

Degree of Curvature.	Rate of Speed in Miles per Hour.								
	15	20	25	30	35	40	45	50	60
	In.	In.	In.	In.	In.	In.	In.	In.	In.
30′	1/16	1/8	3/16	1/4	3/8	1/2	11/16	13/16	1 1/8
1° 00′	1/8	1/4	7/16	5/8	11/16	1 1/16	1 5/16	1 5/8	2 3/8
1° 30′	3/16	3/8	5/8	7/8	1 3/16	1 9/16	2	2 1/2	3 1/2
2° 00′	5/16	1/2	13/16	1 1/8	1 5/8	2 1/8	2 11/16	3 1/4	4 5/8
2° 30′	3/8	11/16	1	1 1/2	2	2 11/16	3 5/16	4 1/16	5 15/16
3° 00′	7/16	13/16	1 1/4	1 3/4	2 7/16	3 3/8	4	4 15/16	7
3° 30′	1/2	15/16	1 7/16	2 1/16	2 13/16	3 11/16	4 5/8	5 3/4	8 5/16
4° 00′	9/16	1 1/16	1 5/8	2 3/8	3 1/4	4 3/16	5 5/16	6 4/16	9 7/16
4° 30′	11/16	1 3/16	1 7/8	2 5/8	3 5/8	4 11/16	6	7 3/8	10 9/16
5° 00′	3/4	1 5/16	2 1/16	3	4	5 1/4	6 5/8	8 3/16	11 7/8
6° 00′	7/8	1 9/16	2 7/16	3 1/2	4 13/16	6 5/16	8	9 7/8	14 1/16
7° 00′	1	1 7/8	2 7/8	4 3/8	5 5/8	7 3/8	9 1/4	11 1/2	16 1/2
8° 00′	1 3/16	2 1/8	3 5/16	4 11/16	6 7/16	8 3/8	10 5/8	13 1/8	18 7/8
9° 00′	1 5/16	2 3/8	3 11/16	5 5/16	7 1/4	9 7/16	11 15/16	14 3/4	21 5/16
10° 00′	1 1/2	2 5/8	4 1/8	5 7/8	8	10 1/2	13 1/4	16 3/8	23 1/2
12° 00′	1 3/4	3 1/8	4 15/16	7 1/16					
15° 00′	2 1/4	3 15/16	6 1/8	9 1/16					
18° 00′	2 11/16	4 11/16	7 3/8	10 9/16					
20° 00′	2 15/16	5 1/4	8 3/16	11 3/4					
25° 00′	3 13/16	6 13/16	10 5/8	15 5/16					
30° 00′	4 3/8	7 13/16	12 3/16	17 1/2					
35° 00′	5 1/16	9 1/16	14 1/4	20 5/16					

Table for the Elevation of the Outer Rail on Curves.

GAUGE, 5 FT.

Degree of Curvature.	RATE OF SPEED IN MILES PER HOUR.								
	15	20	25	30	35	40	45	50	60
	In.	In.	In.	In.	In.	In.	In.	In.	In.
30′	1/16	1/8	3/16	5/16	7/16	9/16	11/16	7/8	1 1/4
1° 00′	1/8	1/4	7/16	5/8	7/8	1 1/8	1 7/16	1 3/4	2 9/16
1° 30′	1/4	7/16	5/8	1	1 1/4	1 11/16	2 1/8	2 5/8	3 13/16
2° 00′	5/16	9/16	7/8	1 1/4	1 11/16	2 1/4	2 13/16	3 1/2	5 1/4
2° 30′	3/8	11/16	1 1/16	1 5/8	2 1/8	2 13/16	3 1/2	4 3/8	6 3/8
3° 00′	1/2	7/8	1 5/16	1 15/16	2 9/16	3 3/8	4 1/4	5 1/4	7 11/16
3° 30′	9/16	1	1 1/2	2 3/16	3	3 15/16	5	6 1/4	8 13/16
4° 00′	5/8	1 1/8	1 3/4	2 1/2	3 3/8	4 1/2	5 5/8	7	10 1/16
4° 30′	11/16	1 1/4	2	2 13/16	3 13/16	5 1/16	6 3/8	7 7/8	11 3/8
5° 00′	13/16	1 3/8	2 3/16	3 3/16	4 1/4	5 5/8	7 1/16	8 3/4	12 5/8
6° 00′	15/16	1 11/16	2 5/8	3 13/16	5 1/8	6 3/4	8 1/2	10 1/2	15 3/16
7° 00′	1 1/8	2	3 1/16	4 7/16	6	7 13/16	9 7/8	12 1/4	17 3/4
8° 00′	1 1/4	2 1/4	3 1/2	5 1/16	6 13/16	9	11 5/16	14	20 5/16
9° 00′	1 7/16	2 1/2	3 15/16	5 5/8	7 11/16	10 1/16	12 11/16	15 11/16	22 9/16
10° 00′	1 9/16	2 13/16	4 3/8	6 1/4	8 1/2	11 3/16	14 1/4	17 7/16	25 1/4
12° 00′	1 7/8	2 3/8	5 1/4	7 1/2					
15° 00′	2 3/8	4 3/16	6 1/2	9 3/8					
18° 00′	2 13/16	5	7 13/16	11 1/4					
20° 00′	3 1/4	5 9/16	8 11/16	12 1/2					
25° 00′	4 1/16	7 1/4	11 5/16	16 5/16					
30° 00′	4 11/16	8 1/4	12 15/16	18 5/8					
35° 00′	5 7/16	9 5/8	15	21 5/8					

Table for the Elevation of the Outer Rail on Curves.

GAUGE, 6 FT.

Degree of Curvature.	RATE OF SPEED IN MILES PER HOUR.								
	15	20	25	30	35	40	45	50	60
	In.	In.	In.	In.	In.	In.	In.	In.	In.
30′	1/16	1/8	1/4	3/8	1/2	11/16	7/8	1 1/16	1 1/2
1° 00′	3/16	3/8	1/2	3/4	1	1 3/8	1 11/16	2 1/16	3
1° 30′	5/16	1/2	3/4	1 1/8	1 1/2	2	2 9/16	3 1/8	4 1/2
2° 00′	3/8	11/16	1	1 1/2	2 1/16	2 11/16	3 3/8	4 3/16	6 1/16
2° 30′	1/2	13/16	1 5/16	1 7/8	2 9/16	3 3/8	4 1/4	5 1/4	7 1/2
3° 00′	9/16	1	1 1/2	2 1/4	3 1/16	4	5 1/16	6 1/4	9 1/16
3° 30′	11/16	1 3/16	1 7/8	2 5/8	3 9/16	4 11/16	5 15/16	7 5/16	10 1/2
4° 00′	3/4	1 3/8	2 1/16	3	4 1/8	5 3/8	6 13/16	8 3/8	12 1/16
4° 30′	7/8	1 1/2	2 3/8	3 3/8	4 5/8	6	7 5/8	9 7/16	13 9/16
5° 00′	15/16	1 11/16	2 5/8	3 3/4	5 1/8	6 11/16	8 1/2	10 1/2	15 1/16
6° 00′	1 1/8	2	3 1/8	4 1/2	6 3/16	8 1/16	10 3/16	12 9/16	18 1/16
7° 00′	1 5/16	2 3/8	3 11/16	5 1/4	7 3/16	9 3/8	11 7/8	14 11/16	21 1/8
8° 00′	1 1/2	2 11/16	4 3/16	6	8 1/8	10 11/16	13 9/16	16 3/4	24 1/8
9° 00′	1 11/16	3	4 11/16	6 3/4	9 3/16	12 1/16	15 1/4	18 13/16	27 1/8
10° 00′	1 7/8	3 3/8	5 1/4	7 1/2	10 1/4	13 3/8	16 15/16	20 15/16	30 1/4
12° 00′	2 1/4	4	6 1/4	9					
15° 00′	2 13/16	5	7 13/16	11 1/4					
18° 00′	3 3/8	6	9 3/8	13 1/2					
20° 00′	3 3/4	6 11/16	10 3/8	15					
25° 00′	4 7/8	8 11/16	13 5/8	19 9/16					
30° 00′	5 9/16	9 15/16	15 1/2	22 3/8					
35° 00′	6 1/2	11 1/2	18	26					

To show the French rule for elevating the outer rail, the following table has been compiled from a more extended one given in a work by M. H. Sabin, called "Manuel Pratique des Poseurs de Voies de Chemins de Fer" (Railroad Tracklayer's Practical Manual):

Radius in Metres.	Degree of Curvature.	RATE OF SPEED IN MILES PER HOUR.				
		19	31	37	43	50
		In.	In.	In.	In.	In.
3,500	30′	$\frac{1}{8}$	$\frac{5}{16}$	$\frac{1}{2}$	$\frac{11}{16}$	$\frac{7}{8}$
1,800	58′	$\frac{4}{16}$	$\frac{5}{8}$	$\frac{15}{16}$	$1\frac{1}{4}$	$1\frac{11}{16}$
1,200	1° 28′	$\frac{3}{8}$	1	$1\frac{3}{8}$	$1\frac{7}{8}$	$2\frac{1}{2}$
900	1° 55′	$\frac{1}{2}$	$1\frac{5}{16}$	$1\frac{7}{8}$	$2\frac{1}{2}$	$3\frac{5}{16}$
600	2° 55′	$\frac{11}{16}$	$1\frac{15}{16}$	$2\frac{13}{16}$	$3\frac{13}{16}$	$4\frac{15}{16}$
500	3° 30′	$\frac{13}{16}$	$2\frac{5}{16}$	$3\frac{3}{8}$	$4\frac{9}{16}$	$5\frac{15}{16}$
450	3° 55′	$\frac{7}{8}$	$2\frac{9}{16}$	$3\frac{11}{16}$	$5\frac{1}{16}$	$6\frac{9}{16}$
400	4° 20′	$1\frac{1}{16}$	$2\frac{15}{16}$	$4\frac{3}{16}$	$5\frac{3}{4}$	$7\frac{5}{16}$
350	5° 00′	$1\frac{3}{16}$	$3\frac{5}{16}$	$4\frac{3}{4}$	$6\frac{1}{2}$	$8\frac{1}{2}$
300	5° 50′	$1\frac{3}{8}$	$3\frac{7}{8}$	$5\frac{5}{8}$	$7\frac{9}{16}$	$9\frac{15}{16}$

TABLE

For Determining the Degree of Curvature and the Elevation of the Outer Rail, by Versed Sine of 43-foot Chords. Gauge, 4 feet 8 1-2 inches.

Radius.	Degree of Curve.	Centre Distance to the Rail from 43-foot Chord, or Elevation in ins.	Radius.	Degree of Curve.	Centre Distance to the Rail from 43-foot Chord, or Elevation, in in.
5730	1° 0′	½ in.	1146	5° 0′	2½ in.
3820	1° 30′	¾ "	1042	5° 30′	2¾ "
2865	2° 0′	1 "	955	6° 0′	3 "
2292	2° 30′	1½ "	882	6° 30′	3¼ "
1910	3° 0′	1½ "	819	7° 0′	3½ "
1637	3° 30′	1¾ "	764	7° 30′	3¾ "
1433	4° 0′	2 "	717	8° 0′	4 "
1273	4° 30′	2¼ "			

NOTE.—Select a part of the curve in good alignment, and take two points 43 feet apart on the inside of the outer rail. Measure the distance from the middle of a line connecting the points to the rail, and this distance will give the required elevation; it will also show the degree of curvature according to the table. It is well to take two or more observations.

One-half of the elevation in the above table is to be used in yards and sidings.

For a 6-feet gauge the proper elevation is ¾ in. per degree of curvature. This will be given by the middle ordinate to a chord of 53 feet, instead of 43 feet, as above.

For a 3-feet gauge the proper elevation is ⅜ in. per degree of curvature. This will be given by the middle ordinate to a chord of 37½ feet.

For a 5-feet gauge the elevation should be somewhat greater than for a 4 feet 8½ in. gauge, and the chord may be taken 45 feet long.

BILLS FOR FROG AND SWITCH TIMBERS—GAUGE SIX FEET.

A FROG—SINGLE-THROW. ANGLE 1 TO 9.					B FROG—SINGLE-THROW. ANGLE 1 TO 7.				
No. of set.	No. of pieces.	Length.	Size.	REMARKS.	No. of set.	No. of pieces.	Length.	Size.	REMARKS.
1	1	16′	8″×12″	Head-block.	1	1	16′	8″×12″	Head-block.
2	4	10′ 6″	7″× 9″		2	3	10′ 6″	7″× 9″	
3	4	11′	"		3	3	11′	"	
4	4	11′ 6″	"		4	3	11′ 6″	"	
5	4	12′	"		5	3	12′	"	
6	4	12′ 6″	"		6	3	12′ 6″	"	
7	4	13′	"		7	3	13′	"	
8	4	13′ 6″	"		8	3	13′ 6″	"	
9	4	14′	"		9	3	14′	"	
10	2	14′ 6″	"		10	3	14′ 6″	"	
11	2	15′	"		11	3	15′	"	
12	2	15′ 6″	"		12	3	15′ 6″	"	
13	1	16′	"		13	2	16′	8″×10″	} Frog-timbers.
14	2	16′	8″×10″	} Frog-timbers.	14	2	16′ 6″	"	
15	2	16′ 6″	"		15	2	17′	7″× 9″	
16	2	17′	7″× 9″		16	2	17′ 6″	"	
17	2	17′ 6″	"						
	48					42			

BILLS FOR FROG AND SWITCH TIMBERS—GAUGE SIX FEET.

AA FROG—SINGLE-THROW. ANGLE 1 TO 11.

No. of set.	No. of pieces.	Length.	Size.	REMARKS.
1	1	16′	8″ × 12″	Head-block.
2	5	10′ 6″	7″ × 9″	
3	5	11′	"	
4	5	11′ 6″	"	
5	5	12′	"	
6	5	12′ 6″	"	
7	4	13′	"	
8	4	13′ 6″	"	
9	4	14′	"	
10	4	14′ 6″	"	
11	4	15′	"	
12	3	15′ 6″	"	
13	1	16′	"	
14	2	16′	8″ × 10″	Frog-timbers.
15	3	16′ 6″	"	
16	2	17′	7″ × 9″	
17	2	17′ 6″	"	
	59			

AA FROG—THREE-THROW. ANGLE 1 TO 11.

No. of set.	No. of pieces.	Length.	Size.	REMARKS.
1	1	16′	8″ × 12″	Head-block.
2	3	11′ 6″	7″ × 9″	
3	3	12′	"	
4	3	12′ 6″	"	
5	3	13′	"	
6	3	13′ 6″	"	
7	4	14′	"	
8	4	14′ 6″	"	
9	4	15′	"	
10	4	15′ 6″	"	
11	4	16′	"	
12	4	16′ 6″	"	Crotch-frog.
13	4	17′ 6″	"	
14	4	18′ 6″	"	
15	2	19′ 6″	"	
16	2	20′	"	
17	3	21′	8″ × 10″	Frog-timbers.
18	2	22′	"	
19	2	23′	7″ × 9″	
20	2	24′	"	
	61			

BILLS OF TIMBER FOR SWITCHES.

Gauges of 4 feet 8½ inches, 4 feet 9¼ inches, 4 feet 10 inches, or 5 feet.

A FROG—SINGLE-THROW. 1 TO 9.					B FROG—SINGLE-THROW. 1 TO 7.				
No. of set.	No. of pieces.	Length.	Size.	REMARKS.	No. of set.	No. of pieces.	Length.	Size.	REMARKS.
1	1	16′	8″×12″	Head-block.	1	1	16′	8″×12″	Head-block.
2	7	9′ 6″	7″× 9″		2	4	9′ 6″	7″× 9″	
3	5	10′	"		3	4	10′	"	
4	4	10′ 6″	"		4	4	10′ 6″	"	
5	4	11′	"		5	2	11′	"	
6	3	11′ 6″	"		6	2	11′ 6″	"	
7	2	12′	"		7	2	12′	"	
8	2	12′ 6″	"		8	2	12′ 6″	"	
9	2	13′	"		9	2	13′	"	
10	2	13′ 6″	8″×10″	Frog-timbers.	10	2	13′ 6″	8″×10″	Frog-timbers.
11	2	14′	"		11	2	14′	"	
12	2	14′ 6″	7″× 9″		12	2	14′ 6″	7″× 9″	
13	2	15′	"		13	2	15′	"	
	38					31			

BILLS OF TIMBER FOR SWITCHES.

Gauges of 4 feet 8½ inches, 4 feet 9¼ inches, 4 feet 10 inches, and 5 feet.

AA FROG—THREE-THROW. 1 TO 11.					AA FROG—SINGLE-THROW. 1 TO 11.				
No. of set.	No. of pieces.	Length.	Size.	REMARKS.	No. of set.	No. of pieces.	Length.	Size.	REMARKS.
1	1	16′	8″×12″	Head-block.	1	1	16′	8″×12″	Head-block.
2	4	10′	7″× 9″		2	5	9′ 6″	7″× 9″	
3	4	10′ 6″	"		3	6	10′	"	
4	4	11′ 6″	"		4	4	10′ 6″	"	
5	4	12′ 6″	"		5	4	11′	"	
6	4	13′ 6″	"		6	4	11′ 6″	"	
7	4	14′ 6″	"	Crotch-frog comes here.	7	4	12′	"	
8	4	15′ 6″	"		8	4	12′ 6″	"	
9	4	16′ 6″	"		9	4	13′	"	
10	2	17′ 6″	"		10	1	13′ 6″	"	
11	2	18′	"		11	2	13′ 6″	8″×10″	} Frog-timbers.
12	3	19′	8″×10″	} Frog-timbers.	12	3	14′	"	
13	2	20′	"		13	2	14′ 6″	7″× 9″	
14	2	21′	7″× 9″		14	2	15′	"	
15	2	22′	"						
	46					46			

APPENDIX I.

RULES FOR THE GOVERNMENT OF TRACK AND BRIDGE REPAIRERS, ADOPTED FOR THE ATLANTIC & GREAT WESTERN RAILROAD.

1. *Condition of Engagement.*—Before any laborer or foreman is employed he must be made to understand that the wilful transgression of any of these rules will be met with prompt punishment. Any insubordination, drunkenness, being found off duty during working hours, or the commission or omission of any act whereby engines or trains shall or might be endangered, will be punished by dismissal.

No Employce to be discharged without Cause.—No employee, whether foreman or laborer, shall be discharged without sufficient cause, and never for the purpose of making room for other parties.

2. *Must always have Time-Table.*—Section-foremen and foremen of bridge repairs must have a copy of the time-table for the moving of trains always with them when on duty, and must understand its use and know the time of all trains at the point of their work.

3. *Track-Walker.*—An experienced man must

pass over each section every morning—on foot—and see that the track is in a safe condition; and he will especially look at each frog, switch, and switch-lock, and all culverts and cattle-guards, and know that each is in perfect order for the moving of trains. He will also examine each bridge and see that all the nuts are in place, and, if loose or off the rods, will report the fact at once by telegraph to the Superintendent of Bridges and the nearest bridge foreman.

4. Track and bridge foremen will be held responsible for the men under their charge, and must be satisfied of the competency of each man for the work under his charge.

5. *Trains carrying Signals, etc.*—Track and bridge repairers while on duty must watch every train as it passes, and observe whether notices are thrown off, or whether signal-flags or lamps are exhibited on the engine, denoting that a special train is following. Under the present system of running trains by telegraph, it is necessary to be prepared at all times for special or irregular trains.

6. *Signals to be used.*—The signals to be used by track and bridge repairers are red and bi-colored (combined red and white) flags, red lamps, and torpedoes (to be used in case of fogs or storms, when flag and lamp signals are liable to be obscure). Red flags by day and red lamps by night. The bi-colored flag signifies

caution and the red danger. Such signals must be sent half a mile, or 16 telegraph poles, in each direction from the place of danger, and must be waved across the track on the approach of trains. Foremen of track and bridge repairers will see that each gang of workingmen have the signals always with them when at work.

Red Shirts not to be worn.—Track-men must not wear red shirts as outer garments, as they are frequently mistaken for danger signals.

Danger Signals.—Whenever it is necessary to exhibit a danger signal, it should be waved high in the air.

☞ Torpedoes must also be carried by the track and bridge men, and when the track is obstructed during fogs or storms by night or day, in addition to all other signals, at least two torpedoes shall be placed upon the rails 16 telegraph poles from the place of danger.

7. *Doing Work that will make the Track unsafe.*—Whenever it is necessary to remove or replace a rail in the track, or to repair a bridge, culvert, or cattle-guard, or in the event of any cause by which the track is rendered unsafe, a red signal must be placed conspicuously at a distance of not less than half a mile, or 16 telegraph poles, in each direction, by men sent out expressly (even when no train is due), and the signal shall be exhibited until the track is known to be clear. And in case a curve or the summit of a

grade shall be near the point of half a mile, signals must be sent further, so as to be entirely safe. A man must invariably be with the signal, and remain with it until he receives orders to return.

8. *Work on Sunday.*—When it is necessary to make any repairs to the track, or any bridge that will cause an obstruction of the track, and it cannot be done between trains, such work must be done (in cases of absolute necessity) on Sunday, and the road-master or bridge superintendent will notify the Chief Engineer at least three days before the day on which the work is to be done, and the track must not be disturbed or rendered unsafe until permission has been given.

9. *No Work to be done during Fog or Snow or Rain Storms.*—In no case, except where there is absolute necessity, is any work to be performed *during a fog or snow-storm* by which an obstruction may be caused to the passage of trains.

10. *Failure of Train Men to regard Signals.*—Section foremen and foremen of bridge-repairers will report the failure of train-men to respect a signal at once to their immediate superior, giving the number of the train and the number of the engine.

11. *Section-Foremen to be on Duty during Storms.*—During heavy storms of rain, snow, or hail, whether by day or night, whereby the

works may be liable to sudden injury, section foremen must be on duty; and immediately after the abatement of the storm, or, if necessary, during its continuance, they must go over their sections with danger signals and an axe for the purpose of ascertaining if the track is safe for the passage of trains and to remove all obstructions. The points on the sections most liable to injury are to be first visited. In case of heavy winds, they must be sure that no trees or telegraph poles have been blown across the track.

12. *Reporting Accidents.* — Section foremen must report all accidents occurring on their sections, by telegram, to the road-master and Chief Engineer as soon as possible, giving the nature of the accident. On the same day they must send a written report of the accident to the road-master.

13. *Keeping Highway Crossings in Repair.*— Section foremen will see that highway and farm crossings are kept in the best possible repair and not obstructed by any material, and will in no case have hand or repair cars on highway crossings unnecessarily interfere with the proper use of any crossing.

14. *Examining the Foundation of Bridges, etc.*— Section foremen and foremen of bridge repairs must examine particularly the foundation of all bridges, culverts, and cattle-guards, and prevent

all washing or undermining, and see that the openings are kept clear of driftwood and old ties. They shall also remove all combustible material from the vicinity of the bridge, and see that all necessary appliances for preventing fire are prepared.

15. *No Timber, Wood, Cross-Ties, etc., to be piled within six feet of the Track.*—Whenever wood, cross-ties, lumber, or other material is piled along the track, notice must be taken by track-men that it is at least six feet from the rail; and should any such material be found nearer, they shall at once remove it to the proper distance; nor shall signal post or board be placed nearer the rail than six feet.

16. *Hand-Cars not in actual use to be removed from the Track.*—When hand or repair cars are not in actual use they must be lifted off the track and placed entirely clear of passing trains, and, when not under the immediate eye of the men, must be locked; and no hand or repair car will be used on the track without orders from the section foreman.

17. *Must not carry Rails on Hand-Cars.*—Iron rails must not be carried on hand-cars, except in cases of emergency.

18. *Hand-Cars not to be used on Sunday*—No hand-cars must be used on Sundays or nights, except in cases of necessity, and then only by the authority of the section foreman; and under

no circumstances must they be used except on company business.

19. *Use of Hand-Cars, etc., at Night and during Fogs and Snow-Storms.*—Great care must be exercised when it is necessary to use hand or repair cars in case of fogs or snow-storms or in the night, and the section foreman must be with it. In no case must a hand or repair car be attached to a train when in motion.

20. *Ascertaining what Trains have passed before going to Work in the Morning.*—Section foremen will ascertain, if possible, before going out to their work in the morning from the station agents or telegraph operators whether all regular trains have passed, or whether any special trains are on the road, but in no case shall the men be delayed by waiting for information.

21. *Section Foremen responsible for the safe condition of the Fences.*—Section foremen will be held responsible for the safe condition of the fences joining the railroad grounds, and, in case of a temporary break, will at once repair it. They will also use due diligence to keep all farm or other gates closed, and will instruct their men to see this always attended to. Road-masters will see that each section is supplied with material, such as nails, boards, and rails, to make all temporary repairs.

22. *Section Foremen responsible for the Tools and Material in their charge. Disposition of*

Scrap, etc.—Section foremen will be held responsible for all tools and materials left in their charge, and must report the loss or destruction of the same to the road-master; and under no circumstances will they be permitted to lend the tools or materials of the company to any person. All unused spikes, chairs, fish-plates, bolts, or other light material must be taken each day to the car-houses; and all scrap rails must be piled upon rough platforms, placed as much as possible in straight lines, and near sidings, and assorted. And they must pick up each day any material lost from cars or engines—such as car-doors, brakes, bolts, nuts, and small scrap, or other property belonging to the company—and take it to the car-houses, where it will be assorted and shipped to the scrap depots on the first and third Mondays of each month. And any packages or articles of freight that may fall from any train must be taken to the station agents, who will report the same to the General Freight Agent.

23. *Damage to Persons.*—In case of accident to any person or persons caused by the operations of this road, an immediate report must be made by telegraph to the Chief Engineer and road-master, so that all persons whose duty it is to take action in such matter can be notified; and in case of an accident causing *death*, the coroner must also be summoned by the nearest employee,

should it not be possible for the road-master, foreman, or other person in charge to do so.

24. *Damage to Live Stock.*—Whenever cattle, horses, sheep, or hogs are killed by a train, a cattle report must be made out and forwarded to the road-master at once.

25. *Repairing the Telegraph Wire.*—Track-men will notice any temporary injury to the telegraph line, poles or wire, and will report the same at once to the nearest station agent, to be forwarded to the proper officer, and, when the injury can be substantially or temporarily repaired by themselves, will do so without delay.

26. *Shanties.*—Section-foremen will see that track-men who have shanties or houses on the company's right of way keep the same in reasonable repair and the grounds clear of rubbish. No one will be allowed to build a new shanty, remove an old one, or build any addition without the consent of the Chief Engineer.

27. *Old Ties renewed.*—No cross-tie should be removed until it has had its full life. All old ties which may be removed must be gathered at the close of each day and put in some convenient place for burning.

28. *Employing additional Men.*—No additional labor must be employed by a section-foreman without the consent of the road-master.

29. *Section Foremen must be with their Men.*—

Section foremen are expected to be with their men and to assist in all work in which they may be engaged. They will keep an accurate account of the time of their men, and the distribution of the labor, in their time-books, returning time only for the amount of work performed. In case of injury of any of their men they will continue his name on the pay-roll, noting in writing the number of idle days consequent upon the injury.

30. *Guaranteeing Board-Bills.*—No one except the Chief Engineer will be authorized to guarantee board-bills for laborers.

31. *Foremen must be respectful to Farmers, etc.*—Section foremen must, in all cases, be civil and respectful to the farmers and patrons of the road along the line, and must instruct their men to be obliging and accommodating in all cases. They must treat the men under their charge with the consideration due to men, and in no case use profane and abusive language towards them.

32. *Making Presents not permitted.*—As the practice of making presents to foremen and officers of the company is neither reputable nor conducive to good discipline, all employees of the engineering department are earnestly requested and are required to refrain from offering presents or testimonials to their superiors, directly or indirectly.

33. *Receiving Bribes or Gifts.*—It will be considered criminal for any employee to take a commission or bribe, or receive a consideration, for any position or favor granted to any subordinate.

34. *Cleanliness.*—The observance of the foregoing rules is strictly enjoined upon the employees of the engineering department, and it is hoped that in carrying out the most essential part of their duty, the maintenance of a good track, they will not fail to take proper care of the property of the company, and keep the right of way and depot grounds clean and neat. An untidy section will be considered as evidence of an incompetent foreman.

35. *Replacing Iron Rails.*—All rails and parts of rails *that are fit* for use, purchased and laid since   shall be kept together, not moved from section to section, nor sent in as scrap until specially ordered, so that the full life of each make can be ascertained.

36. *All Joints to be fully Bolted.*—Road-masters and section foremen will see that all joints are fully bolted. Where this is not the case, owing to improper punching, the compromise fish-plate must be substituted for the old ones, and, in case these should not fit, new holes must be drilled.

37. *Split Switches must be used on Main Line.*—Split switches or points are, in all cases, to be

used on the main line. Wherever other kinds are in use their places should be supplied with split switches as soon as practicable.

38. *Cutting Grass and Weeds.*—Weeds and grass growing on the right of way must be cut before seed-time, and collected and burned as promptly as possible.

39. *Cultivating the Right of Way.*—Road-masters will permit section foremen and laborers to cultivate the land lying between the boundaries of the right of way.

40. *No one allowed to occupy a Shanty without paying Rent.*—No one must be allowed to occupy a company shanty without permission of the road-master nor without paying rent, and the road-master must notify the Chief Engineer of all changes.

41. *Reporting Burnt Fences.*—An immediate report by telegraph must be made to the Chief Engineer of all fences burned, stating mile-post, number of rods burned, and the cause.

42. *Road-Masters must inspect their Track.*—The divisions on the road have been sub-divided into lengths of about 50 miles each, to enable road-masters to *walk* over them, and it is expected they will not fail to fulfil this important duty.

43. *Smoking on Duty.*—Smoking while on duty must not be allowed.

44. When a foreman is about quitting the ser-

vice of the railroad, the road-master must see that all tools and other property belonging to the company committed to his charge are properly accounted for, and also examine his time-book to see that all accounts are straight, and to get full explanations where needed.

45. Whenever any building or structure of any kind is being placed upon the property of the company by other than the company's men, the fact should be at once reported to the Chief Engineer, unless it is positively known that proper authority has been obtained.

GENERAL INSTRUCTIONS TO BE FOLLOWED IN THE MAINTENANCE OF TRACK.

Ditching.—Where the cuts will admit, all ditches must be made to conform to the following diagram:

Fig. 1.
The dotted portion of above diagram indicates the ballast.

All old ditches should be cleaned and all new ones dug by October 1 of each year.

Ballasting.—At places where the ballast is very thin or where there is none at all, the filling between the ties should be sloped from the centre to the bottom of the ends of the ties.

Where there is an abundance of ballast, shoulder out, from two inches of the top of the tie to two inches above the bottom of the tie, as far as the material will go, without obstructing the ditches. See Fig. 1. In all cases the ballast should be two inches above the top of the tie at the centre.

Raising Track.—The object should always be to get a good solid bearing for the cross-ties on a gravel bed, and, when once obtained, the ties should not be raised until a new bed of gravel is required.

Quality of Cross-Ties.—The best quality of ties must be used for the main track—white oak to rank first, cherry and chestnut respectively second and third. Where there is an abundance, white oak only must be used on main line. No hemlock ties will be allowed in the main track.

Distribution of Cross-Ties.—Cross-ties must be distributed over the different sections during the winter months, in time to be put in the track in the spring.

Lining Ties.—The ends of the ties must be lined on the south side of the track, because:

1st. That symmetry may be preserved.

2d. That, the surface being uniform, the road-bed will thaw equally in the spring.

Wooden Spikes.—Every foreman must keep a supply of wooden spikes in his hand-car house, and with his gang while on work, and the invariable rule must be to plug every hole wherever a spike is drawn. Arrangements have been made by which each section can be supplied, and road-masters will see that none is without them.

Elevating Curves.—Get the full elevation of the outside rail at point of curve. For this purpose, and to insure smoothness where trains strike the curves, the elevation should commence back on the tangents and continue gradually as follows:

For a 1° curve, 50 feet back on the tangent,
For a 2° " 100 " " "
For a 3° " 150 " " "

and so on, increasing 50 feet for each degree of curvature.

To determine the elevation of the outer rail on curves, stretch a line between two points 54 feet apart, on the running side of the outer rail, and the distance from the centre of this line to the rail will give the elevation required. For 4 ft. 9¼ in. gauge use a line 45 feet long.

Foul Switches.—In order to prevent foul joints at switches, the switch-rods should be confined between two ties laid three inches apart. This precaution is not rendered necessary in split switches, as the rods are secured to the rail by small bolts.

INSTRUCTIONS FOR TRACK-LAYING.

I.—Receiving Iron.—All rails, as they are received by the road-masters, must be carefully counted and measured, and an accurate statement made to the Chief Engineer daily of the receipts, stating the following:

1. Number of car load.
2. Initial of car and number.
3. Number of rails.
4. Length of rails.
5. Weight of rails per yard.
6. Height of rails.
7. Marks on rails.
8. Place of shipment.
9. Date of way-bill and number.
10. Place of receipt.
11. Condition of the rails.

II.—Unloading.—No rails must be unloaded while the cars are in motion. The distribution of bars must be made over the section by the section iron-cars.

III.—Surfacing Old Track preparatory to Laying new Iron.—Before laying the iron the track must be surfaced, so that the new iron will not be battered and bent. Old rotten ties must be removed and others put in, and all ties must be laid or brought at right angles to the track. No tie must be laid obliquely to suit two joints not exactly opposite each other.

IV.—Adzing Ties.—The ties must be adzed, if necessary, in order to obtain a true and uniform bearing for the base of the rail, and in order that the tread of the wheel may have a fair bearing.

V.—Spacing Ties.—In all new work the ties must be uniformly spaced, and on surfacing old work any improper spacing must be corrected. The best ties must be placed at the joints, and the ties next to the joints must be, as near as may be, of uniform size.

VI.—Gauges.—Road-masters will see that their gauges are exactly correct by standard in engineer's office before laying track.

VII.—Crooked Rails.—All crooked rails must be straightened before they are laid in the track.

VIII.—Curves.—All rails for curves must be curved before being placed in the track, according to table No. 6.

IX.—Shims.—Iron shims must always be used in laying track. Supervisors must keep themselves provided with them. Wooden chips will not do. Shims are to be used with greatest expansion of 3/8 in., mediums of 1/4 in. or 1/8 in., and least of 1/16 of an inch. In the coldest weather use the 3/8 in., at freezing point 1/4 in., at 70° 1/8 in., and in very hot weather use 1/16 in. This may be modified by grades, irregularity of surface, or bad line when first laid.

X.—Laying the Rails.—The rails must be laid even joints—that is, with the joints opposite; but if, in laying around curves, they do not come exactly opposite, the iron must not be cut, but shorter or longer rails must be used until the joints are brought opposite. Space for expansion of rails must not be used to lengthen out the outer rail. In case bevelled rails are furnished, lay them with the bevel towards the centre of track.

XI.—Lining Track.—When the iron is laid it must be perfectly lined. No imperfections in the alignment will be permitted.

XII.—Level and Elevation on Curves.—The track must be brought to a perfect level on straight lines with a track-level; and on curves, for each degree elevate the outer rail one-half an inch on track of standard gauge (4 ft. 8½ in.); for six-foot gauge use three-quarters of an inch. Table No. 7.

XIII.—Gauge.—The track must be laid to a perfect gauge.

XIV.—Step-Chairs.—All rails laid adjoining others of different heights must have a step-chair to bring the tops of the rails to an equal height.

XV.—Different Punching.—All rails joined to others of different punching must have fish-plates made to fit the different patterns of irons.

XVI.—Spiking.—All rails must be spiked full—two spikes to each tie; and every spike must be driven perpendicularly and close home, with a full hold upon the rail.

XVII.—Spiking in Slots.—The slot-spikes must be driven into their proper places. In cold weather place them against the side of the slot nearest the end of the rail; in hot weather, the contrary.

XVIII.—Marking Beginning and Ending Points of New Rails.—Place a painted stake (red), marked with a white letter indicating the kind of rail laid, at the beginning and terminal points of each lot, with the date of laying, so that the exact wear of the iron may be ascertained.

XIX.—Investigation.—Road-masters will make careful investigation into the wear of the rails, fish-plates, spikes, bolts, washers, and ties, and encourage their foremen to investigate and examine and make reports and suggestions frequently.

XX.—Frogs and Switches.—In putting in frogs and switches the exact distance from head-block to point of frog must be observed, according to tables Nos. 1 and 2. Cut always to get proper distance.

XXI.—Same Pattern of Rails to be Kept Together.—In laying the new iron you will use the old rails that are good to repair track with the same pattern of rails, so that each kind may be kept together.

XXII.—Road-masters will use the appliance furnished them in determining the degree of curvature and the amount of elevation of the outside rail

APPENDIX II.

RULES AND INSTRUCTIONS FOR THE GOVERNMENT OF TRACK-MEN ON THE LOUISVILLE & NASHVILLE AND SOUTH & NORTH ALABAMA RAILROADS.

FOR SECTION FOREMEN.

DITCHING.

1. *Shape and Drainage.*—In determining the shape and depth of all ditches at the highest point, where the grade of the ditch begins, section foremen must be guided by the standard diagram. The ditches must be graded so as to pass all water freely during the heaviest rains, and to thoroughly drain the road-bed.

2. *Direction.*—The direction of ditches must in general be parallel with the rails, and the outlines of them must be well and clearly defined.

3. *Cross-Drains.*—Cross-drains must be put in wherever they are necessary.

4. *Disposition of Earth.*—All earth taken from ditches or elsewhere must be dumped over the banks and levelled off so as to allow complete drainage of water from under the cross ties.

5. *Frequent Examination.* — Ditches, box-drains, and culverts must be often inspected and cleared of all obstructions. Masonry which has been washed or undermined must receive prompt attention, and serious cases reported to the supervisor or road-master.

6. *Neighboring Streams.* — Channels and streams for a considerable distance to the right and left of the road must also be frequently examined and cleared of brush, drift, and other movable obstructions.

7. *Cleaned for Winter.*—It is expected that all new ditches will be dug and all old ones cleaned for the winter season by the first day of November of each year.

BALLAST.

8. *Earth-filling.*—At places where the ballast is very thin, or where there is none at all, the filling between the ties must be sloped from the centre of the track to the bottom ends of the cross-ties.

Thickness of Stratum of Gravel.—The height of gravel ballast in the centre of the track should be two (2) inches above the top of the tie. When gravel is abundant it may be left two (2) inches below the base of rail at the ends of the cross-ties, and then extended out on a slope without obstructing the side-ditches.

9. *Preparation of Sub-Grade.*—Before distribut-

ing any kind of ballast, whether rock or gravel, the sub-grade must be properly prepared and banks widened, so that none of the ballast is wasted or washed away.

10. *Size of Rock Ballast.—Rock ballast* must be broken evenly in pieces which can be passed through a ring two (2) inches in diameter.

11. *Thickness of Rock Ballast.*—There should be a uniform depth of twelve (12) inches of clear fine broken stone *under the ties.* The ballast must be filled up evenly between but *never above the ties.* Six (6) inches from the ends of the cross-ties the ballast must be sloped evenly at the rate of 1 to 1 to sub-grade.

12. *Filling between Main Track and Sidings.*—Between main track and sidings large, coarse stones may be placed at the bottom, but not at the ends of the cross-ties.

13. *Gravel and Rock Ballast used together.*—Wherever gravel is within payable hauling distance it must be used to the depth of four (4) inches under the cross-ties, upon a stratum of fine broken rock ballast eight (8) inches deep. The filling between the ties, sloping from the centre toward the ends, as above specified, should be of clear or screened gravel.

14. *Purpose of Ballast.*—The object of ballast is to transfer the applied load over a large surface, to hold the cross-ties firmly in a horizontal position, to prevent freezing in winter, to carry

off water during rains, and to give elasticity to the road-bed. The material in all cases should be clear and hard, so as not to pack in a solid mass and thus prevent the passage of water away from the track. The aim should be to get a good solid bearing for the cross-ties on a bed of gravel or finely-broken rock uniform throughout; and when once obtained the cross-ties must not be raised until a new bed of gravel or stone is required.

CROSS-TIES.

15. *Specifications.*—The best quality of cross-ties must be used for the main track; all to be of post or white oak, perfectly sound and straight. With rock or gravel ballast the size is to be 6 in. × 8 in. by 8½ feet long. On those parts of the line where ballast is not to be obtained the size of the cross-ties should be 7 in. × 9 in. by 9 feet long. In all cases they must be hewed to the exact thickness, with parallel faces throughout, and both bark and sap-wood entirely removed.

Sawed cross-ties must only be used where it is impossible to get the required number of hewed ones.

16. *Spacing and Choice of Ties.*—In all new work the cross-ties must be uniformly spaced, and while surfacing old work any previous improper spacing must be corrected. The largest

and best ties, if there is any variation in width, are to be placed at joints, and the ties next to the joints should be as nearly as possible of the same size.

17. *Ties with Suspended and Supported Joints.*—Where suspended joint with flange splice is used the proper spacing of ties is sixteen (16) inches in the clear between the edges of timber for intermediate ties, and ten (10) inches in the clear between the two joint-ties. Where supported joint is used the distance in the clear from the joint-tie to either of the shoulder-ties is ten inches; the rest of the ties are to be spaced sixteen inches apart, as in suspended joints.

18. Cross-ties should never be notched, but, if necessary, must be adzed, in order to obtain a true and uniform bearing for the base of the rail.

19. *Ends even on East Side.*—The ends of all cross-ties must be lined true on the east side of the track, in order that symmetry may be preserved, and that, the bearing surface being uniform on that side, the road-bed will *thaw equally* in spring.

20. *Ties Protecting Switch-Rods.*—In order to prevent foul joints at switches, and to protect switch-rods in cases of derailment, all rods for stub-switches must, in every case, be confined between two cross-ties laid three (3) inches apart.

21. *Wooden Plugs.*—Every foreman will keep a supply of wooden spikes in his hand-car house and with his gang. While at work the *invariable rule* must be to plug every hole wherever a spike is drawn.

Each section foreman will be supplied with wooden spikes made by machinery, and supervisors will see that none is without them. In case the stock is exhausted and new ones do not arrive, foremen will have them made by hand when no other work can be done.

RAILS.

22. *Unloading and Distribution.*—Steel or iron rails must never be unloaded while cars are in motion. The distribution of bars over the section must be made by push-cars.

23. *Preparation of Road-Bed.*—Before laying any new iron or steel the track must be surfaced so that the new iron will not be battered and bent. All old decayed ties must be removed and new ones substituted. All ties must be laid at right angles to the track, and no tie should be put in obliquely to suit a joint which does not come out exactly.

24. *Bent Rails.*—All crooked and bent rails must be carefully straightened before they are laid in the track.

25. *Broken Joints.*—The joints of the rails in suspended joints must be exactly midway be-

tween the two joint-ties; and the joint on the line of one rail must be opposite the middle of the rail on the other line of the same track. In other words, the track is to be laid with broken joints.*

In supported joints the joint must be exactly over the centre of the cross-tie underneath.

26. *Curving Rails.*—All rails for curves must be bent before they are laid in the track. See Table VII.

27. *Space between the Ends of Rails.*—Iron shims to separate the rails at the joints must always be used in laying track. Wooden chips will not answer and must not be used. The proper thickness for coldest weather is five-sixteenths of an inch; during spring and fall use one-eighth of an inch; and in the very hottest weather one-sixteenth of an inch should be allowed—the rails supposed to be of uniform length.

This rule must be carefully observed, as many serious accidents have occurred by neglecting this simple method of making proper allowance for expansion. Any rail or fastening is weak compared with the powerful expansive force of the sun's rays.

28. *Complete Splice.*—The splices must be properly put on with the *full* number of bolts, nuts,

* I differ. The joints should be opposite or even joints.—C. L.

and washers. Nuts must always be kept screwed up tight.

29. *How many Spikes, and where to Place Them.* —All rails must be spiked full on main track—four spikes to each tie—and every spike must be driven home close, with a full hold upon the rail. On sidings between the clearing points only half-spiking is permitted. Spikes must always be driven where there are slots in the iron. In cold weather place them against the side of the slot nearer the end of the rail; in hot weather on the other side of the slot.

30. *Spiking at the Joints.*—In suspended joints with flange splice the inside splice-bar is slotted, and spikes must be driven in their proper places as above. But the outside splice-bar is not slotted, and spikes must be driven close to the rail and at each end of the splice-bar, taking a firm hold of the base of the rail. The splice is thus closely confined between the spikes driven into the joint-ties.

31. *Accurate Track-Gauges.*—Track-gauges in the possession of foremen will from time to time be compared by road-masters and supervisors with the standard in the engineer's office.

32. *Widening of Gauge on Curves.*—The track must be laid to a perfect gauge on straight lines, and also on curves on which the line fifty-three feet long, stretched as per paragraph 33, shows

less than four inches. If this distance is more than four inches, the gauge of the track must be widened one-fourth of an inch; if the distance is more than six inches, it must be widened one-half an inch. This increase of gauge is to be accompanied by an elevation of the outer rail, as per paragraph below.*

33. *How to Determine the Elevation.*—To determine practically the elevation of the outer rail on curves laid to five-feet gauge, stretch a line between two points fifty-three feet apart on the running or inside of the outer rail; then the distance from the centre of this line to the rail will be the elevation required. Care should be taken to use a fine line, and have it well stretched on a curve in good alignment, and to measure the distance at the centre of the line, which is 26½ feet from either end.

34. *Begin the Elevation on Straight Track.*—The elevation at the beginning of a curve should be as great as at any other part of it. To ensure smooth running, especially for trains at fast speed, the elevation must commence back on the straight line, and continue gradually until the curve is reached. The following table shows how far from the beginning of the curve the elevation should commence:

* This is like the Prussian system. I do not follow this practice in curves less than 9°, as I think the wheel-gauge gives allowance enough—viz., ¾ inch. —C. L.

For a 1° curve, 50 feet back on a straight line.

"	2°	"	100	"	"	"
"	3°	"	150	"	"	"
"	4°	"	200	"	"	"
"	5°	"	250	"	"	"
"	6°	"	300	"	"	"

increasing thus fifty feet for each degree of curvature.

35. *Alignment.*—When new iron is laid it must be *perfectly lined.* No imperfection in the alignment will be permitted.

36. *Top of Rails Level.*—On all straight lines the top of the rails must be made to conform strictly to the track level.

37. *Distance of Head-Block from Point of Frog.*—In putting down frogs and switches the exact distance from head-block to point of frog must be observed, according to Table I.

38. *Guard-rail Brackets.*—Every guard-rail at switches must have three cast-iron brackets, to prevent it from turning over.

39. *Cleaning Frogs and Switches, and Inspection of Same.*—Switches and frogs must be kept well in line, and free from ice and snow. During severe winter weather they must be inspected every day. They must work easily, and have no lost motion.

40. *Step-Chairs.*—All rails adjoining others of a different height must have a step-chair to bring the top of the rails on the same level.

41. *Different Punching at Ends of Rails.*—All rails joined to others of different punching must have fish-plates made to fit the different patterns of iron.

42. *Closures, and Bolt-Holes in them.*—Steel rails will be neither cut nor slotted under any circumstances. All closures must be made of iron rails of the same pattern, if pieces of steel rail are not at hand. Foremen must use the drills which are furnished to make holes for bolts whenever iron is cut or closures made. No joint must permanently remain without the full number of four bolts to each joint.

43. *Disposition of Rails taken from Track.*—In laying new iron or steel rails the old rails that are good enough to repair the track must be used again where the same pattern of rail has been laid, so that each kind of iron may be kept by itself.

WATCHING.

44. *Foremen to be always Alert.*—Foremen are required to pass over the whole extent of their sections at least every alternate day, to observe particularly the condition of the main track, sidings, culverts, cattle-guards, bridges, and fences. They must always have with them a time-table for the movement of trains, and must understand its use, and know the time of all trains at whatever point they may stop to work.

45. *Obstructing Track in order to make Repairs.*—Foremen of repair-gangs, as well as of bridgemen and construction trains, must never obstruct the track in any way whatever without protecting themselves properly, as per special rules issued.

Special trains or engines may pass over the road at any time without previous notice, and foremen must be prepared for them. Anything that interferes with the safe passage of trains is an obstruction, and must not be attempted without using the proper precaution. "Employees are permitted to use the track for making repairs to within twenty minutes of the time of passenger trains, and ten minutes of the time of freight trains; but *always under cover of a danger signal.* Such signals must be placed at least fifteen telegraph poles in both directions, firmly and conspicuously planted in the ground on the side of the engineer. If an obstruction of the track occurs on sharp curves and heavy grades, so that the danger signal cannot be seen by the foreman at the point where he is working, a man must be left in charge of it. In all cases the staff with horizontal arm must be used, so as to display fully the whole red flag, even in the calmest weather."

46. *Signals on passing Trains.*—Foremen must very carefully observe the signals carried by trains, and be sure that all following trains,

running on the same schedule, have passed, before obstructing the track.

47. *Track-Walker.*—Foremen will send an experienced and reliable man *every morning* to walk over the whole section, to examine carefully all joints and rails, and to look for broken rails and burned joint-ties. This man must start on his trip of inspection in a direction opposite to that in which the section force goes out. The track-walker should carry with him a few bolts and spikes, a wrench, and a tamping-pick. He is expected to put in missing bolts, tighten loose nuts, replace broken spikes, and raise low joints.

48. *Watching in Bad Weather.*—During heavy rains and storms section-foremen must take every precaution to prevent accidents; all hands must be placed on duty, and every part of the section watched. They must be supplied with the necessary signals and torpedoes to stop trains. After every freshet culverts and drains must be inspected, and all drift-wood immediately removed.

49. *Visit by Special Watchmen.*—Section-foremen must notice whether special watchmen attend to their duties by frequently visiting them at night, and reporting them if found negligent.

50. *Material Piled near Track.*—Whenever wood, cross-ties, lumber, or other material is

piled along the track, notice must be taken by section-foremen that it is at least six feet out from the rail. If found nearer, it must be at once removed to the proper distance. Signals or mile-posts must not be placed nearer the rail than six feet.

51. *Every One to Work.*—Every foreman will engage in his work personally, and must require all laborers under him to faithfully perform their duties.

MATERIAL.

52. *Responsibility in Regard to Material.*—Section-foremen will be held strictly responsible for all tools and material left in their charge. They must report promptly any loss of the same to their immediate superior officer. They will not be permitted to lend the tools or material of the company to any person under any circumstances.

All material, new or old, must be kept locked up in tool-houses as far as possible, or under the eye of the section-foreman.

53. *Where to put Scrap Iron.*—All scrap rails should be piled up at side tracks ready for shipment by freight. All the iron on hand for repairs of track must be well assorted, and piled upon rough platforms along straight lines of straight track as much as possible.

54. *Care of Old Spikes.*—All spikes in the

track must be carefully drawn, with the view to use them again. No old ties are to be thrown aside with spikes left in them. All old spikes which cannot be used again must be carefully gathered up and well boxed, or put in kegs securely fastened. The section-foreman will ship them by regular freight, with bill of lading, to headquarters, as may be directed for each division of the road.*

"Each foreman is charged with the amount of new spikes furnished him, and the accounts at the end of every six months should show nearly the same amount of new spikes furnished and old ones returned, provided no new tracks are laid."

55. *Requisitions for Material.*—Section-foremen, as well as supervisors and road-masters, will make requisitions in writing for all necessary material, such as cross-ties, spikes, chairs, splices, bolts, nuts, washers, and tools, and will hand them to their immediate superior officer.

56. *Responsible for Loose Property of Railroad Company.*—Section-foremen will have care of, and be responsible for, all loose property of the company, such as wood, ties, lumber, scrap iron, etc., and will notice that none of it is *lost* or *stolen.*

*** This is objectionable. All shipments of scrap should be made in coal-cars, not boxed or barrelled.—C. L.**

ACCIDENTS.

57. *Prompt Action when Accidents Occur.*—In case of accidents to trains the nearest section-foreman will at once take his whole force to the assistance of the train, even if it is not on his own section. Conductors always send for assistance to the nearest section-house, and section-men must obey at all times, night or day, any call from conductors or engineers of trains in distress. If notified of broken rails on adjoining sections, they will at once go and make the track safe for the passage of trains.

58. *Whom to Obey.*—When assisting a train delayed by an accident, section-foremen will act under the direction of the conductor until the arrival of the supervisor or road-master.

59. *Watchmen at a Wreck.*—In case of a wreck, foremen must at once appoint the necessary watchmen to prevent freight or company's property from being stolen. Said watchmen are to remain on duty until the goods are removed.

60. *Report of Injuries.*—In case of injury to any person, caused by the operations of the road, an immediate report must be made by the section-foreman to the supervisor or road-master, so that the officer whose duty it is to take action in such matters can be notified.

HAND AND PUSH CARS.

61. *Care of Cars.*—When hand or push cars

are not in actual use they must be lifted off the track and placed entirely clear of passing trains. When not within sight of the men they must be locked, and no car shall be used without the knowledge of the section-foreman.

62. *Foremen Responsible for Cars.*—No car will be run at night or on Sunday, except in case of actual necessity. All damages to cars or to company's material and tools in charge of the foreman, caused by his own neglect, will be paid for by him. Cars must be kept under lock and key, and in no case be used for personal purposes.

63. *Use of Cars in Foggy Weather and at Night.*—Great care must be exercised when it is necessary to use hand or push cars during foggy weather or in the night. Foremen must always accompany the car.

64. *Hand-Car never attached to Trains.*—In no case is it allowed to attach a hand or push car to a train in motion.

65. *Rails not Carried on Hand-Cars.*—Rails must never be carried on hand-cars, except in cases of emergency.

WATER-STATIONS DURING FREEZING WEATHER.

66. *Water-Stations in Cold Weather.*—During extreme cold weather, when water-stations are likely to suffer by frost, foremen on whose section a water-station is located, *if called upon* by

the pumper, will send a man to the tank, who shall keep up a fire in the stove during the night, and see that everything is in working order during the absence of the pumper. The section-foreman will put the expense of this in his time-book, properly classified, and charged to the respective water-station.

POLICING.

67. *Collect old Ties.*—All the old ties which are taken from the track must be gathered up at the *close of each day* and put in some convenient place for burning, or fuel and fencing.

68. *Road-Crossings.*—All highway and farm crossings must be kept in the best possible repair and not obstructed by any material. Foremen are specially directed not to leave hand or repair cars unnecessarily on crossings.

69. *Burned Cross-Ties in Track and Extinguishing Fires.*—Cross-ties partly burned by fire dropped from engines must be at once replaced. Track watchmen and section gangs must put out fires on track or adjoining fences wherever seen. They will also remove all combustible material from the vicinity of tracks and bridges.

70. *Gather up Scrap Iron and lost Freight.*—Section forces must pick up each day any material dropped from engines and cars, such as draw-bars, car-doors, brakes, bolts, nuts, or other property belonging to the company, and

take it to the tool-house, from whence it will be shipped as directed.

All packages or articles of freight that may fall from any train must be taken to the nearest station agent, who will forward it to the superintendent of transportation.

71. *Cutting Weeds and Bushes.* — Weeds, bushes, trees, and grass growing on the right of way must be cut down close to the ground over the entire section before seed-time. They must be collected and burned promptly during the month of August. In burning rubbish so gathered care is to be taken that the adjoining fences are not injured by fire.

72. *Neat Wood-Yards.*—Foremen must pay attention to the condition of the wood-yards on their respective sections. They must see that the wood platforms are properly filled for the trains; that no pieces are left in the ditches; and that the yards are neat and clean.

73. *Side Tracks and Platforms in good Order.*—All side tracks must be maintained in good order, and the platforms and station grounds should always present a cleanly appearance.

74. *Bright Signals.*—All switch signals must be kept bright and in good order.

75. *Watch and Repair Telegraph Wires.*—Foremen will pay particular attention to the telegraph wires, and see that they are not obstructed or down on the ground. If broken or

crossed they must be repaired at once in a temporary manner, and notice sent to the nearest office by special messenger.

76. *Notice Boundary Lines.*—Foremen will make themselves familiar with all the boundary lines of the company's property on their respective sections, and see that no person encroaches upon them.

No person is allowed to erect fences and buildings or otherwise occupy the company's ground without special permit. Any such action must be reported in a written statement to the supervisor or road-master, giving the name and residence of the party who trespasses upon the company's property.

REPORTS.

77. *Report Disrespect of Signals.*—Section-foremen will promptly report in writing to their immediate superior officer any failure of train-men to respect their signals, giving the number of train and engine.

78. *Report Accidents by Telegraph.*—They will report *all accidents* occurring on their sections by telegraph to the road-master or superintendent of road department as soon as possible, according to special instructions, giving in brief the nature of the accident. The telegram must be followed by a full report on the proper

blank, and given or sent by the foreman to his superior officer.

In case of very serious accidents, requiring a collection of forces and material, foremen must immediately report by despatch in full to the superintendent of road department.

79. *Damage to Stock.*—Foremen will promptly report all horses, cattle, sheep, and hogs killed or crippled by a train on their sections, on proper blanks furnished them.

80. *Damage by Fire.*—An immediate report in writing must be made by the section-foreman to his superior officer of all fences burnt, or other property and material—whether belonging to the company or to private parties—destroyed by fire from the sparks of passing locomotives. The report should state the location, the exact damage done, the lineal feet of fencing destroyed, the dimensions of the wood-pile burned, and the owner of the property.

81. *Use of Time-Books, and when to Send them in.*—The time-books must be written up every night of the day which has closed. The time of foremen and men must be given for each kind of work under the proper heading in the book.

Time-books, as well as monthly reports of all tools and material on hand, whether good or bad, and reports of new tools and materials received during the month, must be handed by the foreman to his superior officer on the last day of each month.

82. *Discharge noticed in Time-Books.*—When any employee is discharged the foreman will write on the page of the time-book containing his name, " Discharged and time given."

83. *Pay-Day of those who Leave the Service.*—Employees of this department who leave the service of the company of their own accord will not receive pay for their service until the regular pay-day in the month following that in which they leave the service. Foremen must so inform men before engaging them.

84. *Power to Discharge and Employ Men.*—Section foremen may discharge or suspend from duty any employee under their control.

They must not engage more than the regular force allowed.

85. *Strict Discipline and Attention to Duty.*—Section foremen are not at liberty to excuse any neglect of their men in the performance of duty, but are required to discharge them *in all cases* upon the first evidence of unfaithfulness.*

86. *Report High Speed of Freight Trains.*—Section foremen must report all freight trains which they may notice passing by at a higher speed than schedule time allows; and also report promptly to their immediate superior any

* Discharges are frequent when the superior is unfaithful. They are rare when mercy rules. The law of kindness governs best.—C. L.

other carelessness or misdemeanor of trainmen.

87. *General Instructions regarding the Duty of Section-Men.*—Section-foremen must remember that while their particular duty is to look after their own sections, to keep them in safe running order, and to steadily improve their condition, they must not fail to do everything to make the road secure and to prevent accidents, even though they may have to perform the duty of some other man.

FOR CONDUCTORS OF CONSTRUCTION TRAINS.

88. *By whom Appointed and the Extent of their Responsibility.*—The conductors of all ditching and material trains are appointed by the road-master, subject to the approval of the division superintendent, and are responsible for the safety and proper care of their trains, for the good conduct of all the men employed thereon, and for any material entrusted to their care.

89. *Connection with Transportation Department.*—They must obey all orders for the safe movement of their trains from the train-despatcher or superintendent of division, and they must faithfully observe all time-card rules.

90. *Dismissal for the Violation of Time-Card Rules.*—Any violation of the existing time-card rules is at once followed by suspension from the charge of directing the movement of the train;

but the conductor will still remain in charge of all the men, and will be responsible for the proper execution of all construction work until investigations are made, and he is reinstated or dismissed. In such cases the superintendent of transportation will immediately appoint a man to have temporary charge of the safe movement of the train *only* until the case is decided and a new appointment made by the road-master. Under no circumstances should a delay in the construction work occur.

91. *Passengers on Construction Trains.*—No one except an officer of the road is permitted to ride on construction trains.

92. *Condition of Cars.*—Conductors of work-trains must see that all the ditching and boarding cars are in good running order; that the boarding cars are neat and clean at all times; and that good, substantial food is furnished to the men.

93. *Business Information Required.*—They must study the rules and instructions issued to all track and bridge men, and fully familiarize themselves with all kinds of work pertaining to the maintenance of track.

Ditches must be cut as per directions to section foremen.

94. *Handling Material.*—The greatest care must be taken in unloading material. Steel and iron rails must never be unloaded while cars are

in motion; and skids must be used to prevent bending and breaking the rails.

95. *Supervisor to be present when Material is distributed.*—Conductors must always notify the proper supervisor when ordered by the road-master to distribute material, such as cross-ties, iron, and ballast, so that the supervisor can in all cases be with the train when it is distributing material on his own division.

96. *When to give Wood for Fuel.*—Conductors must not give any employee wood or other material without the proper order from the road-master.

97. *Reports.* — Conductors must make such monthly reports as are directed.

On Monday of each week they must send to the road-master a written report of all the delays experienced during the past week on account of not receiving orders promptly, or from other causes.

98. *Where the Train should be at Night.*—From the first day of December to the first day of March they must *always* spend the night at a telegraph station; and observe the same rule during the rest of the year without losing time.

99. *How to spend Time while waiting for Orders.*—Whenever conductors of construction trains have delays at a station, whether in waiting for orders or from other causes, they must keep the whole force employed. There is no

place on the whole line where some kind of work is not needed, and no time will be wasted by a good conductor. When delays occur (and some are unavoidable), the men should be set to work on sidings, at cleaning station grounds, weeding ditches, ballasting, or whatever other work is mostly needed.

100. *Prompt Relief after an Accident, and what to do.*—In case of accidents to trains they will hasten to give assistance as soon as called upon by the superintendent of transportation or train-despatcher, and they must do everything in their power to facilitate the quick and safe passage of trains. They must take full charge of any wreck until the arrival of the supervisor or road-master.

When wrecked cars are burned the numbers and initials must be carefully noted and reported to the road-master.

101. *Report insufficient Motive Power.*—Conductors must report at once in writing to road-master whenever inadequate motive power or incompetent engine-men are furnished them.

102. *Permission to leave Train.*—Whenever it is necessary for them to leave the train they must ask permission to do so from the road-master, and also notify the train-despatcher, so that in case of accident the supervisor or road-master can take the train or make another appointment. Under no circumstances will they

leave their men without permission from the road-master.

FOR TRACK SUPERVISORS.*

103. *Extent of Duty.*—Wherever the system of track supervisors is established the supervisors will have immediate charge of all the foremen of sections and road watchmen on their respective divisions, and are authorized to discharge any employee for neglect of duty. They will, however, in case an accident results from the negligence of an employee, report the case to the road-master.

104. *Length of Divisions.*—Supervisors will have charge of divisions from thirty to sixty miles in length, so that they can walk over the entire length every week. They are held responsible for the safe-keeping of their divisions.

105. *Audit and Collect Time-books.*—They will carefully see that the time of the men and the rate of pay are correctly reported and properly classified on the time-books.

They will note the time each foreman is absent from work, and make proper deductions on time-books.

* **All the work of supervisor and road-master properly belongs under one head, viz., the road-master. The chief engineer should exercise the duties of general road-master. If an assistant is necessary let the term be assistant engineer. The best way to *reach the men* is to have no authority between the road-master and the chief engineer. The road-master should have entire supervision of his division, with the exception of the bridges, unless in the rare case of his being also a bridgeman.—C. L.**

On the last day of each month they will go over the entire division, collect time-books, make notes and explanations, approve each man's time by endorsing his own name on the page allotted to it, and forward the time-books to the proper person, as may be directed.

106. *Approve Discharge-Tickets.*—They will countersign all discharge-tickets given by their foremen, and see that the proper memorandum in such cases is made in the time-book.

107. *Close Attention to his Division.*—Each supervisor must walk over at least five miles of his division every day, and over the whole division once a week. Passenger trains must be used by them *only in case of necessity.*

They must spend all their time out on the road, and see that foremen and laborers fully understand and perform their duties.

108. *Notice the Condition of Track and Use of Material.*—They must pay untiring attention to the proper adjustment and alignment of the track, and to the economical use of all material.

109. *New Iron and Steel to be laid with Special Care.*—They must personally observe whether new iron and steel laid on curves conform in alignment and elevation of the outer rail with the rules given for section foremen.

110. *Shims for Expansion.*—They must keep themselves supplied with iron shims to test the

distance between the ends of rails, according to the season of the year.

Track-Gauges.—They should also frequently examine the track-gauges, and compare with the standard.

111. *Familiarity with Land Lines.*—They should be thoroughly posted in regard to the right of way and other land boundaries on their respective divisions, and keep constant watch against infringement by adjoining occupants.

112. *Number of Men at Work to be Known.*—They should keep a memorandum of the number of men at work on each section, and compare with the reports returned with the section-foremen.

113. *Requisitions for Material, and Receipts for same.*—All requisitions for material, such as cross-ties, spikes, chairs, splices, bolts, nuts, washers, tools, etc., must be made in writing to the road-master.

When material is ready for delivery to the section-foreman the supervisor must make out a written statement of the amount received and of its condition, and send the same to the road-master as soon as possible.

114. *Switch-Keys for Foremen.*—Supervisors will see that each foreman is supplied with *one* switch-key and gives a written receipt for the same. In case the key is not returned when the foreman leaves the service of the company

five dollars ($5) will be deducted from the amount then due the foreman. Supervisors will make the proper remark respecting the switch-key on the discharge-ticket.

115. *Require from Foremen an Account of Tools.*—When a foreman is discharged or leaves the service of the company supervisors must make out a correct list of tools on hand. They will note all tools missing or not accounted for, and send such reports at once to the road-master, so that the proper settlement can be made. In all such cases they will write on the discharge-ticket, "*Tools not accounted for as per report.*"

116. *Connection with Construction Trains.*—They will have charge and control of all construction trains while at work on their respective divisions, and will personally see to the proper distribution of all material for the use of their foremen. They must always be with construction trains when distributing material on their divisions, especially when unloading iron and steel rails, and see that no time is lost in so doing.

117. *Report of Accidents, and Personal Attention to a Wreck.*—In case of accidents on their divisions they will send the reports of the section-foremen, certified and, if necessary, corrected by themselves, to the road-master. On being notified of a wreck they will immediately proceed to it and take charge of all track-men.

They will superintend the work of clearing the wreck in the absence of the road-master.

118. *Distribute Printed Instructions.*—All printed circulars, instructions, and orders to section-foremen or watchmen must be delivered in person by the supervisor, who will read and explain the same to all his foremen.

119. *Use of Signals to be Explained to Subordinates.*—Supervisors of track must see that all the rules for signals with flags and torpedoes and other instructions are understood and obeyed by every man in their employ; and that all their foremen and watchmen are supplied with time-tables and watches while on duty. They must compare time with their foremen at least once a week.

120. *Supervisor's Duties may be Performed by Road-Master.*—Where there is no supervisor of track the above duties will be executed by the road-master in addition to the following.*

FOR ROAD-MASTERS.

121. *Nature of Duties.*—Road-masters must pass over a *part* of their division *every day*, and over their whole division—walking or on a hand-car at slow speed—*once every month.* They must see that the track and culverts are in safe

* I do not approve the system of supervisors and road-masters also. The more heads there are before the chief-engineer reaches the men, the worse it is.—C. L.

condition and in good order. They must require supervisors of track, foremen, and all employees in their charge to make *proper use* of material furnished for the repair and good maintenance of road-bed, track, and other portions of the railroad committed to their charge.

122. *Always in Communication with Transportation Department.*—Road-masters, as well as supervisors of track, conductors of construction trains, and section-foremen, *must at all times be ready, both night and day,* to render any assistance that may be called for by the train-despatcher, master of transportation, or superintendent of transportation *in case of accidents* or *of detention to trains,* and to provide facilities for the safe and quick movement of trains.*

123. *Clear up every Wreck, and Report same from Personal Examination.*—On receiving notice of a wreck or accident they must at once proceed to the place, and take *full charge and control* of all track forces and construction trains; put the track in condition for the safe passage of trains; and remove the wreck with the quickest possible despatch. When cars are burned they must note the number and initials of the cars so destroyed, and send a written report of the same to their superior officer.

* The best mode of managing wrecks is to let the transportation department handle the wrecking-car with the shopmen, who are more experienced with the tools, and after the wreck is out of the way or loaded the engineer takes charge with his force and rebuilds track or bridge.—C. L.

In all cases a written report in full, giving the amount of damage done, must be sent in.

124. *Enquiry and Report respecting Accidents.*—They must enquire carefully in regard to every accident that may occur upon the road, to ascertain the cause of it, and they will write a full report thereof to their superior officer.

They must reserve such material as broken rails, cross-ties, axles, or other *débris* which may be of value in determining fully the cause of the accident.

125. *Connection with Construction Trains.*—Road-masters must have full charge of all construction trains on their division, and lay out the work for them on each subdivision as may be required. They must also see that the ditching-cars are kept in good order, and that boarding-cars are clean and tidy. They will often examine into the boarding arrangements of all their men, and see that wholesome and sufficient food is furnished them.

126. *Report unsatisfactory Motive Power.*—It is also the duty of the road-master to see that each construction train is supplied with a good engine and a competent engineer. In case insufficient motive power is furnished to his train he must at once report the matter to his superior officer. Construction trains, being very expensive, require the best kind of motive power for their economical working.

127. *Receive Material delivered by Contract.*—Road-masters must *personally* receive all material contracted to be delivered on their divisions, such as cross-ties, wood, and ballast. They must in all cases enforce strictly the printed specifications.

128. *Piling Cross-Ties.*—Cross-ties must be raised from the ground and symmetrically cross-piled, not higher than six feet, so that each tie can be properly inspected and marked with hammer and brush.

129. *Inspecting Wood for Fuel.*—When wood is taken up the measurement is to be put down in the book, after making proper deductions for under size, bad piling, or other deficiencies. All wood received is to be cross-piled on the top, and each rick is to be profusely marked all around with lampblack or whitewash. Marking in this manner will prevent dishonest parties from disturbing the pile, and appropriating wood already paid for to repile again for measurement.

Ricks should never be over sixty feet in length and six feet high; a space of five feet is to be left between the ricks in order to give free access all around in inspecting and marking it.

130. *Measurement of Ballast.*—In receiving rock or gravel ballast road-masters must see that the stone is piled closely, and that the ballast is of the proper size and quality, as con-

tracted for. Deductions must be made for loose piling or other deficiencies.*

131. *How near the Track Material may be left.*—Road masters must see that nothing is piled nearer than six feet from the main track and sidings.

132. *Notice other Employees besides Track-Men.*—They will keep a general oversight of all work performed on their divisions by contractors or bridge carpenters, lest anything should interfere with the safety of the track.

133. *Reports to Superior Officer.*—They must make such monthly reports to their superior officer as may be directed.

134. *Discharge and Suspension of Subordinates.*—They are authorized to discharge any supervisor of track, conductor of construction train, section-foreman, road watchman, or other subordinate for neglect of duty; but should an accident result from such negligence they will suspend him from duty, and report the case to their superior officer, so that an investigation can be made.

135. *Report of Violation of Time-Card Rules by Train-Men.*—They must make themselves acquainted with all the instructions issued for the government of trains and train-men, and must report to their superior officer in writing any

* This refers to gravel hauled by farmers from creek-bottoms—a practice on the Louisville & Nashville Railroad.—C. L.

neglect of duty or violation of rules that may come under their notice.

136. *Explain whatever Supervisors and Foremen do not understand.*—They must take pains to instruct supervisors and section-foremen in regard to their duties, and satisfy themselves that every employee fully understands all the instructions issued for him.

137. *Acquire Information about the Wear of Rails.*—Road-masters will often make careful investigations into the wear of rails, fish-plates, spikes, washers, nuts, and cross-ties, and will encourage supervisors and section-foremen to make the same observation.

138. *Reports of new Iron and Steel laid every Six Months.*—They must carefully mark on their iron profiles all the new iron laid from time to time, giving the year and the exact location with reference to the nearest mile-post. This must be done in addition to a detailed written report, made every six months, of all new iron or steel rails laid.

In this way a correct account of the wear with reference to tonnage can be kept in the Chief-Engineer's office.

TABLE I.

For Putting in Frogs and Switches (Gauge Five Feet).

Proportion or Number of Frog.	Frog Angle.	TONGUE-SWITCH FOR YARDS.			STUB OR TONGUE-SWITCH FOR MAIN TRACK.						CROTCH FROG.				
		Length of Tongue-rail.	From End of Tongue-rail to Point of Frog.	From Point of Tongue to Point of Frog.	Length of Tongue-rail (or Slide-rail).	From Head-block to Point of Frog.	From Point of Tongue to Point of Frog.	Mid-Ordinate from Point of Tongue to Point of Frog.	Radius of Uniform Curve.	Old Name of Frog.	Number of Frog.	Frog Angle.	From Point of Tongue to Point of Frog.	Radius of Uniform Curve.	Old Name.
		ft.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	in.	ft.				ft. in.		
1 to 10	5° 44′	12	68 0	80 0	29 0	71 0	100 0	15	1000.0	New A.	1 to 7.0	8° 8′	79 10¾	1000.0	N.
1 to 9.5	6° 0′	12	65 7	77 7	27 6	67 2½	94 8½	15	910.5	G. L. B. & I. Co.	1 to 6.8	8° 30′	67 6	910 5	....
1 to 8.0	7° 9′	12	57 3½	69 3⅛	23 1¾	56 6¾	79 8½	15	642.7	Old A.	1 to 5.6	10° 8′	56 7¼	642.7	....
1 to 7.5	7° 36′	12	54 8½	66 8⅛	21 9½	53 5	75 2½	15	569.4	E. & F.	1 to 5.3	10° 46′	53 4¾	569.4	....
1 to 7.0	8° 8′	12	51 11	63 11	20 4¼	50 1¾	70 6	15	497.0	N.	1 to 4.9	11° 30′	49 9⅛	497.0	....
1 to 6.0	9° 28′	12	45 9½	57 9½	17 6	43 1¼	60 7¼	15	367.2	B.	1 to 4.3	13° 05′	43 7¼	384.6	M.&K.

TABLE II.

Bill of Switch-Timbers for Frogs 1 to 10 and 1 to 9.5.

SINGLE-STUB SWITCH.				THREE-THROW SWITCH.			
No. of Pieces	Length.	Size.	Feet, B. M.	No. of Pieces.	Length.	Size.	Feet, B. M.
1	16	10×12	160	3	9	7×9	142
5	9	7×9	236	1	20	10×12	200
4	9½	7×9	199	3	9½	7×9	150
3	10	7×9	157	3	10	7×9	157
3	10½	7×9	165	2	10½	7×9	110
3	11	7×9	173	2	11	7×9	116
3	11½	7×9	181	2	11½	7×9	121
3	12	7×9	189	2	12	7×9	126
3	12½	7×9	197	2	12½	7×9	131
2	13	7×9	136	2	13	7×9	136
2	13½	7×10	157	1	13½	7×9	70
2	14	7×10	163	1	14	7×9	74
2	14½	7×9	152	1	14½	7×9	76
2	15	7×9	158	2	15	7×9	158
2	15½	7×9	163	1	15½	7×9	81
2	16	7×9	168	1	16	7×9	84
				2	16½	7×9	174
			2,754	1	17	7×9	89
				1	17½	7×9	92
				1	18	7×10	105
				1	18½	7×10	108
				1	19	7×10	111
				1	19½	7×10	114
				1	20	7×9	105
				1	20½	7×9	108
				1	21	7×9	110
				1	21½	7×9	113
				1	22	7×9	115
				1	22½	7×9	118
				1	23	7×9	121
				1	23½	7×9	123
							3,638

TABLE III.

Bill of Switch-Timbers for Frogs 1 to 8 and 1 to 7.5.

SINGLE-STUB SWITCH.				THREE-THROW SWITCH.			
No. of Pieces.	Length.	Size.	Feet, B. M.	No. of Pieces.	Length.	Size.	Feet, B.M.
1	16	10×12	160	3	9	7×9	142
3	9	7×9	142	1	20	10×12	200
3	9½	7×9	150	2	9½	7×9	100
3	10	7×9	157	2	10	7×9	105
3	10½	7×9	165	2	10½	7×9	110
3	11	7×9	173	2	11	7×9	116
3	11½	7×9	181	1	11½	7×9	60
2	12	7×9	126	1	12	7×9	63
2	12½	7×9	131	2	12½	7×9	131
2	13	7×10	152	1	13	7×9	68
1	13½	7×10	79	1	13½	7×9	70
1	14	7×10	82	1	14	7×9	74
2	14½	7×9	152	1	14½	7×9	76
2	15	7×9	158	2	15	7×9	158
2	15½	7×9	163	1	15½	7×9	81
1	16	7×9	84	1	16	7×9	84
				1	16½	7×9	87
			2,255	1	17	7×9	89
				1	17½	7×10	102
				1	18	7×10	105
				1	18½	7×10	108
				1	19	7×10	111
				1	19½	7×9	102
				1	20	7×9	105
				1	20½	7×9	108
				1	21	7×9	110
				1	22	7×9	115
				1	22½	7×9	118
				1	23	7×9	121
							3,019

TABLE IV.

Bill of Switch-Timbers for Frogs 1 to 7.

SINGLE-STUB SWITCH.				THREE-THROW SWITCH.			
No Pieces.	Length.	Size.	Feet B. M.	No. of Pieces.	Length.	Size.	Feet. B. M.
1	16	10×12	160	3	9	7×9	142
2	9	7×9	94	1	20	10×12	200
3	9½	7×9	150	1	9½	7×9	50
3	10	7×9	157	1	10	7×9	52
3	10½	7×9	165	2	10½	7×9	110
2	11	7×9	116	2	11	7×9	116
2	11½	7×9	120	1	11½	7×9	60
2	12	7×9	126	1	12	7×9	83
2	12½	7×9	131	2	12½	7×9	131
2	13	7×10	152	1	13	7×9	68
1	13½	7×10	79	1	13½	7×9	70
1	14	7×10	82	1	14	7×9	74
1	14½	7×9	76	1	14½	7×9	76
2	15	7×9	158	1	15	7×9	79
1	15½	7×9	81	1	15½	7×9	81
2	16	7×9	168	1	16	7×9	84
				1	16½	7×9	87
			2,015	1	17	7×9	89
				1	17½	7×10	102
				1	18	7×10	105
				1	19	7×10	111
				1	19½	7×10	114
				1	20	7×9	105
				1	21	7×9	110
				1	21½	7×9	113
				1	22	7×9	115
				1	23	7×9	121
				1	24	7×9	126
							2,754

TABLE V.

Bill of Switch-Timbers for Frogs 1 to 6.

SINGLE-STUB SWITCH.				THREE-THROW SWITCH.			
No. of Pieces.	Length.	Size.	Feet, B. M.	No. of Pieces.	Length.	Size.	Feet, B. M.
1	16	10×12	160	3	9	7×9	142
2	9	7×9	94	1	20	10×12	200
2	9½	7×9	100	1	9½	7×9	50
2	10	7×9	105	2	10	7×9	105
3	10½	7×9	165	1	10½	7×9	55
2	11	7×9	116	2	11	7×9	116
2	11½	7×9	121	1	11½	7×9	60
2	12	7×9	126	1	12	7×9	63
1	12½	7×9	66	1	12½	7×9	66
2	13	7×10	152	1	13	7×9	68
1	13½	7×10	79	1	14	7×9	74
1	14	7×10	82	1	14½	7×9	76
1	14½	7×9	76	1	15	7×9	79
2	15	7×9	158	1	15½	7×9	81
1	15½	7×9	81	1	16	7×9	84
1	16	7×9	84	1	16½	7×9	87
				1	17½	7×10	102
			1,765	1	18	7×10	105
				1	18½	7×10	108
				1	19½	7×10	114
				1	20½	7×9	108
				1	21	7×9	110
				1	22	7×9	115
				1	23	7×9	121
				1	24	7×9	126
							2,415

APPENDIX III.

SPECIFICATIONS FOR A PERFECT SUB-DIVISION ON THE PENNSYLVANIA RAILROAD.

The following specifications were issued under date of August 1, 1874, by the Pennsylvania Railroad:

SUPERSTRUCTURE.

1. The track must be in good surface; on straight lines the rails must be on the same level, and on curves the proper elevation, as set down in the table, must be given to the outer rail and carried uniformly around the curve. This elevation should be commenced from 100 to 150 feet back of the point of curvature, depending on the sharpness of the curve, and increased uniformly to the latter point, where the full elevation is attained. The same method should be adopted in leaving the curve.*

2. The track must be in good line.

3. The splices must be properly put on with

* I think that the distance given at which to commence the elevation is too general. The rule of 50 feet per degree of curvature is preferable.—C. L.

the full number of bolts, nuts, stop-washers, and stop-chairs. The nuts must be screwed up tight.

4. The joints of the rails must be exactly midway between the joint ties, and the joint on one line of rail must be opposite the centre of the rail on the other line of the same track. In winter a distance of five-sixteenths of an inch and in summer one-sixteenth of an inch must be left between the ends of the rails to allow for expansion.*

5. The rails must be spiked both on the inside and outside on each tie, on straight lines as well as on curves.

6. The cross-ties must be properly and evenly spaced, 16 ties to a 30-ft. rail, with 10 inches between the edge of bearing surfaces at joints, with intermediate ties evenly spaced a distance of not over two feet from centre to centre; and the ends on the outside, on double track, and on the right-hand side going north or west, on single track, must be lined up parallel with the rails.

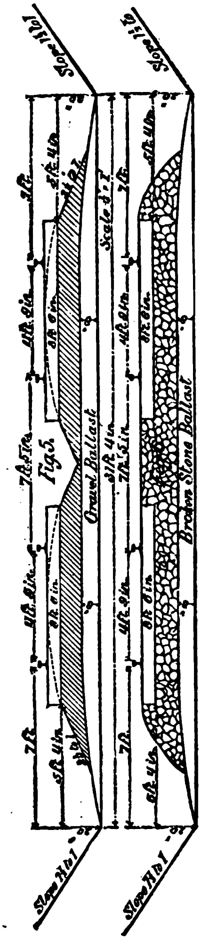
7. The ties must not, under any circumstances, be notched, but, should they be twisted, must be made true with the adze, and the rails must have an even bearing over the surface of the ties.

8. The switches and frogs must be kept well

* I am in favor of even joints as a general rule.—C. L.

lined up and in good order. Switches must work easily, and safety-blocks must be attached to every switch-head.

9. The switch signals must be kept bright and in good order.



SECTIONS OF ROAD-BED, GRAVEL, AND STONE BALLAST, PENNSYLVANIA RAILROAD.

ROAD-BED AND BALLAST.

10. The ballast must be broken evenly and not larger than a cube that will pass through a two and one-half inch ring. There must be a uniform depth of at least twelve inches of clean broken stone under the ties. The ballast must be filled up evenly between, but not above the top of the ties, and also between the main tracks and sidings, where there are any. In filling up between the tracks, coarse, large stones must be placed in the bottom in order to provide for drainage, but care should be taken to keep the coarse stone away from the ends of the ties. At the

outer ends of the ties the ballast must be sloped off evenly to the sub-grade.

11. The road-crossing planks must be securely spiked; the planking should be three-quarters of an inch below the top of rail, and two and one-half inches from the gauge-line. The ends and inside edges of planks should be bevelled off.

DITCHES.

12. The cross-section of ditches at the highest point must be of the width and depth as shown on the standard drawing, and graded parallel with the track so as to pass water freely during heavy rains and thoroughly drain the road-bed.

13. The lines must be made parallel with the rails and well and neatly defined.

14. The necessary cross-drains must be put in at proper intervals.

15. Earth taken from ditches or elsewhere must be dumped over the banks and not left at or near the ends of the ties, but distributed over the slope. Earth taken out of the ditches in cuts must not be thrown on the slope.

16. The channels or streams for a considerable distance above the road should be examined, and brush, drift, and other obstructions removed. Ditches, culverts, and box-drains should be cleared of all obstructions, and the

outlets and inlets of the same kept open to allow a free flow of water at all times.

POLICING.

17. The telegraph poles must be kept in proper position, and trees near the telegraph line must be kept trimmed to prevent the branches touching the wires during high winds.

18. All old material, such as old ties, old rails, chairs, car material, etc., must be gathered up at least once a week and neatly piled at proper points.

19. Briers and undergrowth on the right of way must be kept cut close to the ground.

20. Station platforms and the grounds about stations must be kept clean and in good order.

APPENDIX IV.

THE FRENCH METRIC SYSTEM.

Prepared by A. Mordecai.

THE standard of the French metric system is its unit of length, called the *metre*, = 39.368505 inches, or about 3 ft. 3⅜ in. slack.

Ten of these units squared form the *are*, or unit of square measure, = 1,076.3058 sq. ft., or $\frac{1}{40}$ of an acre, nearly.

One-tenth of a metre cubed is the *litre*, or unit of cubic measure, = 1.05656 quarts, about $1\frac{1}{16}$ quarts, or 0.1135 peck—a full $\frac{1}{9}$.

The weight of the distilled water at its maximum density which is contained in a vessel all of whose dimensions are equal to one one-hundredth of a metre is the *gramme*, or unit of weight, = 15.4331 grains, or 15½ grains nearly, or about $\frac{1}{28}$ of an ounce.

These units, as shown below, are multiplied and divided successively by ten, just as the United States money is now divided into the eagle, or ten-dollar; the dime, or one-tenth of a dollar; the cent, or one-hundredth of a dollar; the mill, or one-thousandth of a dollar.

MEASURES OF LENGTH.

Name. Abbreviation.			
Millimetre...mm... =	$\frac{1}{1000}$ metre,	=	0.03936 in , or $\frac{1}{25}$ in.
Centimetre ..centim.=	$\frac{1}{100}$ "	=	0.39368 " or $\frac{3}{8}$ "
Decimetre...decim..=	$\frac{1}{10}$ "	=	3 93685 " or $3\frac{15}{16}$ in , nearly $\frac{1}{3}$ ft.
Metre.......m.....		=	39.36850 in., or 3 ft. $3\frac{3}{8}$ in., about $1\frac{1}{10}$ yds.
Decametre...decam.=	10 metres,	=	32.8071 ft., or 32 ft. $9\frac{1}{6}$ in., nearly 11 yds.
Hectometre.........=	100 "	=	328 071 ft., or 328 ft. $0\frac{7}{8}$ in.
Kilometre...kilom..=	1,000 "	=	3280.71 ft., or 3,280 ft. $8\frac{9}{16}$ in., about $\frac{5}{8}$ mile.
Myriametre.........=	10,000 "	=	6.21346 mile, or $6\frac{1}{8}$ miles full.

1 U. S. inch, = 0.0254 metres.
1 " foot, = 0.30476 "
1 " yard, = 0.9144 "
1 " mile, = 1.6093 kilometres.

MEASURE OF SURFACE.

Sq. millimetre...........	= .001549 sq. in.,	or $\frac{1}{645}$ sq. in. nearly.
Sq. centimetre..........	= .154988 "	or $\frac{1}{16}$ " "
Sq. decimetre...........	= 15.4988 "	or $15\frac{1}{2}$ " "
Sq. metre or centiare	= 10.76305 sq. ft.,	or $10\frac{3}{4}$ sq. ft. full.
Sq. decametre or are.....	= 1076.3058 "	or $1076\frac{1}{3}$ " nearly.
Sq. hectometre or hectare.	= 2.47086 acres,	or $2\frac{1}{2}$ acres nearly.
Sq kilometre...........	= 24,7.086 "	or $247\frac{1}{12}$ acres, or about $\frac{3}{8}$ sq. mile.
Sq. myriametre..........	= 24708.6 "	or $38\frac{1}{2}$ sq. miles full.

1 U. S. square inch, = 0.000645 ares.
1 " " foot, = 0.09288 "
1 " " acre, = 40.4629 "

Table giving values of every one sixteenth of an inch up to twelve inches in terms of a decimetre.

	0	1 in.	2 in.	3 in.	4 in.	5 in.	6 in.	7 in.	8 in.	9 in.	10 in.	11 in.
		.25401	.50802	.76203	1.01604	1.27005	1.52406	1.77807	2.03208	2.28609	2.54010	2.79411
$\frac{1}{16}$	.01587	.26988	.52389	.77790	1.03191	1.28592	1.53993	1.79394	2.04795	2.30196	2.55597	2.80998
$\frac{1}{8}$	.03175	.28576	.53977	.79378	1.04779	1.30180	1.55581	1.80982	2.06383	2.31784	2.57185	2.82586
$\frac{3}{16}$	.04762	.30163	.55564	.80965	1.06366	1.31767	1.57168	1.82569	2.07970	2.33371	2.58772	2.84173
$\frac{1}{4}$	.06350	.31750	.57152	.82553	1.07954	1.33355	1.58756	1.84157	2.09558	2.34959	2.60360	2.85760
$\frac{5}{16}$	.07937	.33338	.58739	.84140	1.09541	1.34942	1.60343	1.85744	2.11145	2.36546	2.61947	2.87348
$\frac{3}{8}$	.09525	.34926	.60327	.85728	1.11129	1.36530	1.61931	1.87332	2.12733	2.38134	2.63535	2.88936
$\frac{7}{16}$	.11112	.36513	.61913	.87315	1.12716	1.38117	1.63518	1.88919	2.14320	2.39721	2.65122	2.90523
$\frac{1}{2}$	.12700	.38101	.63500	.88903	1.14304	1.39705	1.65106	1.90507	2.15908	2.41309	2.66710	2.92111
$\frac{9}{16}$	.14288	.39689	.65090	.90491	1.15892	1.41293	1.66694	1.92095	2.17496	2.42897	2.68298	2.93699
$\frac{5}{8}$	.15875	.41276	.66677	.92078	1.17479	1.42879	1.68281	1.93682	2.19083	2.44484	2.69885	2.95286
$\frac{11}{16}$	.17463	.42864	.68265	.93666	1.19067	1.44468	1.69869	1.95270	2.20671	2.46072	2.71473	2.96874
$\frac{3}{4}$	.19050	.44451	.69852	.95253	1.20654	1.46055	1.71456	1.96857	2.22258	2.47659	2.73060	2.98461
$\frac{13}{16}$	.20638	.46039	.71440	.96841	1.22242	1.47643	1.73044	1.98445	1.23846	2.49247	2.74648	3.00049
$\frac{7}{8}$	.22225	.47626	.73027	.98428	1.23829	1.49230	1.74631	2.00032	1.25433	2.50834	2.76235	3.01637
$\frac{15}{16}$	.23813	.49214	.74615	1.00016	1.25317	1.50818	1.76219	2.01620	1.27021	2.52422	2.77823	3.03224

To reduce the above table to metres, place the decimal point one place to the left.

CUBIC OR SOLID MEASURE.

Millilitre	$\frac{1}{1000}$ litre,	=	0.06106 cubic inch, or $\frac{1}{16}$ cubic inch.
Centilitre	$\frac{1}{100}$ "	=	0.61016 cubic inch, or $\frac{5}{8}$ cubic inch.
Decilitre	$\frac{1}{10}$ "	=	6.10165 cubic inch, or $\frac{1}{5}$ pint, full.
Litre		=	1.05656 quarts, or $1\frac{1}{18}$ qt., or $\frac{1}{8}$ peck, nearly.
Decalitre, or centistere.	10 litres,	=	2.64141 gallons, or $2\frac{5}{8}$ gals., full, or $\frac{1}{4}$ bushel.
Hectolitre, or decistere.	100 "	=	3 53105 cubic ft., or $26\frac{7}{16}$ gals., or $2\frac{1}{6}\frac{3}{6}$ bushels.
Kilolitre or stere	1,000 "	=	35.3105 cubic ft., or $1\frac{3}{10}$ cubic yards.
Myrialitre	10,000 "	=	353.105 cubic ft., or $13\frac{1}{13}$ cubic yards.

1 U. S. pint,	=	0.4734	litres.
1 " quart,	=	0.9469	"
1 " gallon,	=	3.785	"
1 " peck,	=	8.809	"
1 " bushel,	=	35.236	"
1 " cubic inch,	=	0.01638	"
1 " cubic foot,	=	28 3202	"
1 " cubic yard,	=	0.7646	stere.
1 " cord,	=	3.624	"

MEASURES OF WEIGHT.

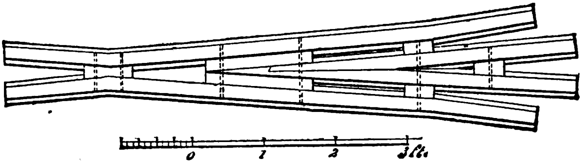
Milligramme	$\frac{1}{1000}$ gramme,	=	0.015433 grain, or $\frac{1}{65}$ grain.
Centigramme	$\frac{1}{100}$ "	=	0.15433 grain, or $\frac{1}{6}$ grain.
Decigramme	$\frac{1}{10}$ "	=	1.54331 grains, or $1\frac{1}{2}$ grains, full.
Gramme		=	15.4331 grains, or $15\frac{1}{2}$ grs., nearly.

Decagramme......	10	grammes,	=	0.02204 pound, or $\frac{1}{45}$ lb.
Hectogramme.....	100	"	=	0.22047 pound, or $\frac{1}{4}$ lb., nearly.
Kilogramme......	1,000	"	=	2.2047 pound, or $2\frac{1}{5}$ lbs., full.
Myriagramme.....	10,000	"	=	22.047 pounds, or $22\frac{1}{20}$ lbs., nearly.
Quintal...........	100,000	"	=	220.473 pounds, or $220\frac{1}{2}$ lbs., nearly.
Tonneau, or tonne.	1,000,000	"	=	2,204.737 pounds, or 1 ton of 2,240 lbs., nearly.

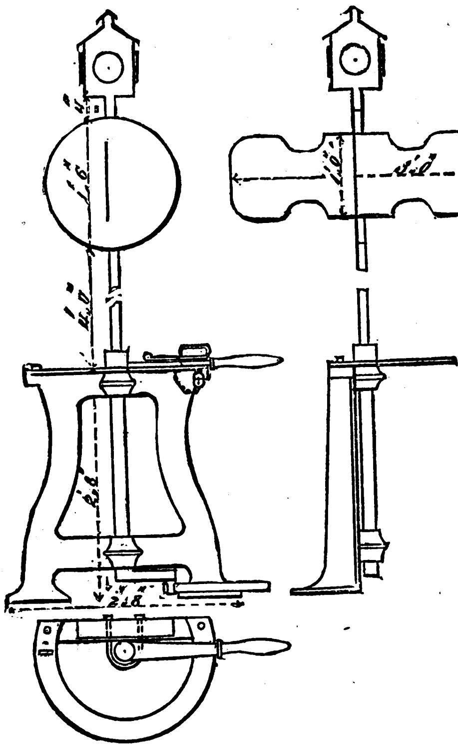
$\frac{1}{2}$ kilo., = $1\frac{1}{10}$ pounds, about.

1 U. S. ounce,	=	28.35 grammes.
1 " pound,	=	453 602 "
1 ton of 2,240 lbs.,	=	1.016 tonnes.
1 " of 2,000 "	=	0.907 "

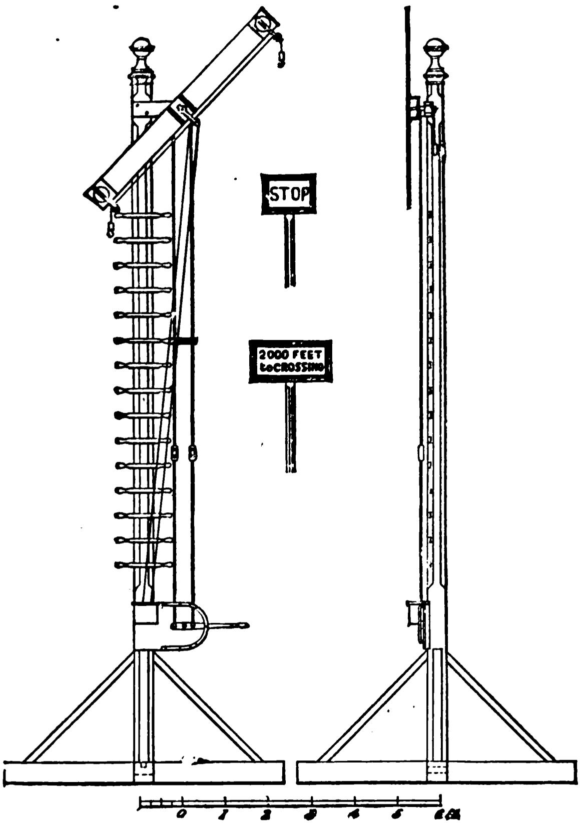
NOTE.—I have here appended an abstract of the metrical system for the convenience of those who may have occasion to refer to it, but I must dissent from the attempt to introduce a new and equally arbitrary unit in place of our long-established foot. I do not, therefore, recommend the metric system by this presentation, but think that our own foot, decimally divided, is superior.—C. L.



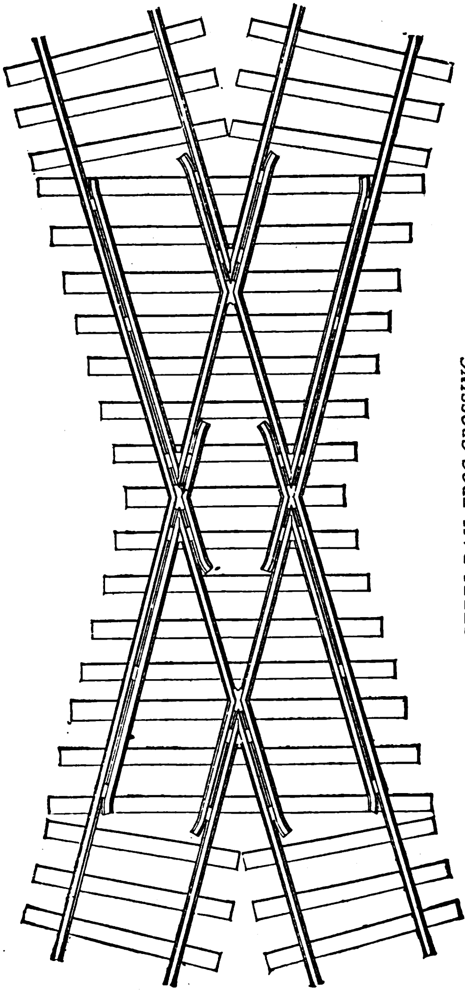
STEEL RAIL FROG.



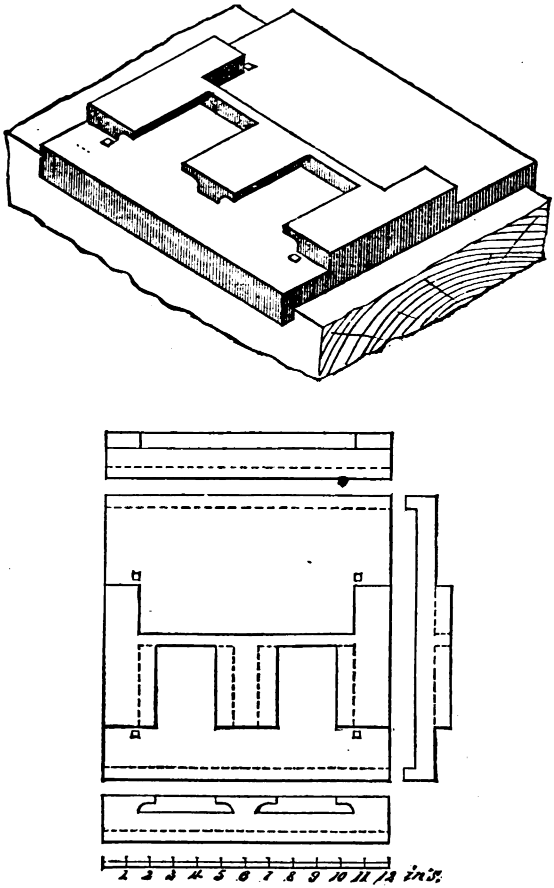
SWITCH-STAND.



SEMAPHORE SIGNAL.

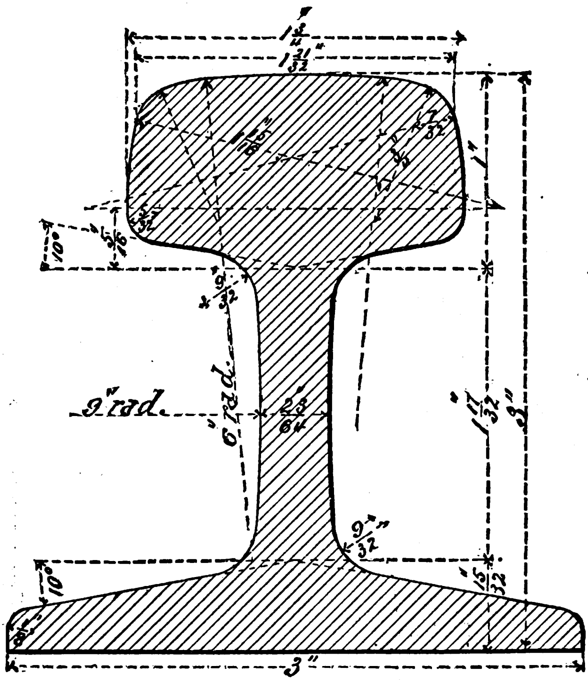


STEEL RAIL FROG-CROSSING.
For angles of less than 30° only.



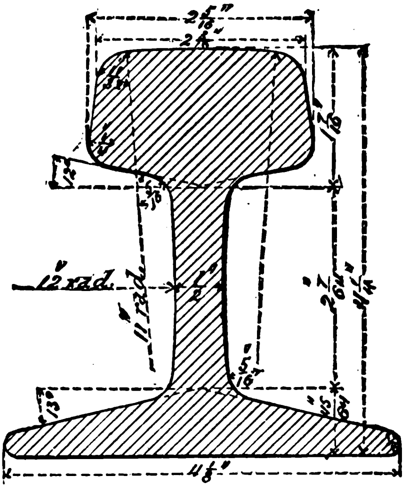
MALLEABLE IRON HEAD-CHAIR.

Designed by R. Gurley, and used on Atlantic & Great Western Railroad.

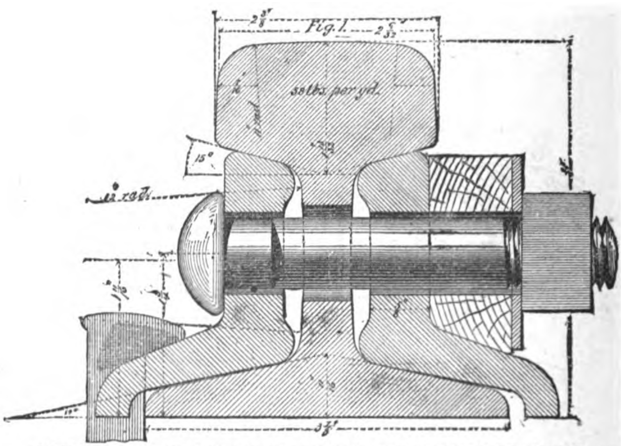


LIGHT RAIL.

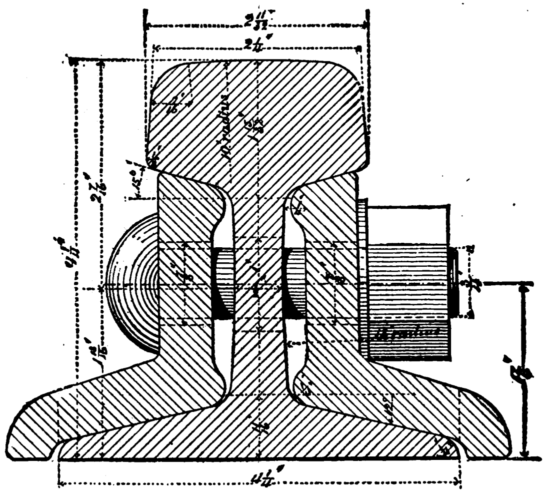
Full Size, 30 *lbs. per yard.*



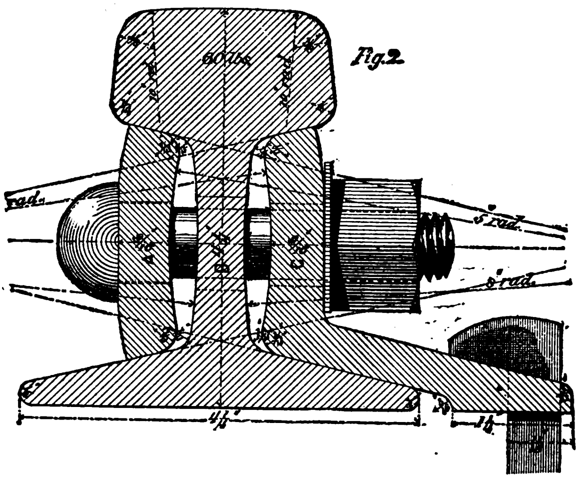
RAIL SECTION, PENNSYLVANIA RAILROAD. *Half size.*
60 *lbs. per yard.*



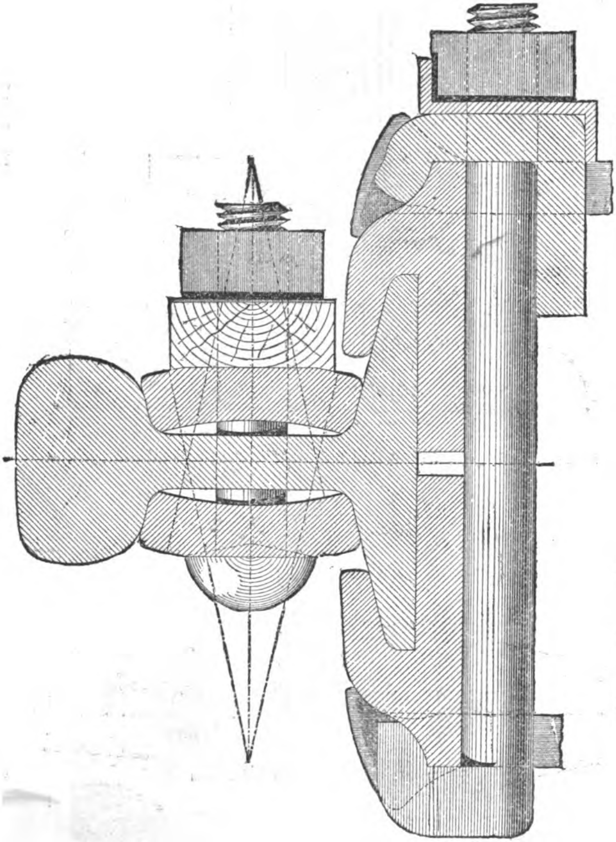
LOUISVILLE & NASHVILLE. RAIL AND JOINT SECTION.
Half size.



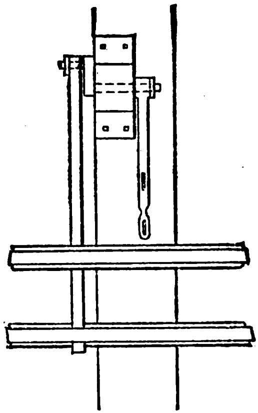
RAIL AND JOINT SECTION, ERIE RAILWAY. *Half size.*



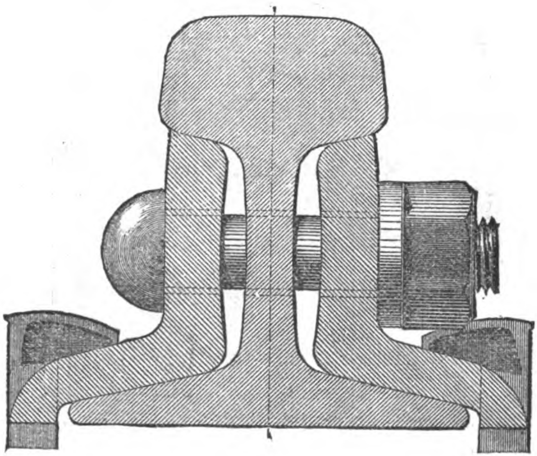
RAIL AND JOINT SECTION, PENNSYLVANIA RAILROAD.
Half size.



RAIL AND JOINT SECTION, ATLANTIC & GREAT WESTERN.
Pattern of 1873. Half size.



GROUND SWITCH LEVER STAND.



RAIL AND JOINT SECTION, PITTSBURGH CINCINNATI & ST. LOUIS RAILWAY.

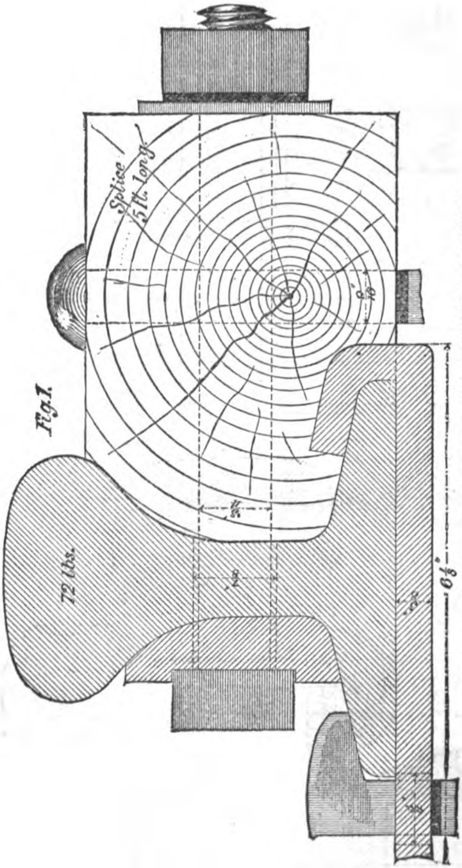
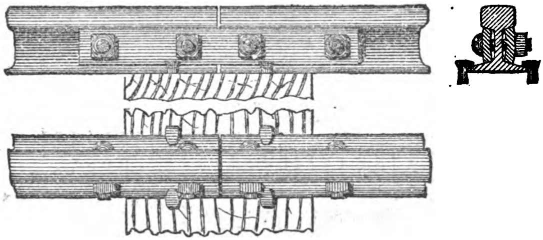
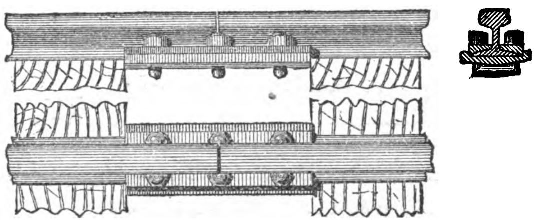


Fig. 1.

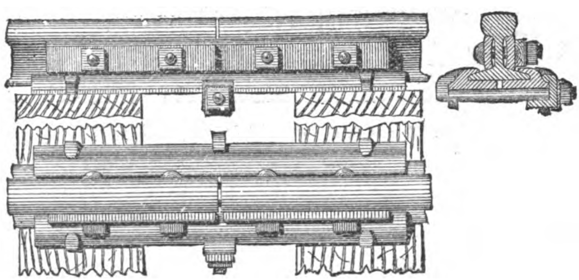
RAIL AND JOINT SECTION, BALTIMORE & OHIO.



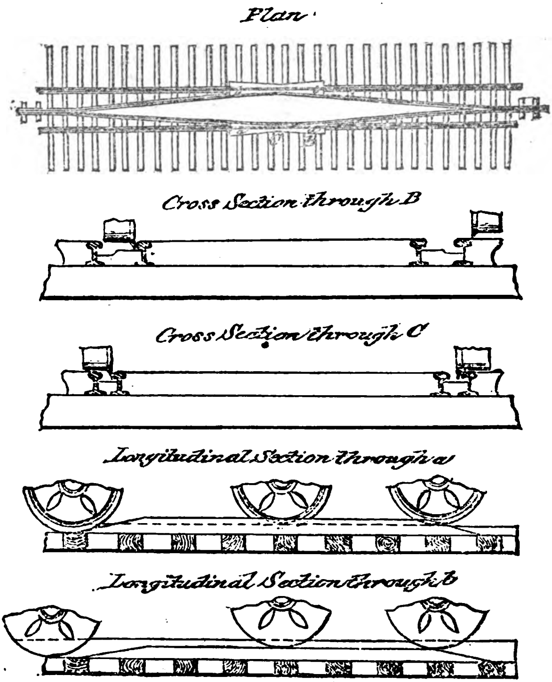
ORDINARY FISH-PLATE.



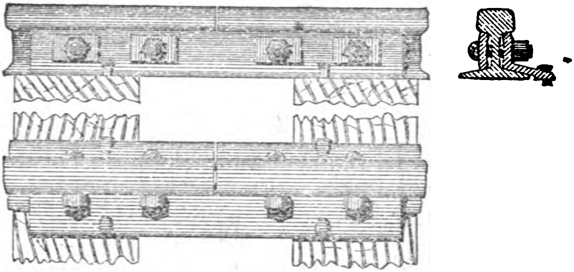
THE FISHER JOINT.



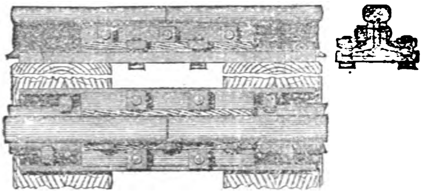
DOUBLE JOINT, ATLANTIC & GREAT WESTERN RAILROAD.



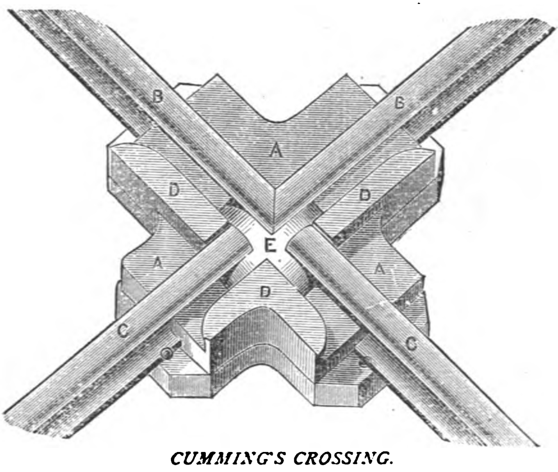
LATIMER'S SAFETY-GUARD FOR TRAINS.



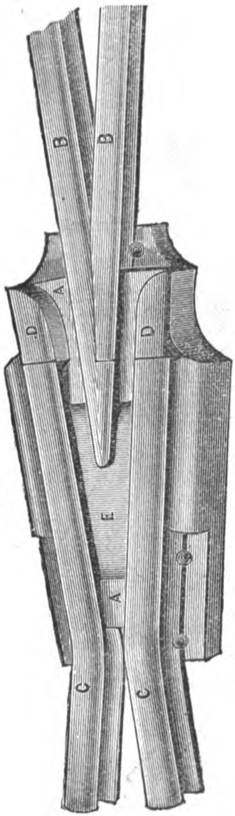
REINFORCED JOINT USED ON PENNSYLVANIA RAILROAD.



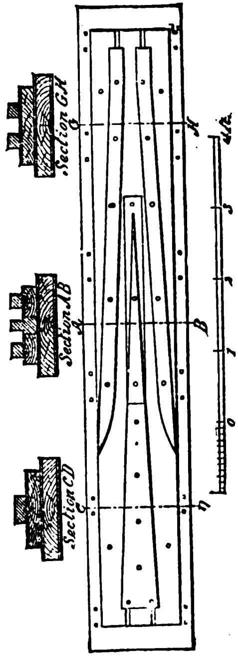
LINDENTHAL'S SUSPENDED RAIL JOINT.
(*The wooden slips in the angle of the fish-plate serve as a nut-lock.*)



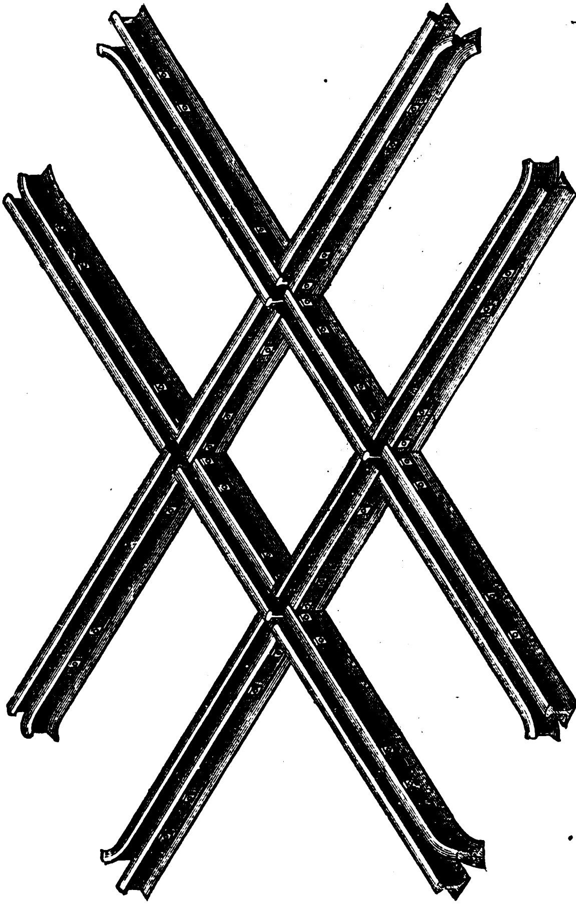
CUMMING'S CROSSING.



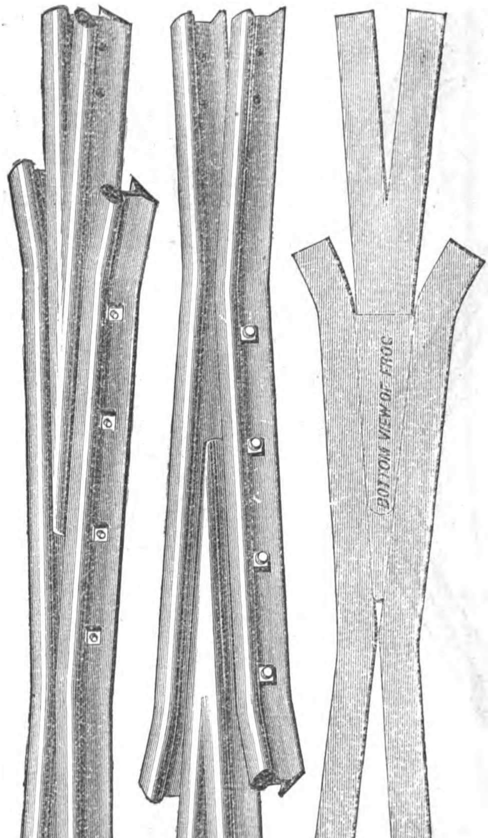
CUMMING'S FROG.



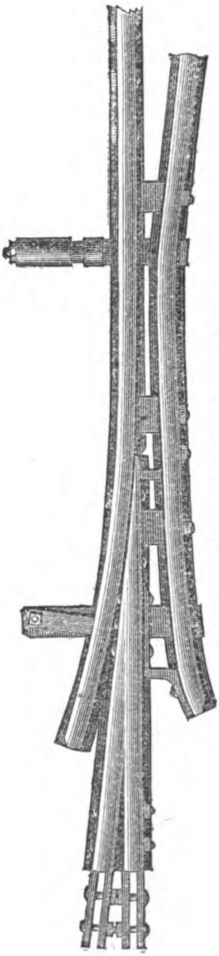
MANSFIELD ELASTIC FROG.



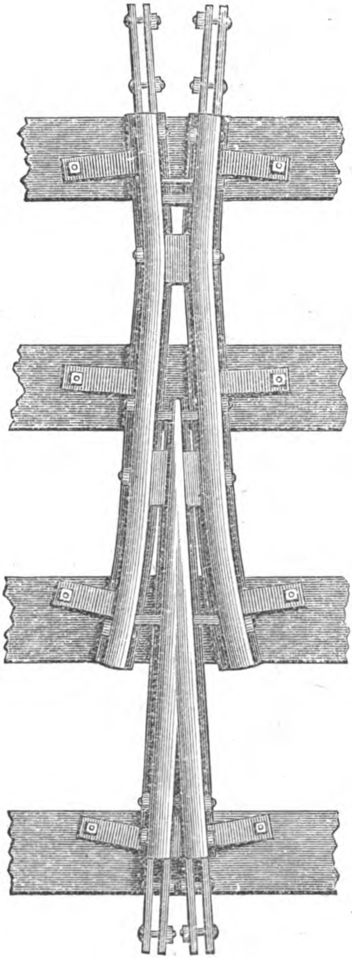
MORDEN'S T-*RAIL CROSSING.*



MORDEN'S T-RAIL LINE FROG.



BRAHN'S MAIN LINE SPRING FROG.



BRAHN'S DETACHABLE STEEL RAIL FROG.

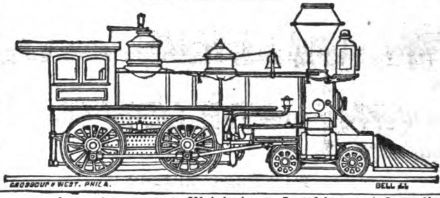
INDEX.

ADVERTISEMENTS.

BALDWIN LOCOMOTIVE WORKS.

Dimensions, Weights, and Tractive Power of Road Locomotives.

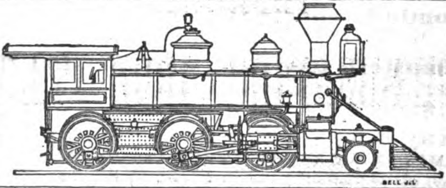
PASSENGER AND FREIGHT LOCOMOTIVE.



"AMERICAN" PATTERN.

Class Designation.	Gauge of Track.	Cylinder	Diameter of Drivers.	Weight in W'k'g Order. On Drivers.	Weight in W'k'g Order. Total	Load in tons (of 2240 lbs.) of Cars and Lading. On a Level	On a grade per mile of 20 ft.	40 ft.	60 ft.	80 ft.	100
8—14 C	3 or 3 ft. 6 in.	10x16	40 to 44 in	22,000	33,000	525	245	150	105	80	65
8—16 C	"	11x16	"	24,000	36,000	600	280	175	125	95	75
8—18 C	"	12x16	"	27,000	40,000	665	310	195	140	105	85
8—20 C	"	13x16	"	31,000	45,000	740	340	215	155	115	90
8—18 C	4 ft. 8 1-2 or 5.	12x22	56 in.	28,000	44,000	665	310	195	140	105	85
8—20 C	"	13x24	56 to 66 in	32,000	50,000	740	340	215	155	115	90
8—22 C	"	14x24	"	35,000	55,000	835	380	240	170	125	100
8—24 C	"	15x24	"	39,000	60,000	930	430	270	190	140	110
8—26 C	"	16x24	"	42,000	65,000	1000	460	290	205	150	120
8—28 C	"	17x24	"	46,000	71,000	1100	525	318	228	169	135
8—30 C	"	18x24	"	50,000	76,000	1200	575	350	283	188	150

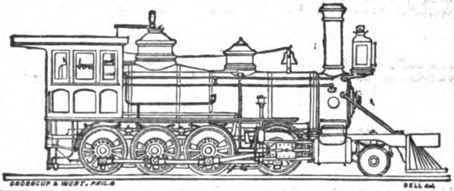
FREIGHT LOCOMOTIVE.



"MOGUL" PATTERN.

8—16 D	3 or 3 ft. 6 in.	11x16	36 to 40 in	29,000	35,000	720	335	210	150	110	90
8—18 D	"	12x16	"	33,000	39,000	840	390	250	180	135	110
8—20 D	"	13x16	"	37,000	44,000	965	445	285	205	160	125
8—22 D	"	14x16	"	41,000	48,000	1000	470	300	215	165	130
8—24 D	"	15x16	"	46 000	53,000	1100	525	318	228	180	145
8—26 D	4 ft. 8 1-2 or 5.	16x24	48 to 54 in	57,000	66,000	1400	655	415	300	230	180
8—28 D	"	17x24	"	62,000	71,000	1500	695	445	320	245	195
8—30 D	"	18x24	"	66,000	76,000	1600	740	470	340	260	205
8—32 D	"	19x24	"	70,000	80,000	1695	820	500	365	275	220

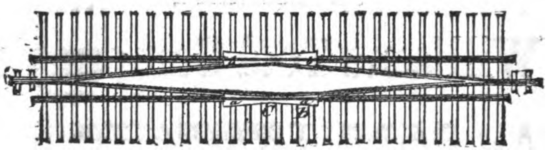
FREIGHT LOCOMOTIVE.



"CONSOLIDATION" PATTERN.

10—22 E	3 or 3 ft. 6 in.	14x16	36 in.	44,000	52,000	1060	490	310	220	175	140
10—24 E	"	15x18	"	50,000	58,000	1200	560	355	255	195	155
10—34 E	4 ft. 8 1-2 or 5.	20x24	48 in.	88,000	102,000	2000	990	635	460	350	285

An ounce of prevention is worth a pound of cure.



Latimer's Safety-Guard.

The safety-guard is placed at each end of bridge, or at dangerous places, and, unlike guards generally, is for the purpose not only of protecting the bridge, but of bringing a derailed train upon the track again the moment it is reached.

It has been practically useful on the Chicago & Michigan Lake Shore Railroad, at St. Joseph, Michigan, in saving trains from going into the river. Also has been useful in saving a bridge on the Atlantic & Great Western Railroad, and is also in use on the Louisville & Nashville and the Michigan Central Railroads.

CHICAGO & MICHIGAN LAKE SHORE RAILROAD,
GENERAL MANAGER'S DEPARTMENT,
ST. JOSEPH, MICH., Feb. 28, 1874.

C. LATIMER, ESQ.

DEAR SIR: The safety-guard which you placed at each end of the bridge across the St. Joseph River at this place has upon two occasions saved our passenger-train from going into the river by bringing it back on to the track after it had been derailed, thus probably saving the drawbridge and the lives of passengers.

On one occasion when an excursion train arrived at the north end of the bridge one of the coaches jumped the track. The pulling of the bell-cord confused the engineer so that he did not stop until the train had passed over the safety-guard and was on the track all right.

It is an invaluable improvement to prevent accidents, and especially when a bridge is approached by a curve, as is the case with both ends of the bridge at St. Joseph. Yours truly,

A. H. MORRISON, General Manager.

Address

CHARLES LATIMER, Cleveland, Ohio.

Si