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A BRIEF HISTORY OF RAIL
AND
TIE RENEWAL AND MAINTENANCE

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Rail Renewal and Maintenance Practices

In recent years there has been an increasing demand that this particular phase of Track Maintenance be done with maximum efficiency and economy. The practices in recent years are of great interest because of this and because of the rapid developments taking place in equipment and methods employed in this work. The work must be of the highest caliber to eliminate possible damage to new rail, and at the same time the interference with traffic must be held to a minimum due to faster schedules in both freight and passenger service.

The use or introduction of power-machines in maintenance work is quite recent, and the expansion of their use has been so rapid that the development of methods for their application has, because of necessity, kept pace with the great expansion and progress made by railroads in recent years. Not over twenty years ago the practice on most railroads was to organize a construction gang commonly known as an "Extra Gang", which was engaged in a series of operations in one season such as laying rail, ballasting, surfacing, ditching, widening embankments, and many other classes of work for which a need arose. Today, in contrast, the "Extra Gang", as known to modern railroads, is organized for specific work and is equipped with power tools adapted for the particular task assigned, to the exclusion of all other work. As a result of this specialization, and the introduction of power equip-

ment, labor costs in laying rail have been reduced in many cases from as much as $1,200 to $1,400 to as low as $400.00 per mile. These figures include all equipment charges and cost of reclaiming the released material.

The rail gang has developed progressively from manual methods, through a transition period, to a standing of complete mechanization. Origionally 25 to 75 men comprised the force organized on the division basis. The work was carried out in these cycles--preparatory work, the actual laying, and the completion of bolting and spiking. Men employed were expected to do any or all of the jobs, and when the rail laying was completed, were turned back to do the ballasting, assigned to some other job, or disbanded for the season.

The introduction of the rail crane increased the speed of rail laying to such an extent that in order to avoid delay in placing of rail, much larger forces had to be employed to do the work. Development of the tie adzing machines, spike pullers, bolting machines, and spike drivers has helped to reduce the large number of men required. At the present time a gang of 150 to 175 men now presents a well balanced operating unit, far more efficient than would be possible using manual or semi-manual methods. The work is divided into separate operations performed by self contained units, which complete the job in one cycle, progressing together at the same rate. Greater economy and efficiency is obtained by turning over this work to specialized gangs equipped with power tools, due to the fact that the individuals are assigned to particular operations and become proficient after a time without an increase in effort expanded.

Power tools may be obtained for almost every operation in rail laying and maintenance, from distribution of new material to the picking up of scrap material. In the general order of sequence of operation in renewal work they are as follows:

> Power rail unloaders including wheel and crawler-mounted cranes of various types operated on flat cars; power-operated nut removers or wrenches for uncoupling the old rail either in the track or lined out of track; acetylene cutting outfits and pneumatically-operated rivet busters for removing bolts with "frozen nuts"; power spike pullers either pneumatic or gasoline operated types; power adzing machines or scoring machines where ties are adzed by hand; special rail laying cranes or locomotive cranes, operated by steam, gasoline, or diesel engines for setting in the new rail; pneumatic, electric and gasoline or diesel engine-operated rail drills; power wrenches of various types for turning up the joint nuts; pneumatic cut spike driving hammers; power rail saws, acetylene cutting equipment and high-speed grinding wheels for making closure cuts in rails; power and hand operated bonding drills and welding equipment for the application of signal bonds; power-operated wood-boring tools and machines for boring ties for either cut or screw spikes; power-operated wrenches for turning down lag screws in tie plates; power nut runners and wrenches for applying special bolted types of rail fastenings where used in place of cut spikes; grinding machines for cross cutting and chamfering rail ends; grinding units for removal of mill tolerances in the height of new rails; electric arc and acetylene torch equipment for hardening ends of new rails in the field; and cranes and rail loaders of various types equipped with tongs or magnets for picking up released rail and scrap.

All of these power tools and equipment are especially designed to facilitate and speed up rail laying operations; to produce high quality work; and to obtain the greatest possible life from the rail.

To show just how this particular phase of track maintenance has developed I will briefly go through the past and the present organization of a rail laying gang. The methods employed in the past are still in use on small roads and on small branches where it is not deemed feasible, due to limited programs, to employ the methods of the specialized gangs.

I have briefly mentioned the organization of the "Extra Gang" before, and will expand upon it, detailing the different operations as they are performed in sequence for rail laying operations.

The "Extra Gang" is composed of the following types of workmen. It is either made up by a bunching of regular section gangs with the aid of local labor, or is organized separate from the regular section forces. This is dependent upon the program to be followed. An extensive program warrants the latter method. We will suppose here, that the program is an extensive one, and the crew will be organized apart from regular section forces.

The housing problem of the two organizations are quite similar so I will go into a brief description veiling nothing of the living quarters. The men are housed in bunk cars. These cars are usually old coaches rebuilt with two rows of double deck cots, one along each wall. There are facilities for washing in each car. Usually a gang of 250 men will require about 20 of such bunk cars. In addition to the bunk cars, there are several cook cars and perhaps 5 dining cars.

These dining cars are quite removed from any idea you may have of a railroad dining car. It consists merely of an old coach with everything removed except the floor and interior fixtures. In the center of the car running the whole length is constructed a table with a row of benches on either side. The camp as it is called consists also of several cars of a little later vintage for the housing of the General Foreman and the Assistant Foreman who are in most cases transferred from a regular job somewhere on the division to supervise the gang during the working season. Some Roads attach so much importance to this work that in many cases a Roadmaster is transferred from his regular duties and assigned full time to the work of organizing and supervising such a gang.

To go on with the description of the old method of doing the work I will write a little concerning the type of labor employed. As a general rule about 25 per cent of the crew remain with it for the duration of the job, the other 75 per cent consists of what one might call migratory workers. These men are drifters and work 2 or 3 days and then move on. This causes a continuous flow of men and very definitely cuts down the efficiency of the gang as a whole. The predominating nationalities are Mexican and Greek with local labor making up a small minority. The men are transported from the Camp to the Job on trains of track-car trailers towed by motor cars.

We shall now look into the actual work of relaying rail. In sequence the operations are as follows. It is first considered essential that the track be in good surface and line, and that all low joints be tamped up in advance of the rail laying operations. The method generally employed was and still is to a great extent, to lay one line of rails at a time and to double back on the other rail.

The first operation consisted of the distribution of material. This includes the rail, angle bars, joint bolts and nuts, spikes and tie plugs. The rail is distributed by work trains from flat cars on which it is shipped from the steel plant. The material for both lines of rails being unloaded simultaneously ahead of the gang proper. A large crane being employed in the work train. The rail is strung out along the track as close as possible to its proposed position in the relaid track with sufficient clearance to do away with any obstruction to the present track, usually about 7 or 8 feet clearance. Spikes, bolts, plugs, and bars are unloaded in large quantities at intermediate points for sub-distribution. Tie plates are unloaded also at intermediate points in a predetermined quantity for replacement of worn out or outmoded plates already in service.

An advance crew prepares the rails for laying by attaching to the end of each rail a set of angle bars. All fastenings are attached with hand wrenches. The actual relaying operation begins with the spike pullers who proceed the main gang, and remove the spikes on the line being renewed, usually the right hand rail in direction of progress. They employ hand tools mainly claw bars. The standard size as given in American Railway Engineering Association specifications is as follows: The standard number one is 5 feet long and weighs

26 pounds. The working end is in the shape of a claw to engage readily with the spike. Leverage, which is at the maximum when the spike is to be started from the wood and diminishes regularly as the spike is being withdrawn, is provided by the heel which is in the arc of a circle, so that the fulcrum is moved continually inward. The toe of the claw has a maximum width of 3¼ inches and the claw opening which is about 1½ inches deep narrows from a width of 7/8 of an inch at the front to 13/16 of an inch at the back. (A.R.E.A. specifications.) The spike pullers are followed closely by the crew that removes the joint fasteners. They employ hand wrenches for losening bolts and in case of frozen nuts, they employ chisels and sledges for the cutting of such fastenings. The rails are then rolled over to the side, clear of the track and the plates removed. The spike holes are then filled with tie plugs which are small wooden pins shaped to fit the hole produced by a spike. They are tapped down with a hammer so as to fill the hole completely. The ties are then adzed or dapped by hand with an adze to secure a level bearing for the tie plates. The hand adze is used in all branches of maintenance and the specifications set up by the A.R.E.A. are as follows: The blade may be either 7, 8, or 9 inches in length and the respective weights are 5, 5½, and 6 pounds. The lift of the adze is 1 5/8 inches and the width of the blade 4 inches. Open hearth or alloy steel with Brinell hardness of between 375 and 450 is specified. The limit of economical wear specified is 2 inches. After the ties have been adzed level, the tie plates are re-

placed and the track is ready to receive the new rail. The rail is set in place by hand, using approximately ten or twelve men with hand tongs to carry the rail to its position in the track. Two of the four bolts in each joint are fastened and the rail is spiked down at every third or fourth tie to gauge from the rail opposite it. This spiking is done by hand using spike mauls complying with A.R.E.A. specifications, which state:

> No. 1 Spike maul with bell face having equal striking faces of 1 5/8 inches diameter and No. 2 having one face 1 5/8 inches and the other face $1\frac{1}{4}$ inches. The length of No. 1 is 14 inches and No. 2 is 15 inches. Approximate weight of each is 10 pounds. A Brinell hardness from 425 to 500 is specified. The eye is so placed that the weight is evenly distributed between the two portions. The oval eye is 1 3/8 inches by 1 inch and beveled upward to permit wedging of the handle in the eye. The spike maul handle is made of hickory and is 36 inches long. About 10 inches from the hammer, its section is reduced to 1 1/8 inches by 7/8 of an inch to afford the necessary resilience.

This is followed by the final spiking and bolting of the newly laid rail. It is spiked to line, and joints are securely bolted; hand wrenches being employed. Loose ties should also be tamped solidly, and in this operation ordinary hand methods are employed, using the regular No. 2 track shovel. The track is then thoroughly anchored with various types of anti-creepers. In the event that a short section of rail had to be employed in making a closure the method of cutting rail was as follows. The rail was placed with each end on a support about 6 to 8 inches in height, and a load applied on the rail which was very much in the position of a simple beam supported at both ends. Using a track chisel and sledge the base of the rail was cut with a succession of chisel marks until, due to the cutting and the stresses set up in the rail by the load, the rail would break giving a fairly even cut. The rail then had to be drilled for the joint bolts. This too was done by hand, using rotating machines for special hard steel boring tools. The track drill, a portable machine tool designed to drill horizontally through the webs of rails, especially for track bolts at rail joints, is made in two all steel types; the one man ratchet drill and the higher speed double-cranked bevel geared machine, with fastenings to clamp it solidly to the rail. This is mainly to show that in all these operations hand operated tools were used. These methods are still employed by the regular Section Crews of 4 or 5 men in the maintenence of a small portion of the division. In contrast to this I would like to go through the same procedure as followed by the highly specialized rail gangs now employed on large scale programs.

The material is distributed in much the same way either types of rail unloading cranes being used. Small locomotive cranes and crawler-mounted cranes, operating from the floor of flat cars or drop-end gondola cars are used most extensively in rail unloading operations. Crawler cranes may operate directly from the floor of the car and for the full length of the train if necessary, while other types operate over temporary tracks constructed on the floor of the cars. The adoption of 39 foot rails almost universally by Railroads has brought into play the track crane which is virtually a full revolving locomotive crane with lifting capacities from 2 to 7½ tons, equipped with a boom 25 to 35 feet long and capable of handling two cars loaded with rail. These cranes adapted to one man operation and powered by gasoline or diesel engines lay rail at an average cost of approximately \$.08 per rail as compared with \$.20 per rail laid by hand. They can be fitted with a magnet for picking up scrap material such as tie plates, spikes, rail, etc.

Many improvements have been made in the design of power wrenches for tightening and loosening nuts, and at the present time they perform this operation at approximately ¼ the cost of hand labor. They incorporate either pneumatic, gasoline engine, or electric power units.

Replacing the claw bar as a spike pulling unit is the power operated spike puller. They are either gasoline or compressed air powered. The pneumatic spike puller is a small one-man tool, which is moved from tie to tie and spotted over each spike, capable of pulling from 10 to 12 spikes a minute. The mechanical spike puller is a self-contained unit, track mounted on four wheels and capable of pulling as many as 35 spikes per minute.

As compared with the hand adze, the power adzer is a gasoline powered rail mounted unit with an adjustable cutting head, which when pressed into the tie provides a uniform and smooth surface for the tie plates or rails in the event that no tie plates are used. The introduction of the power adzer has reduced the cost of adzing per 100 ties from \$.70 to \$.23.

When relaying rail with new ties, especially ties that are not bored and adzed in the plant, the power operated tie boring machine is used. The purpose of boring is to facilitate the spiking operations and to insure the vertical driving of the spikes. Powered by a gasoline engine, one man operated, the mechanical tie borer is mounted on rollers enabling it to be rolled along the top of the rails. It is capable of boring 1200 to 1500 holes per hour.

In place of the back breaking, spiking by hand method, the modern, well equipped rail laying crew resorts to the use of the pneumatic cut-spike driver. These are light weight, easily handled one man machines capable of driving an average of 150 spikes per minute. The cost of driving spikes has been cut from $.75 per 100 spikes for hand labor to $.50 per 100 spikes machine driven.

In making closure cuts where several rails are to be cut the power drills operated by gasoline, pneumatic, or electric power are widely used. Power rail drills are designed to be clamped on the rail head and held firmly in position while the hole is being drilled.

Power rail saws have replaced completely the old method of sledge and chisel cutting of rails for closures. They are portable machines, gasoline driven and used especially in the field on large rail laying jobs. The cutter is held to the rail by a powerful clamping device and needs no attention while cutting is in progress.

Oxy-acetylene welding and cutting equipment is used extensively for cutting rail in making closure cuts and for burning off nuts that cannot be removed by the ordinary methods.

The rail renewal taken care of, the next step is the maintenance of the rail as placed. The wear of rail in the track depends upon many factors, the most important of which are the following: The character of maintenance, the tonnage passing over the track, the individual wheel loads, the elevation of the curves, and the speeds run in relation to the elevation of the curves. Usually the points of the greatest wear are at the joints. The efficiency of the joints is directly proportioned to the degree of tightness maintained in the different parts of the joint. It also depends upon the adequacy of tie support and proper anchorage of the rails. Curve elevation is determined with reference to train speed, but considers also the physical properties which tend to limit train speed. Weather conditions also affect the proper maintenance of rail. The prevention of sun kinks in the summer due to over expansion, and the proper shimming in winter to keep the rail in good surface so that any undue shock might be avoided at that time when the steel is most sensitive and liable to fracture.

The causes, other than actual wearing of the rail joints, which are most common in making rail unfit for use without necessary reconditioning are rail batter, end overflow and chipping. Rail batter is the condition existing when the rail ends are mashed under the repeated blow of the traffic. End overflow, also a product of the impact of traffic, is the flowing of the metal at the top of the gauge side of the rail head into the gap provided at the joint for expansion. This not only is a source of deterioration, but is also a menace at insulated joints as it might result in bridging the gap by the track current. After years of intensive study on the problem of rail batter the A.R.E.A. Committee on Rail has adopted the following recommendations:

1. Objectionable batter can be prevented by the hardening of rail ends through suitable heat treatment with a Brinell hardness not exceeding 450.

2. When rails are laid the difference in surface heights of adjacent rail ends shall be corrected by grinding. After heat treatment of ends, and before traffic, the hardened ends should be cross ground and slotted.

3. For the purpose of securing uniform measurements of rail batter in further studies, a rail batter gauge should be used.

These recommendations have increased to a great extent the actual service period of rail.

The building up of battered rail ends is not a new inovation in the track maintenance, but it was not until the depression period that most Roads adopted it as an expense reducing medium. After long observation and the collection of innumerable service records it has been recognized as a most important means for economical and practical track maintenance. The process of hardening rail ends, as applied to new rail, increases to a great extent the service life of the rail and is a means of prevention rather than one of repair. The operation consists of hardening the upper surface of the rail head for a distance of about 2 inches back from each end, and to a depth of about ¼ of an inch at the end and tapering off proportionally to the distance from the end. This portion is given a hardness that exceeds the regular rail hardness by about 100 divisions on the Brinell scale. Several different methods are employed in hardening rail ends, including methods used in the steel mill during the rolling process. Methods used in the field include oxy-acetylene and electric arc and usually follow the grinding operation. Although this is sufficient for resumption of traffic, the rail is subjected to further treatment which includes slotting the rail ends and providing a slight bevel or chamfer to reduce end flow and chipping; surface grinding to remove any differences in surface heights; and the heat treating of the rail ends which are now being taken up. These are all modern practices and were unknown to the railroad maintenance men a few years back. The battering of rail was corrected in the old days by rerolling and replacement of the battered rail.

With the advent of the streamline trains many problems confronted the railway engineers which prior to that time were relatively unimportant. Among these was the problem of providing the necessary smooth riding quality of track in both surface and line. This was quite serious due to the fact that most roads had many miles of old rail with joints worn to such a degree that smooth riding at high speeds was an impossibility. The renewal of this rail was impractical from a financial standpoint, and the program of reconditioning was quite limited.

Welding practices were employed by many roads to meet the problem. With highly organized management, the work was done swiftly, so that with rail ends rebuilt to their original shape, and with additional hardening, smooth riding track was ready for the fast speed trains. The past few years have provided an excellent proof of the efficiency and economy of such methods.

These methods have now been adopted by most of the Class I Railroads. Both the oxy-acetylene and the electric arc methods are widely used. Both methods employ portable equipment, which in the oxy-acetylene method is limited to the cylinders for the gas, the torches, and the welding rods. These are carried along as the work progresses. The electric arc method employs a self-contained unit which consists of a track mounted generating unit and long transmission lines for carrying the welding current to the welders. The work in both cases is usually organized on the production basis, and several crews work on a confined district under the same supervision. This tends to produce a uniform quality of work, and reduces costs considerably.

Before welding, all of the battered metal is removed from the end of the rail to provide a solid base for the weld. Preheating of the rail end to be welded increases both the speed of welding and the bond between the weld and the rail metal. The type of electrode used in the electric arc method and specially designed welding rods in the gas methods, determines the hardness of the weld, which is carefully controlled. In most cases the added metal is harder than the original rail so that an eveness of wear is obtained. This work is done with the rails in place. Thus eliminating the cost of removing the rail and the transportation cost encountered when the rail is taken up and resawed or cropped at a reclamation plant, as was the practice of years before the introduction of these rebuilding methods.

The most popular oxy-acetylene method employed is the OXWELD process developed by the OXWELD RAILROAD SERVICE CO. of Chicago. The TELEWELD process, as described by TELEWELD INC. of Chicago, is the most widely used electric arc welding method. It combines preheating and differential tempering, for the reconditioning of rail in the track by building up battered and chipped rail ends to their original surface.

Another rail condition, that has demanded correction due to the introduction of high speed traffic, is rail corrugation. It is a condition which develops on the wearing surface of the rail head during service. It is characterized by alternate series of small shiny marks at frequent intervals indicating humps and depressions in the rail surface. After quite an extensive study the A.R.E.A. Committee on Rail found that rail corrugation occurs on almost any type of rail, tangent curves, high speed, and low speed track. The depth of corrugation as measured during the survey averaged from .003 to .005 inches and from 1½ to 10 inches long. Rail corrugation is corrected by grinding, and a specially designed grinder car is most generally used in the correction of this defect. This car is pulled over the rail and abrades the rail head constantly until all surface corrugations are removed to the degree desired.

Many methods have been introduced for the reduction of rail wear. It has been estimated that there is over 60,000 miles of curved track in this country, and considering the wear of rails, wheel flanges, and locomotive tires this amounts to an appreciable waste in the operation of trains. This tre-

mendous waste not only is shown by the frequent rail and tie renewals and in the turning of wheel flanges, but also in loss of locomotive power and traction. As the rail and wheel flanges wear, the contact area progressively increases, thus increasing frictional resistance and curve resistance. It is estimated that rail wear increases approximately as the square of the degree of curvature and that the tonnage necessary to produce the same rate of wear varies almost directly with the degree of curve. Rails in curves worn to any degree fomerly caused a great deal of concern not only from the economy of replacement but also because of the greater number of derailment. Rail and flanges were lubricated manually and although the lubricant was generally applied only intermittently it reduced the wear considerably and increased the service life of the rail. The methods employed in yester-year were developed for operation from locomotives or tenders and applied the lubricant to the flanges of the drivers or to the rail head directly are contrasted to the modern automatic rail lubricators. These lubricators comprise a storage unit for the lubricant and an apparatus which is operated by the passing trucks, and which applies a graphite grease or heavy oil upon each flange passing over it. The application of lubricant by hand methods is too expensive and the automatic oilers have the advantage of being located where they are needed most. The old method is all right but fails in the fact that it does not apply lubrication to all wheels nor does it apply it in proportion to the tonnage as does the automatic device. The use of automatic oilers has shown, that in addition to prolonging the life of the rail from 2 to 4 times as compared to unlubricated rail, many other advantages such as a definite reduction in the amount of gauging and relining of curves and a pronounced increase in the life of switch points and frogs. It likewise is of great importance on lines over which are operated refrigerator cars in the fact that it protects the track and fixtures from the corrosive action of brine and engine drippings.

Another important phase of rail renewal and maintenance practiced by most American Railroads is the reconditioning of worn rails. The Rail removed from the important main lines is classified according to the various defects resulting in its removal from main line service. This procedure is followed only if the rail cannot be built up in place by any of the methods described in the preceding paragraphs. In this reconditioning plant the rail is end-cropped or rerolled. Recropping consists in sawing or cutting off the damaged portion of the rail end by either friction saws or oxy-acetylene cutting torches. The end is then ground and redrilled for track bolts. The advantage of cropping rail ends over the repaired in place rail, is the moderate expense of reconditioning, but due to the added shipping and handling of the rail it has become outmoded.

Rerolling of rail has more or less been discarded by most roads as being too expensive a procedure and also due to the introduction of the practice of rebuilding and hardening of rail in the track. The process was to form rails of a uniform height and contour on the gauge side with a minimum loss in weight per yard and a slight increase in length instead of a loss as in end-cropping.

Thus we see the important saving and efficiency in rail renewal and maintenance brought about by the modern demand for speed and long service. The use of power tools has and definitely will remain an important factor in economical track maintenance.

Tie Renewal and Maintenance

Probably the greatest single item of expense for material, in Railroad maintenance, is the item of ties for tie renewals. The expense of renewing ties is also quite high and for this reason great care has been taken in the selection of standards for ties, and in the requirements for their protection from injury and decay.

The prime purpose of the cross-tie is to bind together the rails to maintain them at proper gauge, and to distribute the load placed upon the rails to the ballast. Main track requirements usually demand 3200 ties per mile of track on an average. With this number the ties support 45.45 per cent of the total rail base area, with the same area bearing upon the ballast.

Wooden cross-ties are generally sawed to form simple beams rectangular in cross section, although on some foreign roads half round wood ties are quite popular. Many substitute ties of metal or reinforced concrete design are in the experimental stage but as yet have not been adapted for general use as cross-ties.

The general size of cross-ties as specified by the A.R.E.A. for main track usage has in recent years changed due to increased traffic, and the various specifications are far too numerous to mention here, but this information with sketches to illustrate, is obtainable in the standard A.R.E.A. handbook.

Switch ties usually come in complete sets and marked for length. The switch ties are used for the entire switch, and extend from the point of switch to a point somewhere behind the heel of the frog where the rails have spread sufficiently to allow the use of standard cross-ties. The purpose of using the long switch ties, is to eliminate the overlapping that would occur if short ties were to be used in the switch and frog layout. This overlapping effect prevents the proper tamping of the ends of the ties.

The wood used in the manufacture of cross-ties usually is timber of almost any serviceable soft or hard wood. The practice formerly was to cut timber as near as possible to their own rail lines to reduce transportation expenses. This, however, has been abandoned due to the scarcity of timber, and has brought about the introduction of using various preservatives to increase the service life, or to make possible the use of timber otherwise unsuitable for cross-tie renewal. It has been shown that the average cross-tie deteriorates 25 per cent due to mechanical wear and 75 per cent due to decay. The A.R.E.A. specifications list 26 different varities of woods suitable for use as cross-ties. The harder and denser woods are used in some cases untreated, but the general practice is to treat all ties with preservatives of some sort.

The A.R.E.A. Committee on Ties in its report at the 1937 convention presented the following recommendations concerning the seasoning of ties prior to their treatment. Almost all wood has to be seasoned before treatment, and it has been proved that almost all woods react best to air seasoning, and treat best after such seasoning. This period of season-

ing varies with the type of wood, time of year cut, location of seasoning yard, rain, humidity, and wind velocity, and, therefore, no definite length of time can be established. Ties stacked for treatment should be inspected periodically to insure their treatment before decay. Ties of the same species and of same cut should be stacked together so that they will all be ready for treatment at the same time. The stacked ties should be kept free from decaying vegetable matter so that their decay is not advanced. The grounds should be well drained so that no water remains standing in the low spots. Ties should be stacked so that the air is free to circulate between them. The ties should be stacked on sills of non-decaying material, and should be at least 6 inches above the ground. To prevent decay at points where the ties bear on one another the ties should be painted with creosote.

A great factor in the decay of both treated and untreated ties is the splitting and checking of the tie due usually to weathering conditions causing unequal contraction during the seasoning period. These splits and checks afford a wonderful lodging place for rot producing fungi. Within these splits and checks the spores develop and eventually the tie is unfit for further service. The splitting may also continue and render the tie mechanically unfit for service. This is corrected to some extent by the use of various devices, including irons of various shapes, formed from wedge shaped stock, which are driven into the end of the tie; spirally twisted dowels for driving 3 to 6 inches from the end; and various banding devices for the reclamation of split ties.

According to the latest statistics released, over two thirds of all treated ties are adzed and bored before treatment. The adzing provides a smooth seat for the tie plate on the tie reducing the movement of the plate on the tie, which is the greatest cause for mechanical wear along with the crushing of the wood fibers under heavy loads. Pre-bored ties retain the wood fiber more nearly in their undisturbed state than ties that have not been bored. The boring also affords a better penetration of the preservative into the tie. It has been the experience of the roads on which pre-boring and adzing are standard practice that beyond a doubt it is a distinct saving in mechanical wear as well as a greater resistant to decay.

The most widely used wood preservatives are creosote and zinc chloride. The faces of the tie are impregnated with the fungi killing preservative, and since any cutting or machining would destroy this coating it is the usual practice to adze and bore the ties before treatment. The economical amount of preservative to use, is that amount which will provide ample protection for the service life of the tie due to mechanical deterioration. Distilled coal tar, creosote, solutions of creosote and coal tar, and water-gas-tar solutions are good waterproof coatings as well as fungi killing solutions. Zinc chloride, while it is poisonous, it also has the disadvantage of leaching out with water soaking, Recently a new form of chromated zinc chloride treatment has been developed to overcome this leaching out problem. The use of creosote and coal tar solution likewise tend to reduce splitting and checking. While no definite statement can be made of the economies of treating cross-ties it has been estimated that the introduction of pretreatment has cut down the renewal cost over 50 per cent below the renewals before ties were subjected to such treatment.

In tie renewal probably the most important operation prior to the actual laying of the ties, is the selection of the ties to be renewed. Because of the difference in organization of every railroad no single method can be outlined, as each road has its own procedure. The number of ties to be renewed is best determined by actual inspection, rather than statistical data as rarely are the renewals for the year the same as for the previous year.

The yearly tie inspection as followed by one of the larger roads, is organized on the Division Basis and the results are compiled and drawn up in each divisional office. The actual inspection is a twofold one and proceeds as follows: The preliminary inspection is made by the individual section foreman on his section and the number and type of ties are filed by the Roadmaster. Then the Division Engineer's office conducts an inspection with each Roadmaster, checking several miles on each section as to the number of ties specified by the foreman of that section. If he has not made an overstatement on the miles checked the rest of the territory is allowed the number of ties he has requested. If the number of ties requested by the particular foreman do not check, the engineer assigned to the Roadmaster of that division must check completely the foreman's territory.

Due to the large number of ties renewed every year, it is important that they should be renewed with the greatest possible economy. This vital segment of the maintenance problem in the past few years has been turned over to special gangs, operating in much the same manner as the steel gangs previously described in this paper. In showing the vast improvement in the renewal over the past few years I will run through briefly the operations involved in the tie renewal work.

The problem of the renewal and maintenance is attacked in quite the same manner as the problem of rail renewal and maintenance. The highly specialized organization equipped with power-operated tools now performs the tasks once accomplished entirely by hand labor. They operate on the division basis and vary in size directly with the extent of the program to be carried out. They travel from division to division on the System in much the same manner used by the rail gang, being housed in Camp Trains.

The operations of a tie gang in the sequence in which they occur are such that I shall attempt to contrast the hand method with mechanized methods as I proceed.

The material must, of course, first be distributed. This includes the ties, spikes, tie plates, and in some cases the rail anchors. This operation is performed with the use of section cars and trailers, and in some cases when the renewal is extremely heavy, a work train is utilized, and the ties are unloaded directly on the job from the cars in which they were shipped. The handling of the treated ties is best accomplished by use of tie tongs, which are quite similar in action to the ordinary ice tongs as we know them. This not only facilitates the handling of the tie, but prevents serious burns that often accompany the handling of creosote treated ties.

A tie gang is organized usually in the following manner in sequence of operation. The spike pullers are what you might call the lead-off men. This operation formerly done by hand labor using claw bars, is now accomplished by the automatic power operated spike puller as described previously.

The head-end gang, as it is know, follows the spike pullers and consists of the major portion of the gang. Their work is to dig out the ties to be renewed. This consists of digging a channel from the end of the tie to a point where the line of the shoulder ballast intersects the plane of the bottom of the tie. This channel is for the speedy removal of the tie. This operation performed in the modern method, has two alternatives. A recent introduction is the tie cutter which saws the tie into three pieces as it lays in the track, thus enabling it to be handled with the greatest possible ease and speed. Another method is the combining of tie and ballast work. In ballasting, the entire track is skeletonized and is jacked up on the top of the old ballast and new ballast is filled in. In the combined operation before the new ballast is applied, the ties to be renewed are removed and new ones inserted in their place. This combination does away with the digging required to remove the old ties.

New ties are slid under the track replacing the old ties, and the next operation performed is the tamping of the ties. Pneumatic tampers have replaced the hand method of tamping with a shovel. Their operation was previously described in the rail section as was the following operation of driving the spikes. The hand method of using a spike maul has completely been replaced by the power spike drivers in the modern large scale tie renewal program.

Following the spiking gang, is the dressing and scrap crew, whose work is to clean up the right-of-way. This includes dressing the ballast, removing scrap, and burning the old ties. They also do the lining and spot surfacing in a great number of instances.

The Railroads, and especially their Maintenance-of-way Department, have been slow in adopting special equipment and tools to accomplish their work. They are a little backward in this respect, but are steadily remedying the situation. In recent years it has been demonstrated beyond a doubt that the old methods of maintenance are expensive, and that if the costs are to be held to a minimum, the present trend toward power tools and equipment must be continued until modern methods are employed throughout the entire maintenance department.

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