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RAILWAY TRACK MAINTENANCE II

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READINESS/
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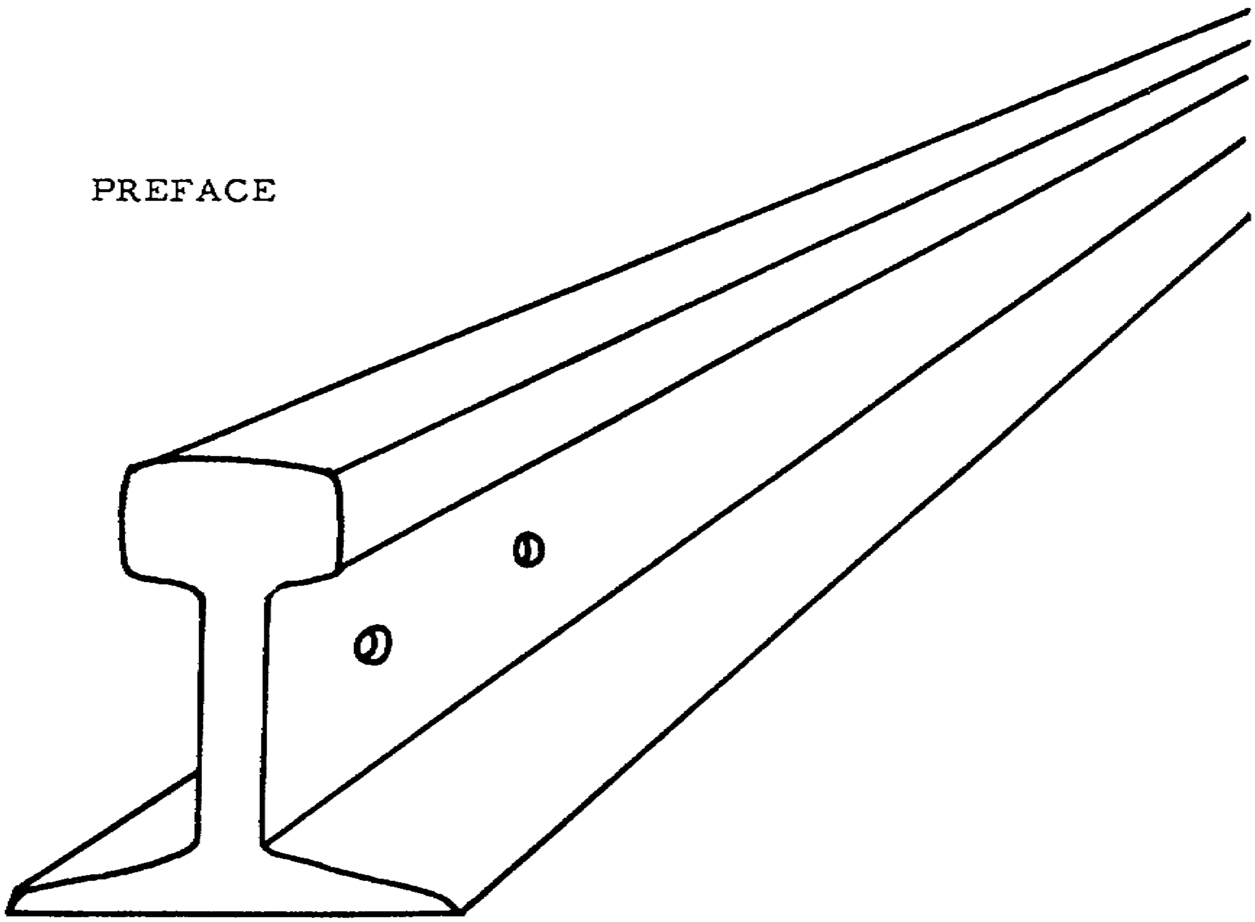
THE ARMY INSTITUTE FOR PROFESSIONAL DEVELOPMENT

ARMY CORRESPONDENCE COURSE PROGRAM

PREFACE



Reference Text (RT) 671 is the second of two texts on railway track maintenance. The first, RT 670, Railway Track Maintenance I, covers fundamentals of railway engineering; roadbed, ballast, and drainage; and track elements--rail, crossties, track fastenings, and rail joints. Reference Text 671 amplifies many of those subjects and also discusses such topics as turnouts, curves, grade crossings, seasonal maintenance, and maintenance-of-way management.

If the student has had no practical experience with railway maintenance, it is advisable that RT 670 be studied before this text. In doing so, many of the points stressed in this text will be clarified. In addition, frequent references are made in this text to material in RT 670 so that certain definitions, procedures, etc., may be reviewed if needed.

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***** IMPORTANT NOTICE *****

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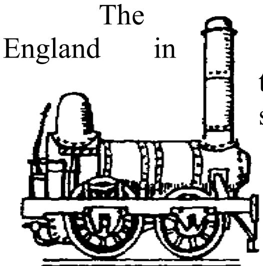
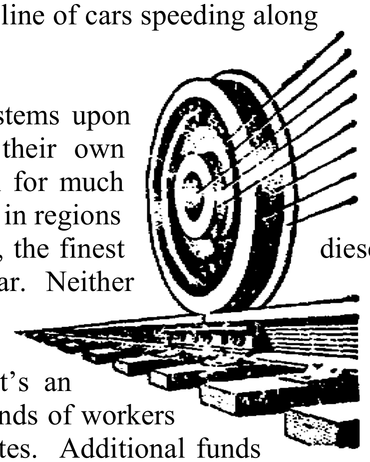
INTRODUCTION



The first railway coach rolled along the tracks of the Stockton and Darlington Railroad in England in 1825. Ever since, trains have attracted widespread attention not only as a kind of transportation but also because of qualities that endear them to an admiring public. The small boy seeing a real train for the first time shares his thrill with the sedate banker whose hobby is making model rolling stock. This special and often sentimental interest in trains is understandable; trains are big and powerful, and they're all going somewhere. They're moving all sorts of people and products to all kinds of places. With cargo unseen and destination unknown, they provide lay observers with a choice of the practical or of the romantic and mysterious upon which to speculate. They excite our curiosity whether we are thinking about a trip, planning a shipment of goods, or just watching a long line of cars speeding along the rails.



But what of tracks and roadbeds, those essential parts of all rail systems upon which all train movements depend? Though tracks and roadbeds have their own interesting history and color and their own importance, they do not come in for much attention from the general public, except possibly when new rails are being laid in regions that train service will benefit. Yet without smooth tracks and sound roadbeds, the finest diesel-electric locomotive and the handsomest new Vista Dome train would not go far. Neither would the products that enhance our personal living nor the men and material our armed forces require, for many of these travel by train. Keeping rail lines and rights of way in good condition is, therefore, a primary necessity. It's an impressively big job, too, involving hundreds of millions of dollars and thousands of workers annually in maintaining and improving trackage in the continental United States. Additional funds are spent each year both for improving materials and equipment used in track work and for research to keep rails and roadbeds ready to adapt to the rapidly changing designs and increasing weight and speed of rolling stock. Advances in track work may be less spectacular than in car and locomotive designs, but to progressive railroading, civilian or military, they are equally important.

Improvements in track maintenance have been made. Among them are a more balanced track structure, with the subgrade, ballast, ties, rail, and fastenings so designed that under traffic they do not become permanently distorted; roadbeds stabilized by grouting water pockets with pressurized concrete; and ballast that serves as a reservoir for rain water to keep it from saturating the roadbed. In addition, longer service life for ties is assured through more effective wood preservatives and better tie plates, and new rail sections provide better distribution of stresses and reduce the problem of shelling--flaking of the top surface. New machines and power tools for lightening and speeding track work are increasing in variety and adaptability. One is an all-purpose loader for heavy track jobs; another raises and lowers tracks; a third cleans ballast. In short, mechanization of track maintenance has become a reality. Pick-and shovel methods have been replaced by machines that lay, repair, and maintain track better than ever before. And even maintenance scheduling is being done by automatic data processing. Rail-welding techniques have advanced, and electric butt welding, first tried in Switzerland and later brought to the United States by the Santa Fe, has proved a boon to many lines. In service now are more than 11,000 miles of main-line track consisting of continuous sections of welded rail up to 1 mile long. And such rail is completely "clickless-clackless." Improved welding techniques foretell nearly universal use of welded rail on main-line tracks.

New tools and machinery have made track work easier to perform, and current techniques make for safer, stronger, and smoother track and roadbed. Knowing how and when to use the tools and apply the new methods is nevertheless vitally important. This is the chief concern of the men charged with maintaining track. They must know the elements of track and the general procedures employed in rail and tie replacement, in the upkeep of roadbeds, and in similar jobs. In addition, they must also know how to handle more difficult work, such as the installation of switches, turnouts, crossings, crossovers, curves, and guard rails. They must also know how to cope with many special problems, situations, and devices, and be well versed in maintenance-of-way management, in making track charts, and in programming. How they deal with the more advance and complex phases of rail renewal and right-of-way repair is explained in this text.

Reference Text 671 contains five chapters. The first, titled track rehabilitation, is about general repair work done on tracks. But track is not the only part of their section the track maintenance men must maintain. They have to understand how turnouts and special switches are operated and maintained, as discussed in chapter 2. Curved track is more complicated to maintain than straight track, and chapter 3 is devoted to the problems it presents. In addition, the track maintenance men must know how to recognize well-maintained highway grade crossings and guard rails, as chapter 4 explains. The final chapter is a discussion of common maintenance problems that track maintenance men might have to solve.

Annexes accompanying the text are annex A, sheets 1 and 2; annex B; and annex C. Annex A illustrates stringlining of curves, annex B is the cover of a track chart, and annex C is a portion of a track chart.

TYPICAL DIVISION

Many of the important points of Railway Track Maintenance II can be best explained by descriptive examples. The hypothetical Burton Division is described in the remaining paragraphs of the introduction; a map of it is shown in figure 1.1. This division includes a wide variety of physical characteristics and operational details, to present as many instructional problems as possible.

The Burton Division, a double-track line running roughly east and west, is centrally located on a major trunkline railroad. Traffic on the division consists of through freight and passenger trains to and from other divisions, and all the local freight. Included are heavy tonnages of mine products originating in the mountainous section north of Hubbard. The terrain varies from swampy and flat in the west to mountainous and rolling at the eastern end of the division. Motive power is diesel-electric.

Assume that you are the track foreman on subdivision 2 on the division. The maintenance-of-way superintendent has asked you to make a routine inspection of the division with him and the two track supervisors on the division. Meeting him at Ames Yard, you board the last car of train No. 4 for the trip to Jessup Yard, 150 kilometers to the east. By following along figure 1.1, assume that you are actually making the trip. The murmur of the diesel changes sharply to a solid roar as the station platform disappears from view. The sound of the wheel flanges against the 115-pound RE-section rail heightens with increasing speed. The inspection party is on the rear platform. All of you will use sight, hearing, and feel to detect any faulty track. All of you will remain constantly alert to every unusual sound, every sight, and every irregularity in the "feel" of the ride as the train rolls over the rails.

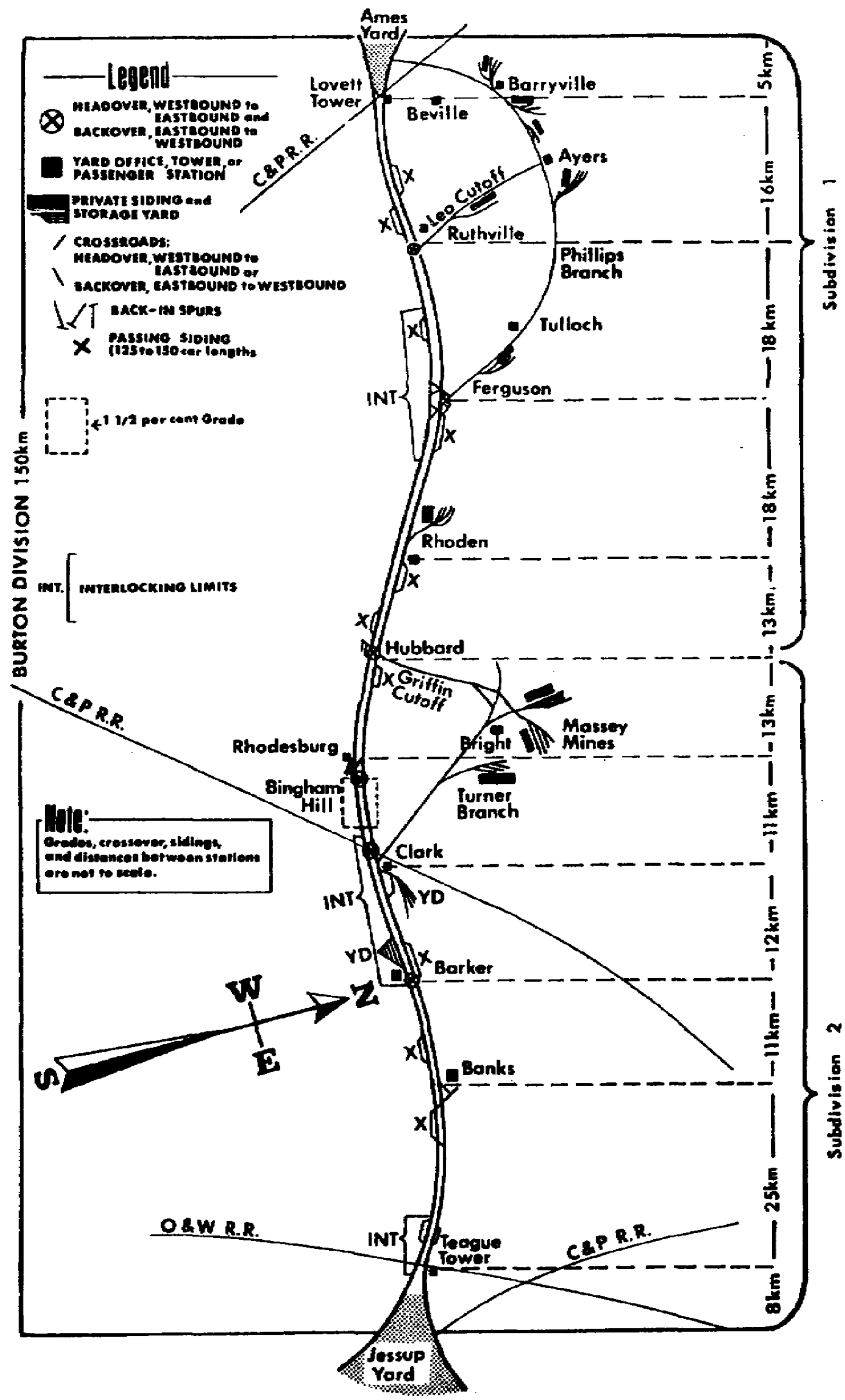
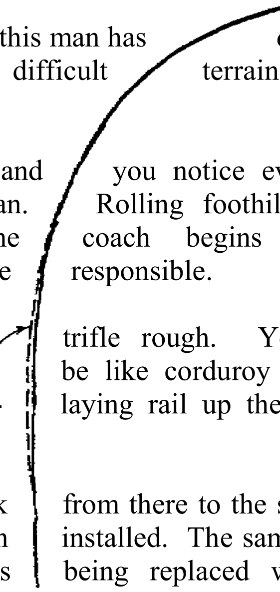


Figure 1.1. The Burton Division.

As No. 4 leaves a sweeping curve near Beville and enters tangent--straight--track, a sudden lurch causes all of you to shift position slightly to maintain your balance. The superintendent focuses his stare on the track supervisor of subdivision 1, and mutters, “Dogleg.” The supervisor flushes. In his notebook, he jots the location of this reverse curve and aimlessly draws a sketch of it. You feel uncomfortable in his embarrassment, and you hope, since most of the curves in your subdivision have been stringlined recently, no doglegs are in it.

The train rides smoothly over the rest of subdivision 1. Dogleg or not, this man has done a good job, despite the many bridges, streams, and swamps in the area. It is difficult terrain to drain satisfactorily, and yet the track is not spongy.



Dogleg

When you pass Hubbard and enter subdivision 2, your senses sharpen and you notice every little bump and jolt, for this is the subdivision on which you are the track foreman. Rolling foothills in the countryside come into view, but the scenery is of little interest to you now. The coach begins to roll slightly front one side to the other, and you mentally curse the low joints that are responsible.

The superintendent remarks casually that the ride is a trifle rough. You wince inwardly at his understatement; you both know that this track would be like corduroy at higher speeds. He suggests to your track supervisor that he take some of the men re-laying rail up the line and have them surface the track.

Just outside Rhodesburg, the ride again becomes smooth. The track from there to the summit of the mountains has just been surfaced and alined; new rail and ties have just been installed. The same kind of job is being done near Bingham Hill. The old 115-pound RE-section rail is being replaced with 133-pound RE-section rail, in line with the current policy of using heavier rail in districts of heavy curvature and grade.

Shortly, No. 4 crosses over to the westbound track; the eastbound is closed because of the rail replacement. As you approach the work under way, you recover a little of the pride you lost on the rough track as the others exclaim at the speed with which this project is being completed. The train slows down for the interlocking switches at Clark, where it crosses over to the eastbound track again.

The remainder of the trip passes quickly. A few comments are made about the poor alinement near Banks; the rough ride along there is marked by quick jolts or bumps.

On the return trip, your track supervisor and you get off the train at Hubbard to stop at your office and make plans for the surfacing to be done and to check the reports of rail laid that day. You also decide which extra men should be taken from the job near Bingham Hill for the surfacing work west of Rhodesburg.

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The foregoing indicates how experienced track maintenance men use their ability to see, hear, and feel train movement, to analyze the track. It also acquaints you with some of the terms used for track defects. This text defines these and other common rail terms and explains how such defects are usually corrected.

Chapter 1

TRACK REHABILITATION

1.1. INTRODUCTION

When rehabilitation of a rail line is proposed, the line must be reconnoitered. To obtain a quick, general impression of the line, an aerial reconnaissance is preferred, supplemented by a personal, on-the-ground inspection. An engineer officer and a transportation railway service officer should reconnoiter it jointly. If the reconnaissance shows the line is worth rehabilitating, the officers then locate the points on the line where major damage or destruction has occurred and determine the amount of rehabilitation or construction effort required to repair the damage. They also determine what portions of the line meet the operating and maintenance standards of the transportation railway service and if any additional facilities must be constructed. As soon as possible after the aerial reconnaissance is completed, it should be supplemented by a close, on-the-spot inspection of the line. This may be done on foot, by jeep, or by a motorized rail car, such as the gasoline-operated one pictured in figure 1.2. Detailed information of damage to the line should be obtained and recorded during the inspection.

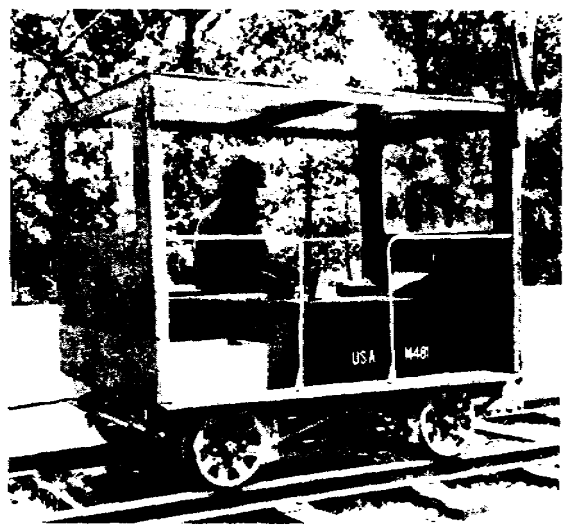

Figure 1.2. Gasoline-operated Railway Motor Car.

The information on the rail line defines what types of work are necessary to rehabilitate the track. It is likely that surfacing is required in some areas and that rails and ties have to be replaced. Each of these jobs is discussed in detail in the three sections of this chapter.

Section I. Surfacing

1.2. GENERAL

Surface and level are the relationships of the rails with respect to height, as paragraph 1.7 of RT 670 explains. Tangent track is in proper surface and cross level only when an imaginary plane rests evenly on the rails. Any deviation results in improper surface and rough riding. To restore proper surface and cross level, the low spots are raised to match the high ones by surfacing.

The remaining paragraphs of the section discuss the two methods of surfacing--spot and out of face; the procedures for raising track and for distributing and spreading ballast; the work to be done in surfacing, and the workmen required, their supervision, and safety procedures to be followed.

1.3. SPOT SURFACING

Several low joints have been found in the westbound track of the 4-kilometer section east of Banks--the same stretch of track that was out-of-face surfaced just last fall. But after the track supervisor inspects the track, he authorizes the track foreman to spot-surface the joints to keep them from getting worse. The track supervisor is assured that no new ballast is required because the raise needed at the worst places is only 1 1/2 inches, and no surface runoffs* are needed. The track foreman also says that this minor "spotting" can be done while the track remains in service. As he talks, the thought occurs to the track supervisor that, because the foreman is experienced, he will have no trouble in determining the correct raise by eye.

Spot surfacing, or "spotting," then, is used to correct minor defects in elevation. It involves raising isolated low spots level with the rest of the track.

1.4. OUT-OF-FACE SURFACING

As the track foreman leaves to go back to work, the track supervisor recalls the out-of-face surfacing done on that stretch

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*A surface runoff is the grade through which the raised portion of a track is connected with the old grade. It usually consists of a long, easy slope.

of track last fall. At that time, the entire track was raised to a new uniform height (elevation).

Out-of-face surfacing corrects a generally poor surface and is always done after reballasting. The two operations are often combined. Surfacing out of face is a little more complicated than spotting and requires using several pieces of equipment and measuring devices. In general, in out-of-face surfacing, raising the track consists of lifting it with track jacks to the desired elevation and then tamping enough ballast under the ties to support the new elevation. Spot boards, grade stakes, sighting blocks, and track -levels are used to establish the desired raise. A spot board and a track level are shown in figure 1.3. The use of this equipment and other procedures followed in raising track are described in paragraph 1.5.

A. Track Level.

B. Spot Board.

Figure 1.3. Track Level and Spot Board.

1.5. PROCEDURES

One morning when the track foreman goes to the track supervisor's office, he tells the foreman about a newspaper article he has just read. It describes a multiple-unit right-of-way device that automatically raises track to the right elevation, tamps rock ballast under the rails to just the right firmness, and shifts and alines the track properly. In addition, a computer on the device makes all the calculations needed to carry out these procedures. The article goes on to say that one railroad finds that a track crew of five and a tamping machine operator can renovate about 20 kilometers of track per week.

The foreman remarks, "What an improvement! It takes us a week and a lot more men to do that work manually on just 1 kilometer!" Needless to say, it will be years before all lines, both commercial and military, are equipped with such computerized devices. In the meantime, the old procedures for raising the track, described here, continue to be used.

Blue-top grade stakes are set at intervals about 6 feet outside the grade rail, with the top of each stake level with the projected height of the top of the rail after the raise. On tangent track, the grade rail is the same as the line rail, as paragraph 1.23 explains; on a curve, the grade rail is the low or inner rail. A spot board, shown in figures 1.3 and 1.4, is laid across both rails with one end

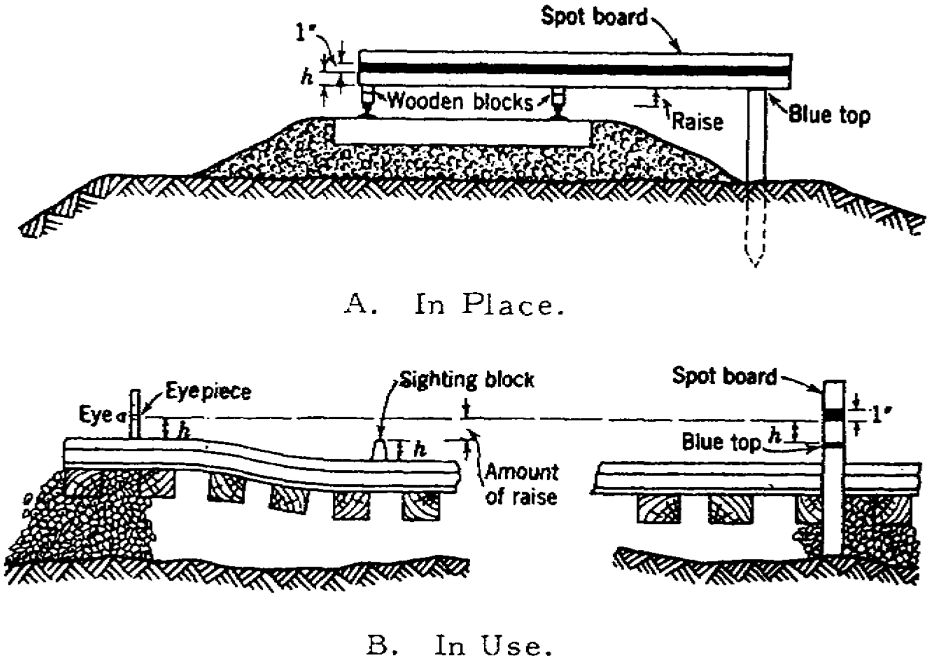


Figure 1.4. Spot Board in Place and in Use.

resting on a grade stake 20 or 30 feet beyond the point where the raise is to be made. Note the horizontal sighting band of contrasting color on the face of the spot board. Wooden blocks or shims are placed between the rails and the board, to elevate it until the top is level, as shown by the track level. A triangular sighting block, of the same height as the distance between the sighting band and the bottom of the spot board, is placed on each rail at the point where the track is to be raised. Jacks are then applied at that point. They must always be set on the outside of the track to permit easy removal. A sighting block with a peephole sight is placed on the same rail where the last raise was made. A workman looks through the peepsight along the rail at the sighting band, and the jacks are operated to raise the track. A ratchet-type jack is shown in figure 1.5; a rail-mounted jack in figure 1.6. When the top of the sighting block is level with the sighting band as seen through the peepsight, the rail is at the correct height, that is, level with the top of the grade stake. Ballast is then forced under the ties to give temporary support until the tamping gang arrives to tamp the ballast. If the track level shows that a rail is too high, that is, above the grade stake, ballast is removed to lower the rail, and it is then jacked up to proper height.

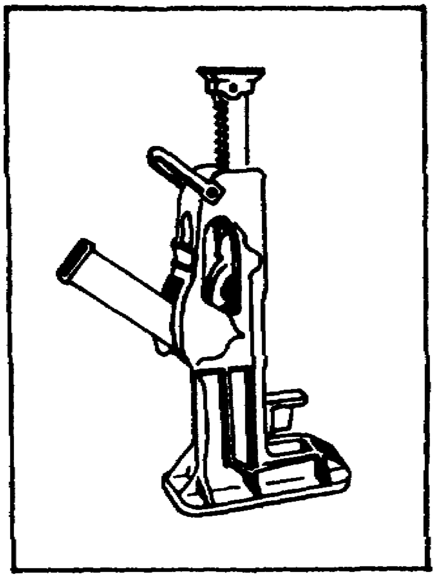


Figure 1.5. Ratchet-Type Jack.

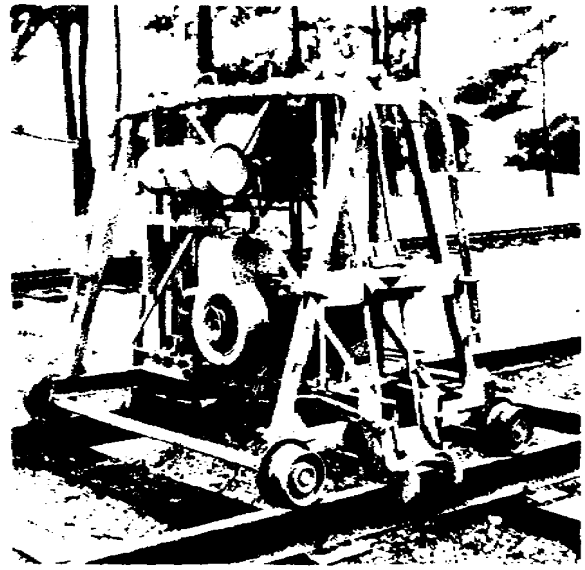


Figure 1.6. Rail-Mounted Jack.

When one rail has been raised to proper height with the spot board, the adjacent rail can be brought to proper surface by using the track level. Then the spot board is moved on to the next grade stake and the process repeated.

1.6. PLANNING

Together the track supervisor and the track foreman must estimate the length of track that can be raised in 1 day. This is based on the number of men in the surfacing gang, the type of tools, the type of ballast, the amount of raise, and the skill of the crew. In a theater, you will ordinarily have only the handtools in Maintenance-of-Way Tool Set No. 4. The set includes track shovels, ballast forks, tamping bars, picks, track jacks, and spot board equipment, shown in figure 1.7. However, if you have such power tools as the pneumatic and electric tampers shown in figures 1.8 and 1.9, your surfacing work will move along much faster.

1.7. CALCULATING THE AMOUNT OF BALLAST

After figuring the length of track to be surfaced in a day, the track supervisor and the track foreman can estimate, based on experience, the amount of ballast required. Or they can calculate the amount by multiplying the width of ballast section by the projected raise and then by the length. In calculating, they are careful that all dimensions are expressed in the same units. For example, if the

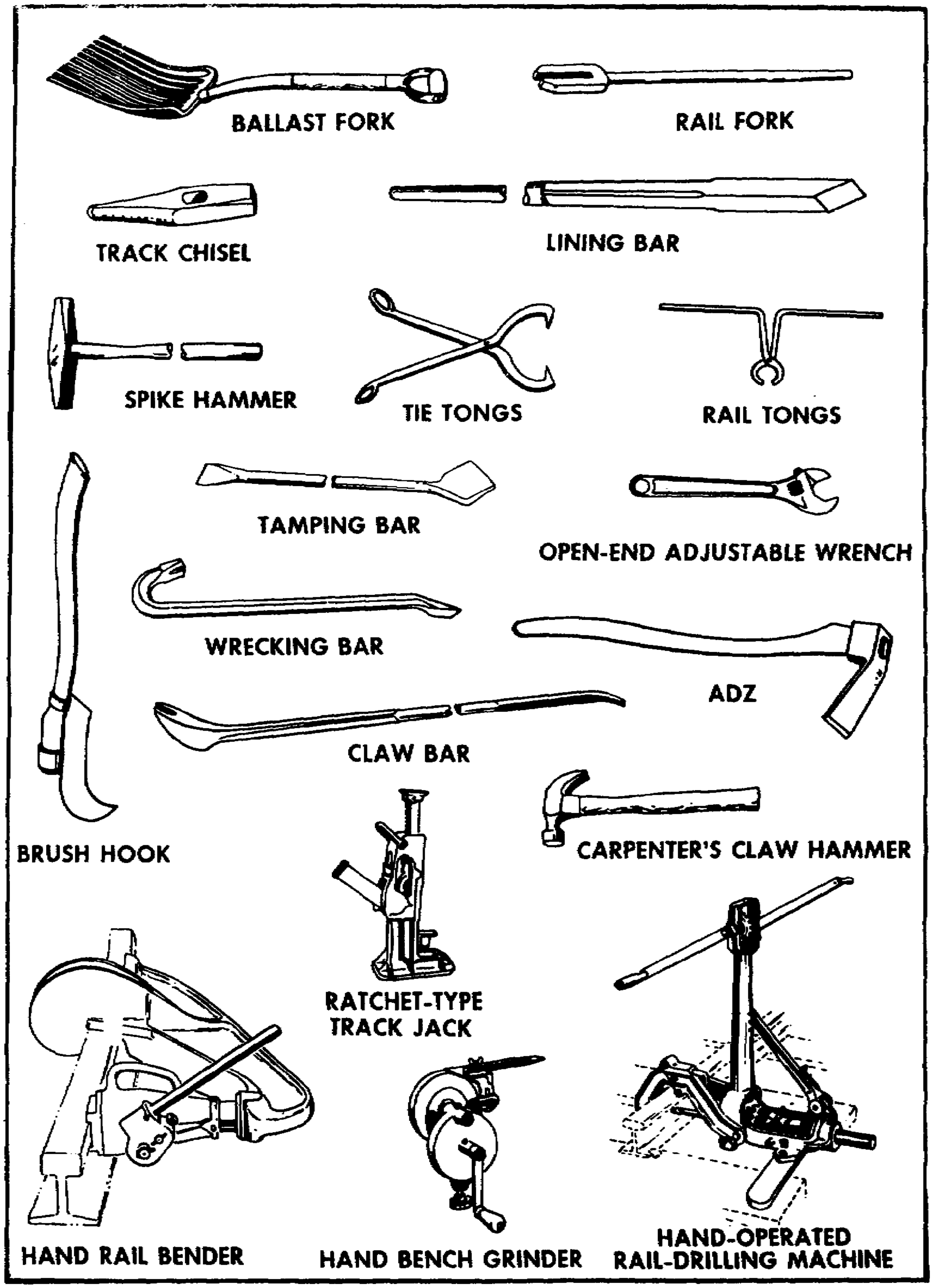


Figure 1.7. Rail Maintenance Handtools.

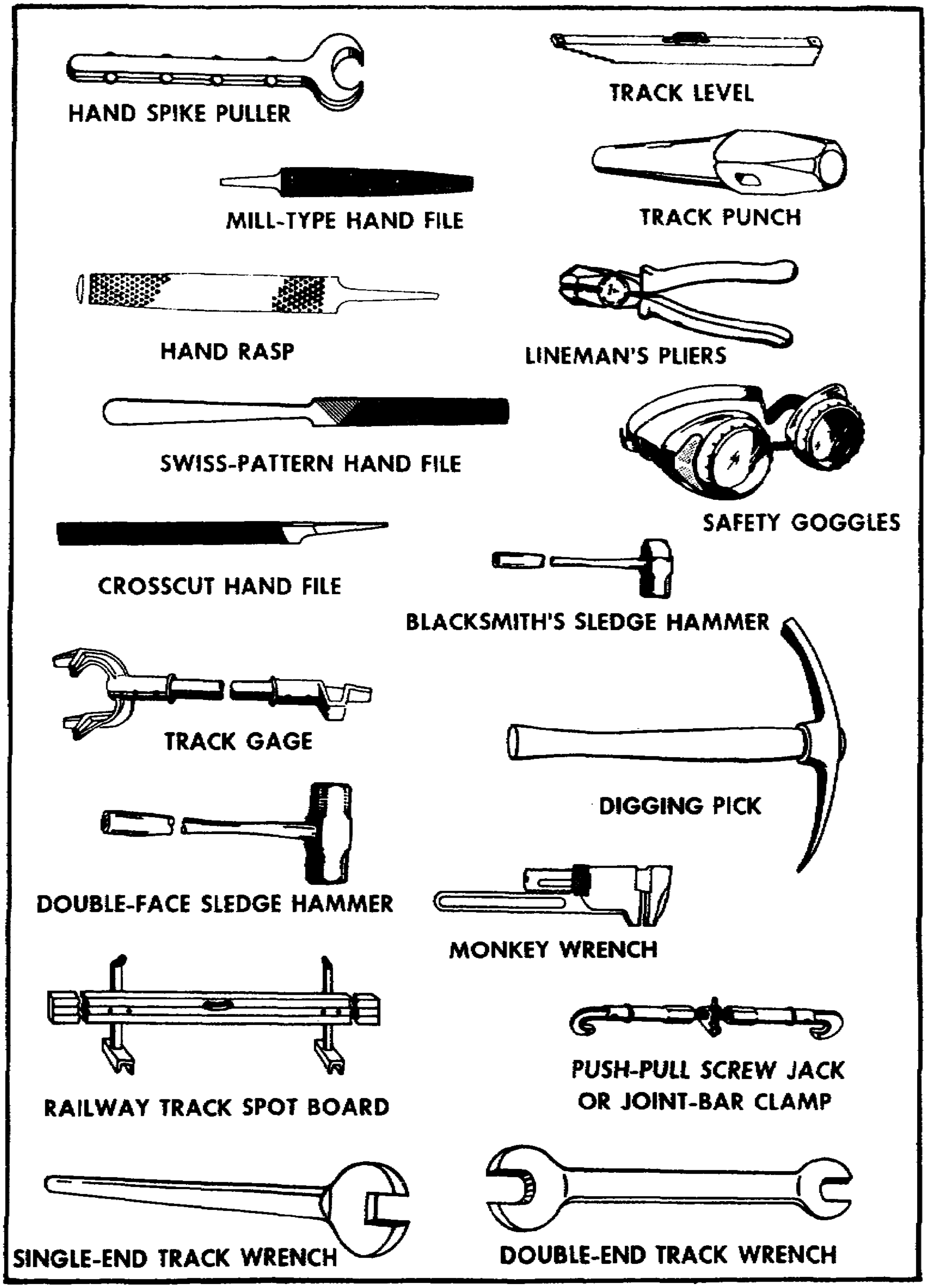


Figure 1.7 (cont). Rail Maintenance Handtools.

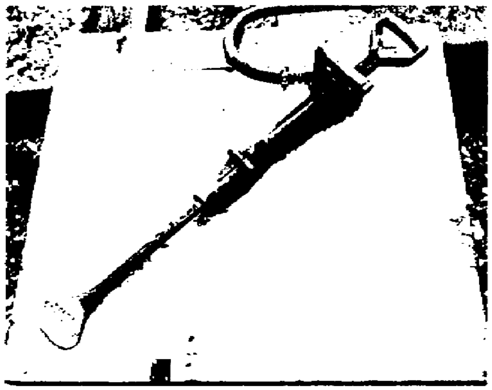


Figure 1.8. Pneumatic Tamper.

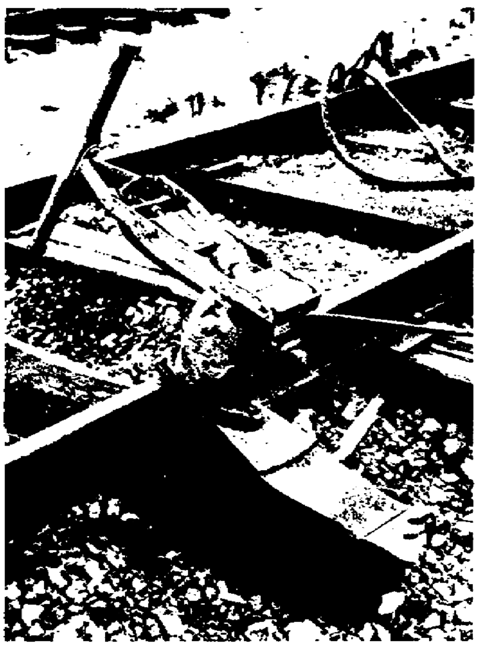


Figure 1.9. Electric Tamper.

length of track is given in kilometers, the amount of raise in centimeters, and the width of the ballast section in meters, then they would need to convert all of the dimensions to one common unit. In the example given here, the measurements are expressed in meters to arrive at the volume of ballast needed.

Length of track = 7 kilometers = 7 x 1, 000 = 7, 000 meters

Amount of raise = 9 centimeters = 9 x 0.01 = 0.09 meters

Width of ballast section = 4 meters

7, 000 x 0.09x4 =
2, 520 cubic meters

1.8. DISTRIBUTING AND SPREADING BALLAST

When track is raised as much as 4 inches, enough new ballast must be distributed in advance of the raise to support the new elevation and maintain the original section. For smaller raises, it is better to use the existing ballast to support the new track elevation, and then restore the original ballast section by placing new ballast.

Either special ballast cars or drop-bottom hopper cars may be used to deliver the material to the work site. Then the ballast maybe spread by using the special car, the hopper car, the Jordan spreader, or a ballast regulator. The special cars are equipped with pockets from which the material is dumped. Hand-operated latches control the rate of flow of the material from the pockets of the car to so-called windows in the track center and outside the rails. When a drop-bottom hopper car is used, as shown in figure 1.10, its pocket is chained to the desired opening, to prevent too much ballast from being dumped in one spot. A tie is placed in front of the rear truck of either car to level the new ballast with the top of the rails. To spread less ballast, notches to fit the rails are cut in the tie, to bring the bottom of the tie below the height of the rail.

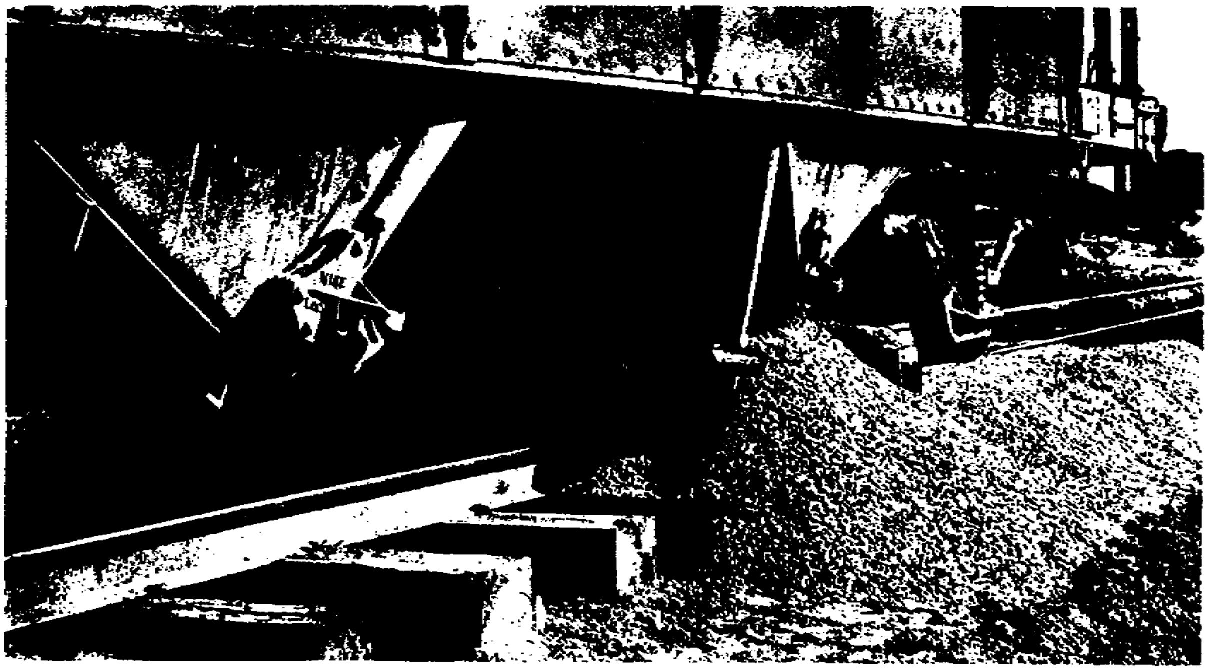


Figure 1.10. Distributing Ballast From Hopper Car.

The Jordan spreader and a gasoline-powered ballast regulator are special rail-mounted equipment used to spread ballast. The Jordan spreader, shown in figure 1.11, not only spreads ballast but also regulates its depth. It operates on compressed air and must be coupled to a locomotive. This spreader is also used to spread dirt on the shoulders and to plow snow. The gasoline-powered ballast regulator, shown in figure 1.12, levels the ballast not only between the rails but also on the shoulders.

No more ballast than can be tamped in 1 day should be spread on the tracks. This amount varies according to the number of workers and types of tools. The inside of each rail should be cleared of ballast for a couple of inches in width and depth, to allow room for the wheel flanges of the cars that are to pass over the track before the ballast is tamped.

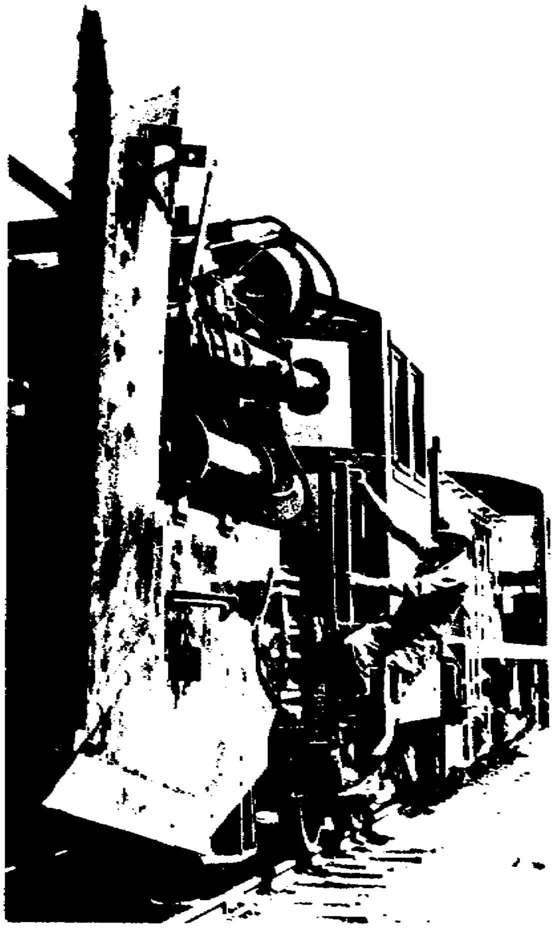


Figure 1.11. Jordan Spreader.

1.9. WORK SUPERVISION

The track foreman is responsible for supervising the track maintenance men. He checks the work to be done, determines the available tools and equipment, and assigns the men their duties. He must see that the work progresses against the direction of traffic except on steep grades when he must preferably work uphill. He makes sure the men operating the jacks place them away from joints so that the joint bars are not bent. The safety of the workmen is his responsibility, as well as the safety of trains he permits over tracks on which work is being done. He is likewise responsible to the track supervisor for the overall quality of the work. The track supervisor checks the progress and quality of the work from time to time while it is under way and checks again when it is finished.

1.10. TRAIN PROTECTION

Certain operating rules must be followed when working on main line tracks. Technical Manual 55-200, Railway Operating Rules, states in rule 101:

> Trains must be fully protected against any known condition, even though not covered by the rules, which interferes with their safe passage at normal speed.
>
> When conditions are found which may interfere with safe passage of trains at normal speed and no protection has been provided, such action as will insure safety must be taken.

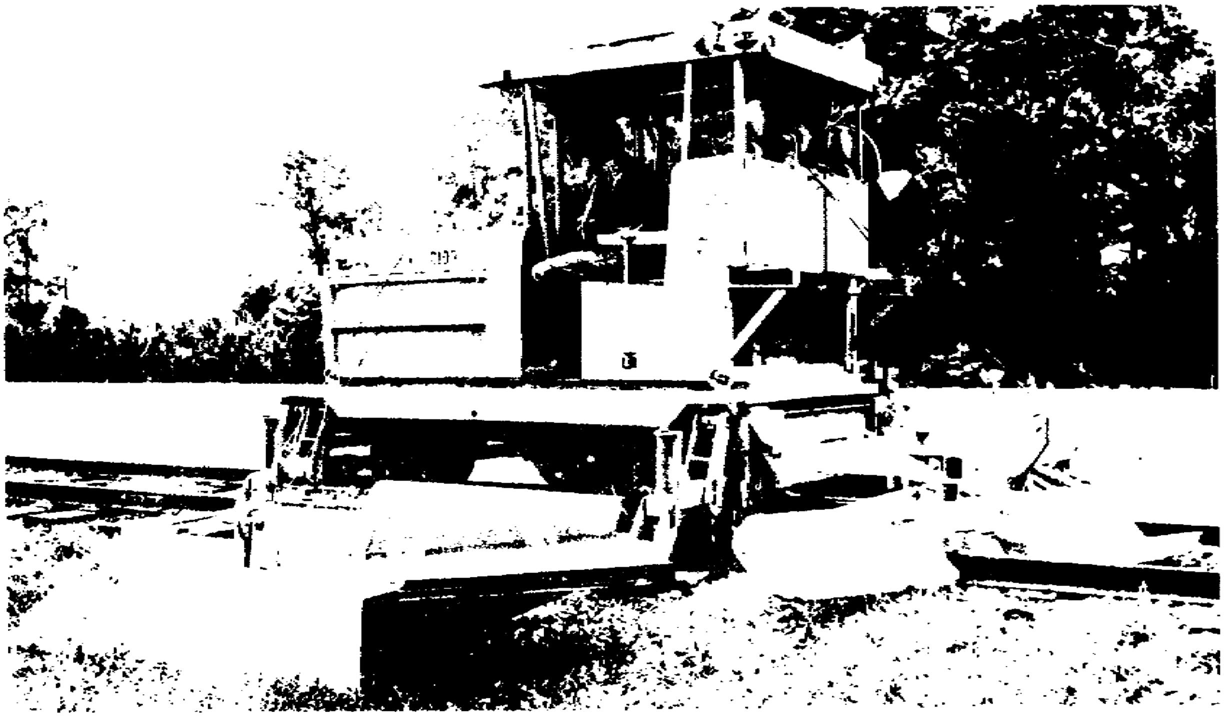


Figure 1.12. Gasoline-Powered Ballast Regulator.

Rule M, c from the same source is so basic its significance is often overlooked: "Personnel must expect the movement of trains, engines, or cars at any time, on any track, in either direction."

Because track raising interferes with the safe passage of trains, protection is necessary. On double track, for example, east-bound trains should be routed over the westbound track to pass the work area, to provide maximum safety for the trains and minimum interference with the work. The track supervisor must check with the dispatcher and get him to "give you the track." He is then required to route the trains around you. Then the track foreman must station flagmen to protect against any train that, because of a misunderstanding, might approach on a track on which work is in progress.

Often the solution is not so simple. The method just described cannot be used on a single- or a multiple-track line where traffic is so heavy that all the tracks are required to take care of the large number of trains. Then the job must be done in such a way that the track maintenance men can not only immediately make the track safe for an approaching train to pass the repair site but also move out of danger themselves while it passes.

When working track that is under service, watchmen with whistles and signs are stationed in the direction of expected trains to give advance warning. The foreman must also refer to his time-table frequently to prepare for scheduled trains and must always be on the alert for unscheduled ones. To keep the track safe for train movement while the track is being raised, a smooth surface runoff, that is, a gradual change from the raised to the lower elevation, must be provided.

1.11. SUMMARY

A track is in proper surface and cross level only when an imaginary plane rests evenly on the rails. If the plane fails to rest evenly, the track is in improper surface, causing a rough ride. Proper surface and cross level of the track are restored by raising the low areas to match the high ones. Both spot and out-of-face surfacing are used in raising rails--spot surfacing for raising isolated low places and out-of-face for raising the entire track to a new uniform height, especially after reballasting. Out-of-face surfacing requires using spot boards, grade stakes, sighting blocks, and track levels. The track is lifted with jacks to the elevation desired and ballast is tamped beneath the ties to support the new elevation. Plans for surfacing and the amount of ballast needed are based on how much surfacing can be accomplished in 1 day. Ballast is brought to the work site in a ballast or a drop-bottom hopper car and then spread by using the car or a rail-mounted spreader. Both surfacing methods are supervised by a track foreman who is responsible for the quality of work, the safety of the workmen, and the safety of all trains operating over the tracks being repaired.

Section II. Re-Laying Rail

1.12. GENERAL

The next phase of track rehabilitation is re-laying rail. Like surfacing, rail may be replaced by either the spot or the out-of-face method. Spot replacements are usually made by hand, while out-of-face replacements are more involved and usually require the use of machinery. Paragraph 1.13 explains the spot method; paragraphs 1.14 through 1.16 explain the out-of-face.

1.13. SPOT REPLACEMENT

Spot replacements are made when individual rails in several locations are found to have flaws. These replacements, as a rule, are made by hand. The joint bars and bolts are removed, the spikes are pulled, and the new rail is set in place of the old. New bolts, joint bars, and spikes are then installed if the old ones are not usable. Crowbars, track wrenches, spike pullers, rail tongs, adzes, and spike hammers, such as those shown in figure 1.7, are used. While this work is under way, rule 101, given in paragraph 1.10, is in effect: flagmen must protect against all trains.

1.14. OUT-OF-FACE REPLACEMENT

Out-of-face rail replacement, the method used to renew long stretches of rail, is more common and more involved than spot replacement. Although the actual replacement takes little time, a great deal of planning must be done before the work is started. On both military and civilian lines, rail renewals are programmed in advance. The reason for renewal may be battered ends, excessive head wear, or a change in section made necessary by a change in traffic. Out-of-face rail replacement is discussed in the next two paragraphs: first the procedures followed in the re-lay, and then the duties of the track maintenance men once the re-lay is finished.

1.15. PROCEDURES

On civilian lines, out-of-face renewal of rail is usually done by gangs of from 50 to 150 men equipped with power tools. Figures 1.13 through 1.18 show some of the power tools that both military and civilian track maintenance men use to re-lay rail. The gangs are organized and trained for this particular job and handle all major rail replacements of several divisions. Even in a theater where the power tools usually associated with such operations may not be available and hand tools must be used, the procedures outlined here should be followed as closely as possible, first on one rail and then on the other.

a. Dismantling and setting out the old rail. The first group of men removes rail anchors, bolts, joint bars, and

Figure 1.13. Gasoline-Powered Track Wrench Used to Tighten or Loosen Track Bolts.

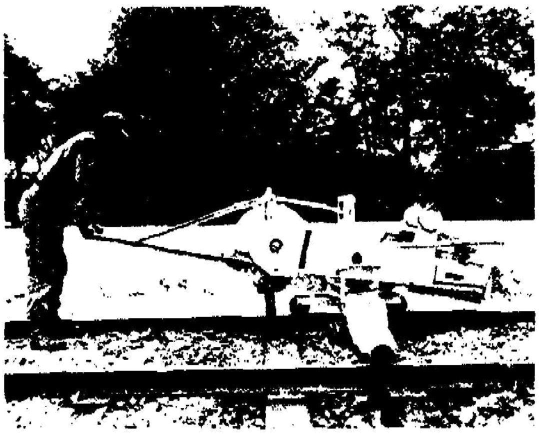


Figure 1.14. Gasoline-Powered Spike Hammer.

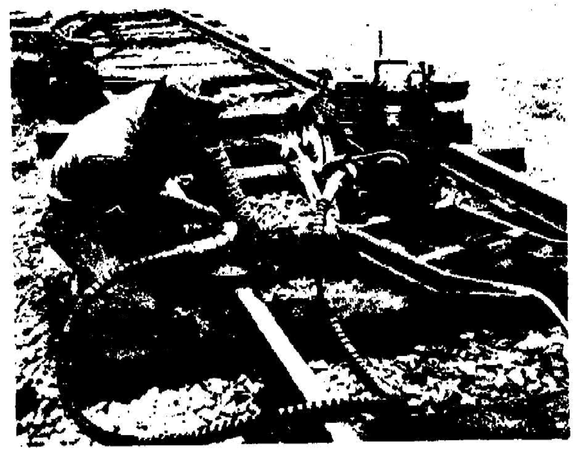


Figure 1.15. Gasoline-Powered Grinder.

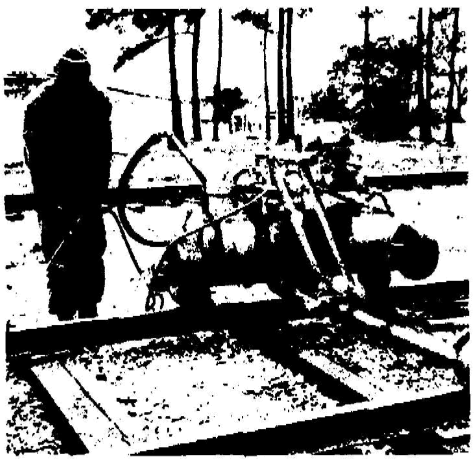


Figure 1.16. Gasoline-Powered Oil-Spraying Machine.

Figure 1.17. Pneumatic Tampers.

Figure 1.18. Electric Tampers.

spikes from one rail--the first step in dismantling and setting out the old rail if all new track accessories are to be used. When power track wrenches, such as the one shown in figure 1.13, and spike pullers are on hand, they are used to remove bolts and spikes. If not, then such handtools as the track wrenches and the claw bars, shown in figure 1.7, * are used. After that, the joint bars are removed with 8-to 10-pound sledge hammers.

Following these men, a worker with an oxacetylene torch burns off any bolts which cannot be loosened with the wrenches. Working closely behind and using track forks and lining bars, two men roll the old rail clear of the track. If it is pushed to the inside of the track, a rail-laying crane can lift and remove it from the track.

b. Preparing the ties. The first step in preparing the ties is for one man to remove the tie plates (RT 670, figs. 3.7, 3.8) if they are to be replaced. The next is for a group of about four men to level the crib ballast so that it is below the tops of the ties. They do this with hand rakes, shovels, and ballast forks. They then sweep the tops of the ties with brooms.

Following this, three men set and drive wooden tie plugs (RT 670, fig. 3.13) in the old spike holes; tamping bars, spiking hammers, or light sledges are the tools they use. Then two men, using sledges and punches, drive down the stubs of broken off spikes. These men are followed by five equipped with power adzing machines to refinish (adz) the bearing surfaces of the ties. The bare wood left exposed by the adzing is then creosoted by three men equipped with brushes, buckets, and a drum of creosote. The last operation in preparing the ties is the setting of new tie plates by two men.

c. Setting and fastening the new rail. A small rail-mounted crane, light enough to move over unspiked rail, picks up one of the new rails already distributed and lowers it as several men guide it onto the tie plates. Then one worker places a shim of the proper thickness between the ends of adjoining rails to provide for expansion (RT 670, par. 3.28a). After that, the rail ends are slushed with rust preventive. Six men follow with joint-bar clamps, installing bars and setting bolts. The rail is then gaged with track gages and lightly spiked in place. A large gang to set and drive spikes follows, using a pneumatic or gasoline-powered spike hammer, such as the one

*Most of the handtools mentioned in subparagraphs a through d are illustrated in figure 1.7.

shown in figure 1.14. Next, the joint bars are tightened to the required pressure with a power track wrench, as illustrated in figure 1.13. The last step in this phase of the work consists of fastening the rail anchors and applying the signal bond wires (RT 670, par. 3.32).

d. Finishing the re-lay. A switch and utility gang of 6 to 12 men complete the re-lay. They take care of the details on turnout installations, provide for temporary closures before trains arrive or at the end of the work day, and tamp old joint locations. A cleanup train follows the switch and utility gang to pick up the old rail and fastenings, leaving the roadway clean and free of obstructions.

1.16. AFTER RE-LAY COMPLETION

New ties are installed where necessary and the track accurately lined and gaged (sec III) following the rail re-lay. These jobs are taken care of by the regular track crew, just as they were before the re-lay. In addition, the crew collects and sorts old rail, most of which is probably in fair condition. Usable sections are prepared for re-laying in yards and sidings and on branch lines. Rails with battered ends are cropped with a rail saw, as shown in figure 1.19. Any new boltholes needed are drilled with a power drill, as figure 1.20 illustrates. Some of the rail is to be re-laid on the Turner Branch, thereby substituting 115-pound RE-section rail for the 80-pound AS-section rail now on this mining branch.

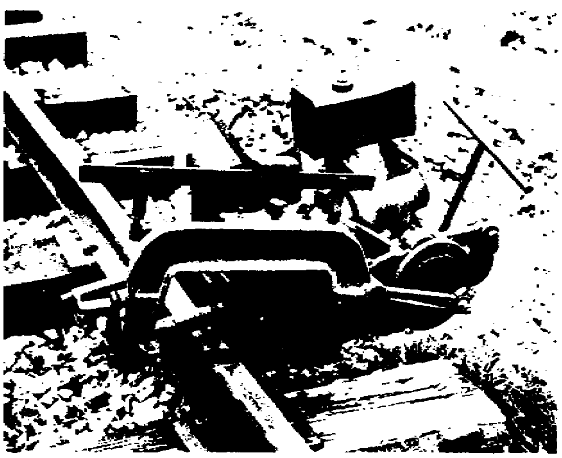


Figure 1.19. Gasoline-Powered Rail Saw.

1.17. SUMMARY

Rails are replaced by either the spot or the out-of-face method. When individual rails in scattered locations are found to have flaws, spot replacements are made, usually by hand. Out-of-face replacement, used for renewing long stretches of rail, normally requires more men and specialized machinery. Because this work is more involved, it must be carefully planned. Work is first done on one rail and then the entire procedure repeated on the other one.

Figure 1.20. Gasoline-Powered Drill to Make Track-Bolt Boltholes.

Section III. Tie Renewal

1.18. GENERAL

The final phase of track rehabilitation is tie renewal. Like surfacing and rail renewal, tie replacement may be done singly (spot) or out of face. Because the life of ties varies greatly, good and poor timbers are usually found intermingled. When this occurs, out-of-face replacement is seldom done. An instance where it might apply would be on a rundown line being built up to handle a heavy increase in traffic. When both ties and rail are to be renewed, it is generally better to lay the new rail first. However, ties should not be replaced during a rerailing operation unless they are completely rotted. If the new ties were placed first, the old rail would have to be spiked to them. Then, before spiking new rail to the new ties, the old spike holes would have to be filled with wooden tie plugs and then the spikes driven into the plugged holes. By installing the new ties last, the spikes are driven into the solid wood of the tie rather than into the plugged holes. Paragraphs 1.19 through 1.25 explain tie renewal. Lining and gaging the track always follow out-of-face rail replacement, although both line and gage must be checked frequently to allow trains to pass safely. Paragraphs 1.26 and 1.27 explain lining and gaging.

1.19. PROCEDURE

The procedure for replacing ties begins with the track foreman's periodic inspection of the ties. Following that comes the actual replacement of the bad ties with good ones. Sometimes traffic must be restricted when the tie-renewal procedure is under way. Spiking the new ties, disposing of the old ones, and lining the new ties with the old are the final steps in the process.

1.20. INSPECTION

The track foreman makes periodic inspections to find out which ties need to be replaced and puts a spot of white lead paint on the web of the rail above the tie to be renewed. The track supervisor spot checks his selections before they are removed, to be sure that he is not discarding good ties. It is not always possible to determine the serviceability of the ties while in the track; therefore, they should be inspected again after removal. By taking out all doubtful ties, the track supervisor makes sure that all bad ones have been removed, but by checking them carefully, he may find some of them still usable.

1.21. REPLACEMENT

After the bad ties have been marked and new ones distributed along the track, a section gang removes the spikes with claw bars, loosens the ballast, and raises the track slightly. The old ties are then pulled out with tie tongs. Clawbars and tie tongs are illustrated in figure 1.7. New ties are slid into place and respiked and the ballast tamped.

1.22. REMOVING TRACK FROM SERVICE

Out-of-face work or the removal of one or more ties may make it necessary to restrict traffic. Track must be thought of as out of service and trains allowed to proceed only at greatly reduced speed when any one of the following conditions exists: (1) two or more adjoining ties are removed; (2) in extremely hot weather, each tie unspiked or removed is not flanked on both sides by at least four good, fully spiked ties with the ballast tamped; or (3) the ballast is untamped and the following number of adjoining ties on each side of the tie removed are not fully spiked and in good condition:

Two ties on tangent track,
Three ties on curves up to 5 degrees,
Four ties on curves over 5 degrees.

1.23. LINING TIES

Although the exact length of ties is specified when ordered, the lengths frequently vary slightly. When placed on the track,. one tie end is lined flush with the next one to present a uniform appearance. Replacement ties are lined with those already in place. Which tie ends should be uniform depends upon the number of main tracks. On single track, line tie ends on the line rail, that is, on the east side when the track runs north and south; on the north side when the track runs east and west. On double track, line the ends on the outside of the tracks. When there are three or more tracks, line the ends on the outside of the tracks; line the ends on the line rail side of the inside tracks.

1.24. DISPOSING OF OLD TIES

Old ties may be used for shoring or cribbing material or for building a retaining wall. They are often used to shore a track while a French drain is under construction. French drains are discussed in more detail in Reference Text 670, paragraph 2.15c. If the old ties cannot be used for these purposes, they are saved for firewood or burned at the removal site.

1.25. SPIKING TIES

When the new ties are installed, they must be properly spiked. Usually, tangent track is spiked with four spikes per tie, that is, one on either side of each rail in the pattern shown in figure 1.21. The two spikes must be driven not closer than 2 inches from either face of the tie. Six spikes are used on curves, two inside each rail and one outside. Spikes must be driven vertically and square.

1.26. ALINING TANGENT TRACK

The next step after out-of-face surfacing or rail renewal is to aline the track. It may be alined at other times as necessary to provide safe and smooth passage for trains. In proper alinement, tangent track is perfectly straight, that is, the rails run parallel to

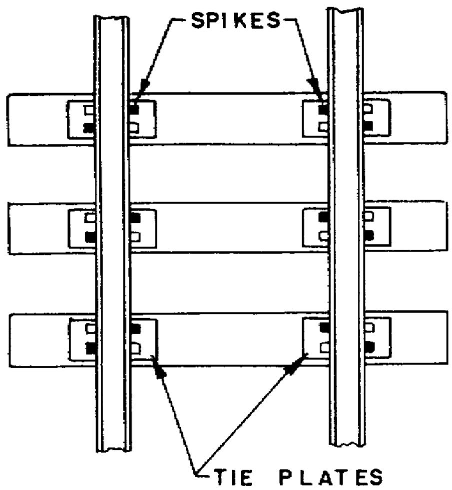


Figure 1.21. Method of Setting Spikes.

the centerline of the track. Alinement is discussed in paragraph 1.4 of Reference Text 670. A simple method to correct poor alinement of tangent track is to establish the proper alinement on one of the two rails instead of on the imaginary centerline. The rail selected is called the line rail, as paragraph 1.23 explains. A rail track liner, figure 1.22, can be used to line the track; however, an experienced track foreman can make a fair adjustment to tangent alinement by eye. But high-speed track must be alined by using a transit and lining bars or the rail-mounted liner.

The transit and lining bars are discussed in the following subparagraphs.

a. The transit. The accurate alinement needed for highspeed track can be obtained only by using a transit--a telescope with crosshairs on the objective lens. This is an instrument similar to the one used by engineers and building contractors to correctly aline the construction each undertakes. The telescope tube is mounted in bearings so that it can be moved either vertically or horizontally. The bearings may be locked so that the line of sight is fixed. When the instrument is set over a line rail, the vertical crosshair determines the proper line for the rail.

b. Lining bars. The line rail is moved to proper position by men using lining bars, such as the one shown in figure 1.7, to move--throw--the entire track structure. The rail opposite the line rail is brought into alinement by gaging it with the line rail. Throwing track is discussed more thoroughly in section V of chapter 3 and illustrated in figure 3.9.

1.27. GAGING

Track foremen check the gage of track frequently. The amount of permissible deviation from true gage varies, depending on the type of track and the speed of trains. It is possible to use a

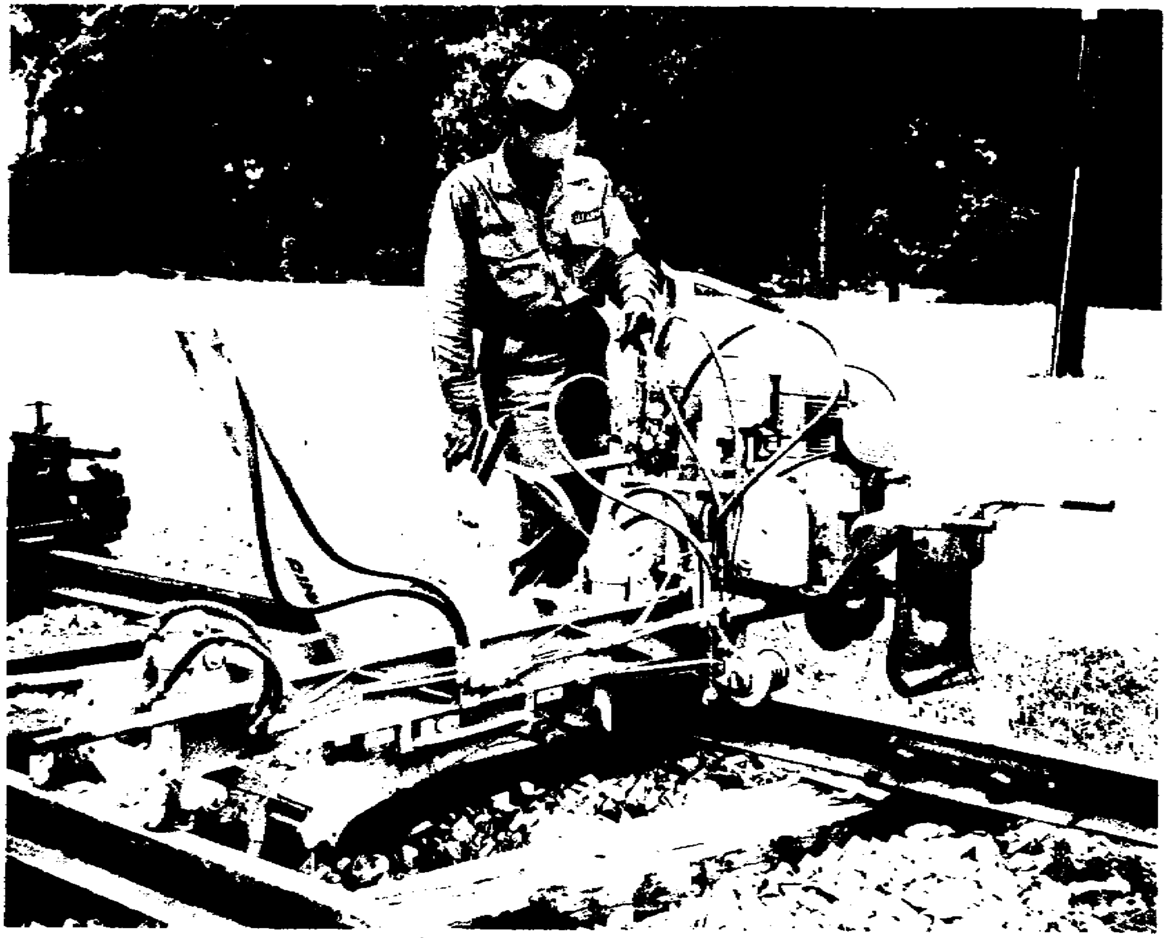


Figure 1.22. Rail Track Liner.

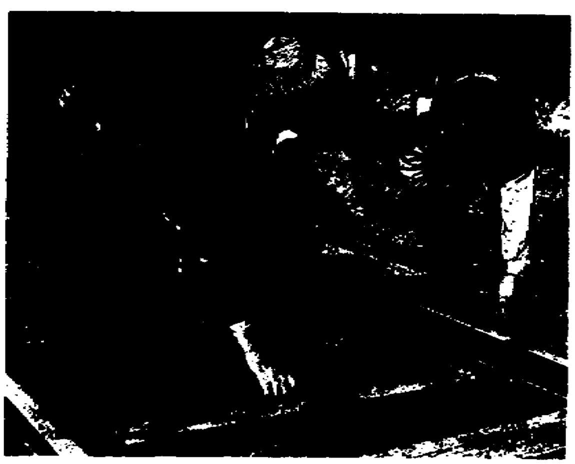


Figure 1.23. Standard Track Gage in Use.

gage one-eighth of an inch less than the standard 56 1/2 inches on high-speed tangent track. Wide gage up to 57 1/2 inches, while safe, is not desirable. It causes rough riding and can contribute to poor alinement and surface. The gage is established and checked by a track gage, as shown in figure 1.23. Gage is corrected by respiking the low or inside rail--never by moving the line rail and never by bending previously driven spikes. More information on gage can be found in Reference Text 670, paragraph 1.6.

1.28. SUMMARY

Like surfacing and re-laying rail, tie renewal is done by the spot or the out-of-face method. Spot replacement refers to single replacements, while out-of-face applies to the large numbers of tie replacements required when a rundown line must be reconditioned to accommodate a heavy increase in traffic. Ties are inspected before they are removed and the bad ones marked. A spot check is made before they are removed to insure that useful ties are not being discarded. Ties should be inspected again after removal because it is not always possible to determine their serviceability while they are in the track. When new ties are distributed along the track, the old ties are removed and the new ones slid into place and spiked, and the ballast tamped. The track is then alined and its gage checked and corrected if necessary.

Now that the elements of track rehabilitation have been explained, you are ready to begin chapter 2 in which turnouts and special switches are discussed.

Chapter 2

TURNOUTS AND SPECIAL SWITCHES

2.1. INTRODUCTION

In the trip on No. 4 described in the introduction, you read that this eastbound train crosses over to the westbound track and later back to the eastbound. On the map of the Burton Division in figure 1.1, you see numerous lines branching from the division's main line. How is it possible for a train to go from one track to another in a main line and from a main line to a branch? This question is answered in chapter 2, for it discusses turnouts and special switches. It is divided into five sections. In section I, turnout components are discussed; in section II, turnout location; in section III, turnout construction; in section IV, turnout maintenance; and in section V, special switches and track constructions.

Section I. Components

2.2. GENERAL

A new installation is under construction north of Burton Division's main line between Barker and Banks, and, because of military necessity, the track supervisor has received orders to help construct a siding to the site. The new siding calls for turnouts from both the eastbound and westbound tracks. When he finishes reading his orders, he begins to think about the project. Because it has been some time since any turnouts have been constructed in the subdivision, he decides to brief the foreman and the men. As he looks over the information on turnouts that he has, he jots down notes for the briefing. They cover the definition of a turnout; switches; the frog; the other parts of a turnout--guard rails, closure rails, stock rails, switch plates and ties; and the switch-throwing mechanism. They also cover information on the path the train wheels follow through a frog and on facing and trailing-point movements. The notes follow, in the remaining paragraphs of section I.

2.3. WHAT A TURNOUT IS

Turnouts make it possible for a train to leave one track and enter another. Without them, yards, sidings, and passing tracks would be impossible. Most operating employees refer to turnouts as "switches," but technically a switch is only one part of a turnout. To distinguish between the two terms in this text, the term switch is used only to refer to the pair of movable rails and the necessary connections that are used to divert a train to another track. The components of a turnout are described in subparagraph a and illustrated in figure 2.1; its classification is discussed in subparagraph b.

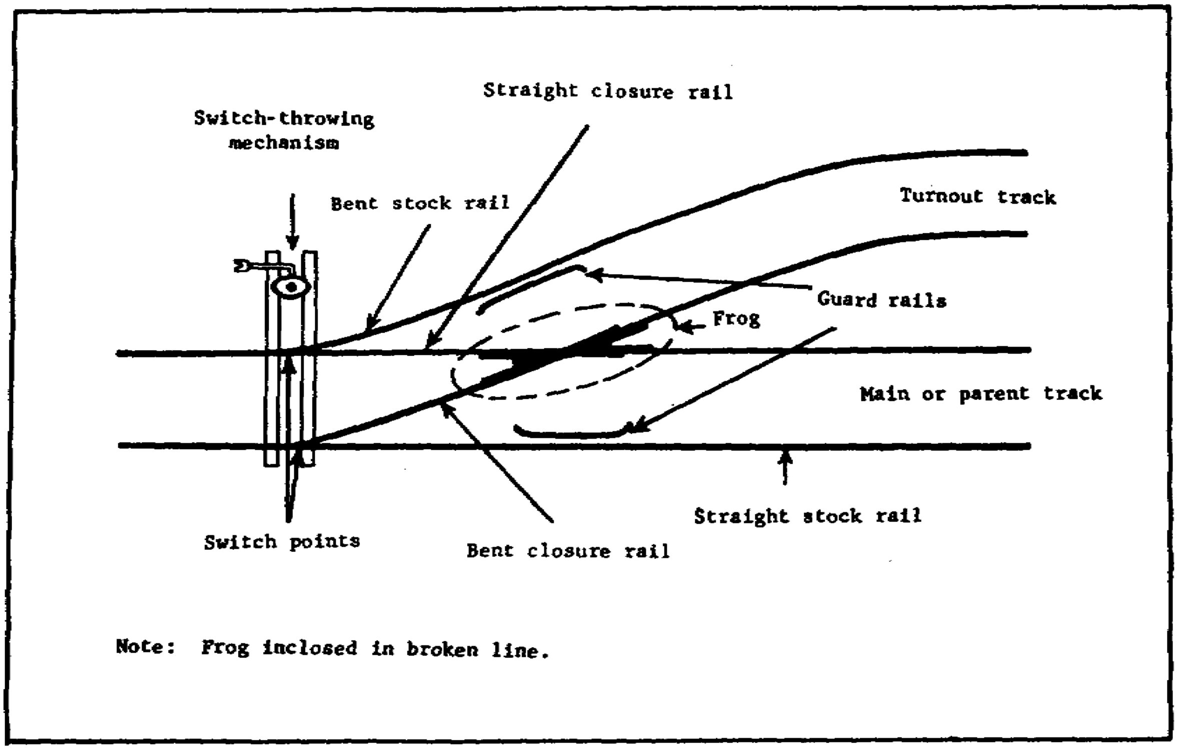


Figure 2.1. Turnout Components.

a. Components. Essentially, a turnout is a combination of five components: a switch, a frog, a pair of guard rails, closure rails, and switch ties. The switch with its controlling mechanism determines the path that moving engines and cars take. The frog provides the means for the wheel flanges to cross the obstructing rail of the alternate path. The guard rails, set opposite the frog point, hold the flanges of the wheels away from it to prevent batter and taking of the wrong route. The closure rails connect the switch and the frog. Switch ties, of a predetermined length for each gage and frog number, extend under both tracks, well beyond the frog. Frog number is discussed in subparagraph b.

b. Classification. Turnouts may be classified according to their direction and sharpness. The direction of a turnout is determined by viewing it from the main track as you face the switch points, that is, the movable rails. If they run to the left, the turnout is left handed; if to the right, right handed.

The sharpness of a turnout is determined by the acuteness of the frog angle, that is, the angle formed by the rails extending from the heel to the actual point of the frog and by the length of the switch rails. Not only is a frog designated by its angle but, more commonly, by its number. The larger the number of the frog, the less sharp the angle of the turnout. The number is approximately the same as the length of the heel given in standard tables of turnout data. For example, the heel of a No. 8 frog is 7 feet 11 inches long and that of a No. 20 frog is 19 feet 10 inches. Common frogs are Nos. 8, 10, 15, and 20. The standard military one is the No. 8, discussed in paragraph 2.5.

2.4. SWITCHES

Through the years, switches have been designed in several ways; however, the two designs that have endured are stub and split switches.

a. Stub switches, once common in the United States, are seldom used here any more. Most states have outlawed them on main lines; however, they may be found in some oversea areas. More information on their use there is given in section V. Though simple and economical to construct and operate, stub switches are difficult to maintain and are quite unsafe; many derailments have been caused by them. They depend upon perfect alinement of the rails for proper operation. Their great advantages consist of economy and adaptability to light, slow traffic.

Study the layout of the stub switch turnout shown in figure 2.2 as you read the remainder of the subparagraph. Up to point A, the rails are spiked to the ties but from there on the rails are not spiked. Instead they are fastened to each other by tie rods that keep them at the correct gage. At B, the rails are held in place by a connecting bar fastened to the switch stand. The connecting bar is indicated by the shaded portion between B and C. Both main-line rails in the stub switch move.

b. Split or point switches have replaced the stub design on modern United States lines, because they have proven safer and more

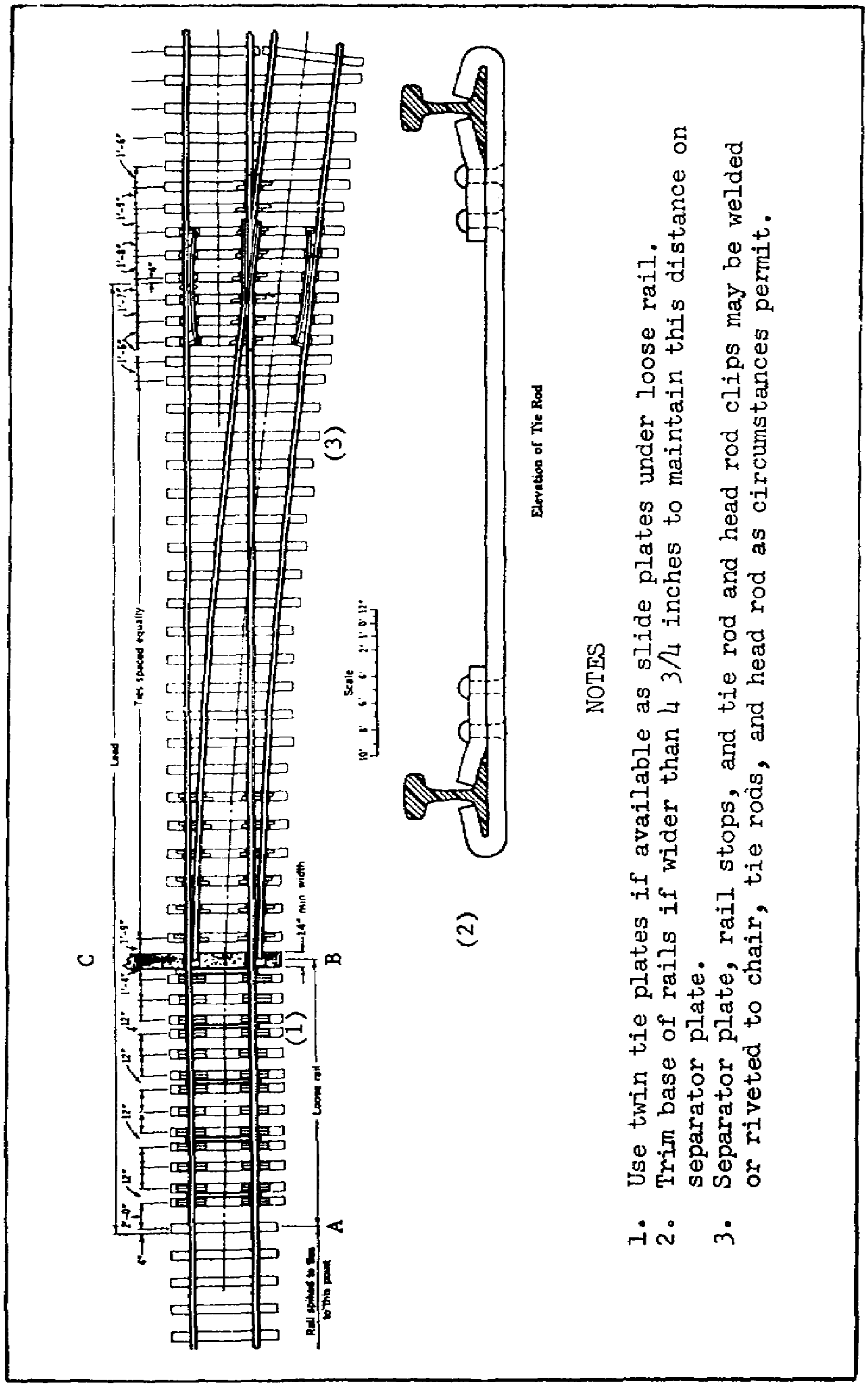


Figure 2.2. Stub Switch Turnout.

satisfactory. Unlike the stub type, the split switch is fastened to crossties, usually referred to as switch ties or timbers. Their lengths vary according to their location in relation to the various parts of the switch. Look now at figure 2.3 which illustrates the layout of a split switch turnout. Note that the ties graduate in length from 8 1/2 feet just beyond the switch points to 15 1/2 feet beyond the heel of the frog.

The split switch, like the stub one, has two movable rails; however, in the split switch one main-line and one turnout rail move. In figures 2.4 and 2.5, the movable rails are marked with X's; the arrow in each figure points out part of the switch-stand mechanism. Figure 2.4 is a view of a split switch closed for main-line movement; figure 2.5 shows it thrown for turnout movement.

The movable rails are tapered to one-fourth inch wide at the top. The sketches inserted at the left are the end views of left- and right-handed movable rails--the shaded areas -- as they appear beside their accompanying stock rails and as viewed from the switch points.

Left Handed Right Handed

2.5. FROGS

A frog is used in a turnout where the two running rails intersect, to provide a flangeway, or channel, for the wheel flanges to move from one rail to the other. It also provides, as nearly as possible, a continuous bearing for the wheels.

Each part of a frog has a name. Study figure 2.6 as you read the next few sentences so that you may identify the parts. Note that the <u>toe</u> is the opening between the <u>wing rails</u> on the end of the frog nearer the switch points. The lead rails are attached to the wing rails at the toe. The <u>throat</u> is the narrowest part, usually 1 3/4 or 1 7/8 inches wide. The <u>theoretical point</u> is located where the gage lines of the stock and the switch rails would intersect if they were extended past the actual point. If the point were planed to the theoretical point, the impact of the car wheels would soon batter and break it. For that reason, the point is rounded off to approximately one-half inch across and is called the <u>one-half inch or actual point</u>. The distance between the two points is equal, in inches, to one half the frog number. For example, on a No. 8 frog, the points would be 4 inches apart. The end of the frog away from the switch points is called the <u>heel</u>. That

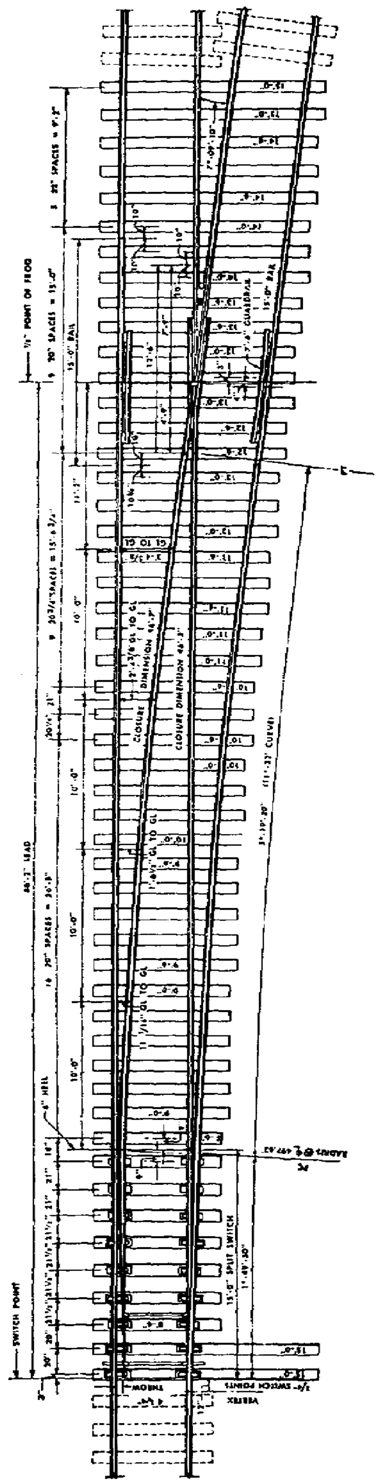


Figure 2.3. Split Switch Turnout.

Figure 2.4. Split Switch Closed for Main- Line Movement.

Figure 2.5. Split Switch Thrown for Turnout Movement.

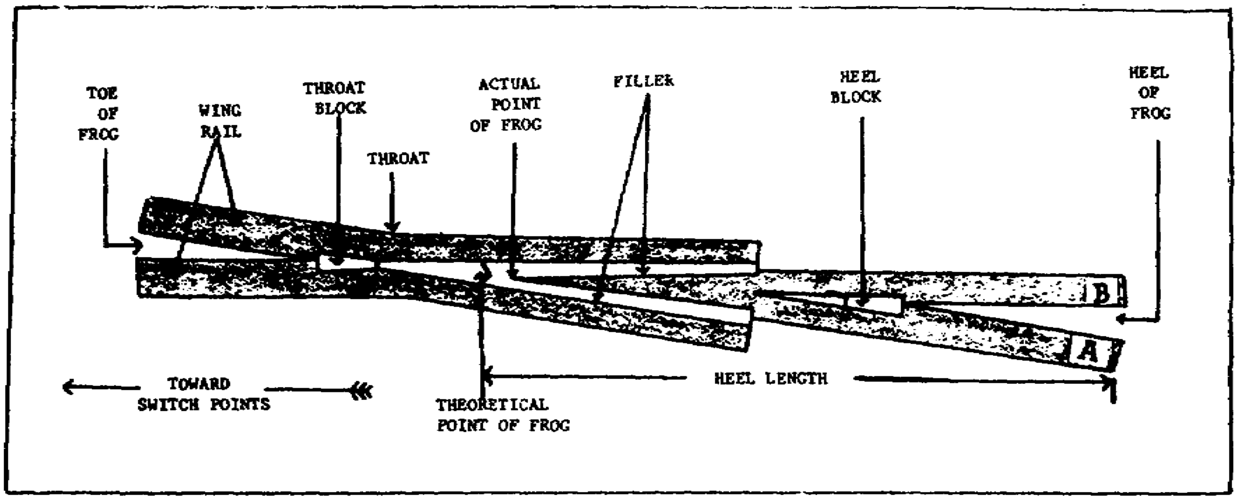


Figure 2.6. Frog Nomenclature.

is where the running rails are spliced to the frog. The primary classifications of frogs are the spring and rigid types.

a. Spring frogs provide a smooth, uninterrupted path through the turnout in one direction. The flanges of wheels passing over the alternate path force the wing rail of the frog open against spring tension. After the train has passed through the turnout side, the springs force the wing rail back against the running rail, maintaining the original route for main-line movements. Figure 2.7 shows the operation of this type of frog. The only justifiable location for spring frogs is in turnouts where traffic is considerably heavier in one direction than in the other and where it would not be desirable to delay movements through the little-used route. A main-track spring frog is pictured in figure 2.8, in which the upper arrow points to the wing rail and the lower to the spring mechanism.

b. Rigid frogs are divided into three groups: bolted-rigid, hard-centered (manganese insert), and manganese-steel; all three are illustrated in figure 2.9. A rigid frog installed in track is shown in figure 2.10. The bolted-rigid type is manufactured from standard rail sections cut as required and bolted together. It is standard military stock and is issued as a unit. Hard-centered frogs have manganese-cast points attached to standard rail sections. Since the point gets the greatest wear, it is made of extremely hard steel and is replaceable. The manganese-steel type is of hard steel and cast in one piece. Since manganese-steel and hard-centered frogs have greater resistance to wear, they are preferable to the bolted-rigid type, especially on main-line tracks and in busy yards. The latter

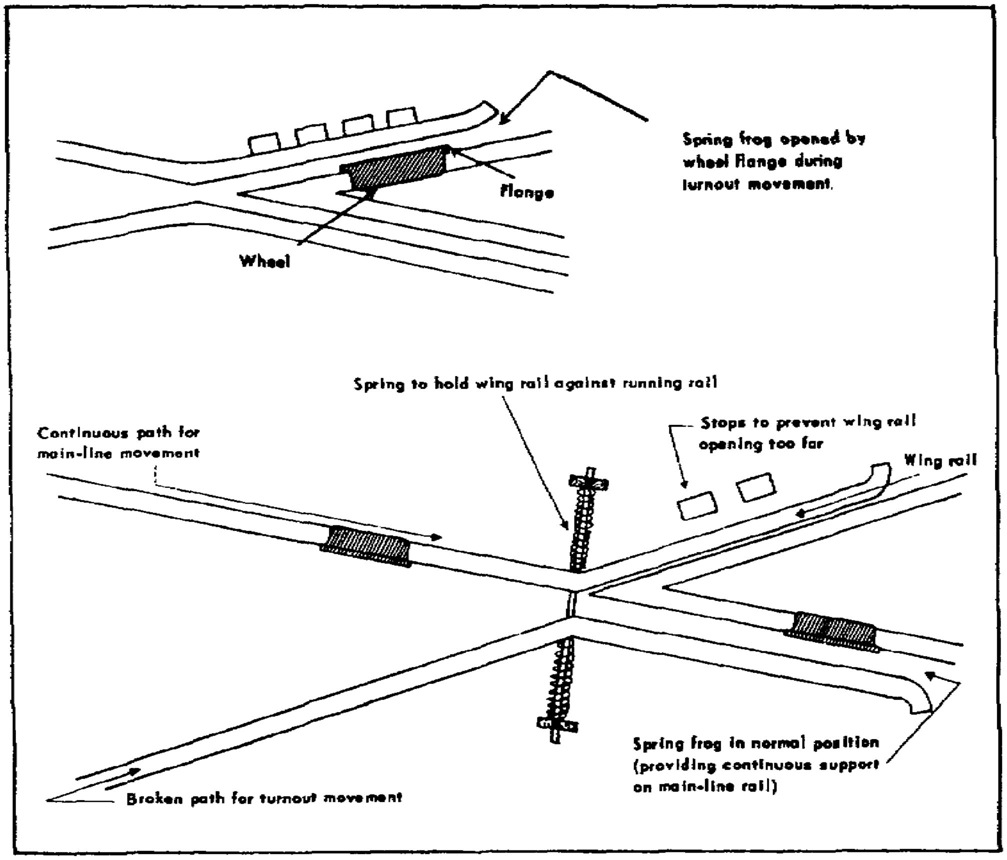


Figure 2.7. Spring Frog in Operation.

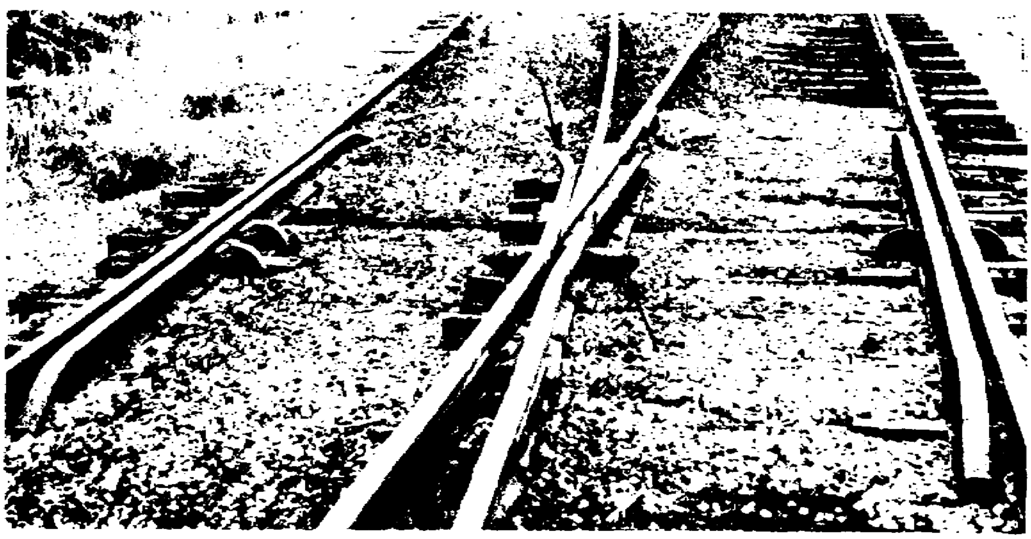


Figure 2.8. Spring Frog in Track.

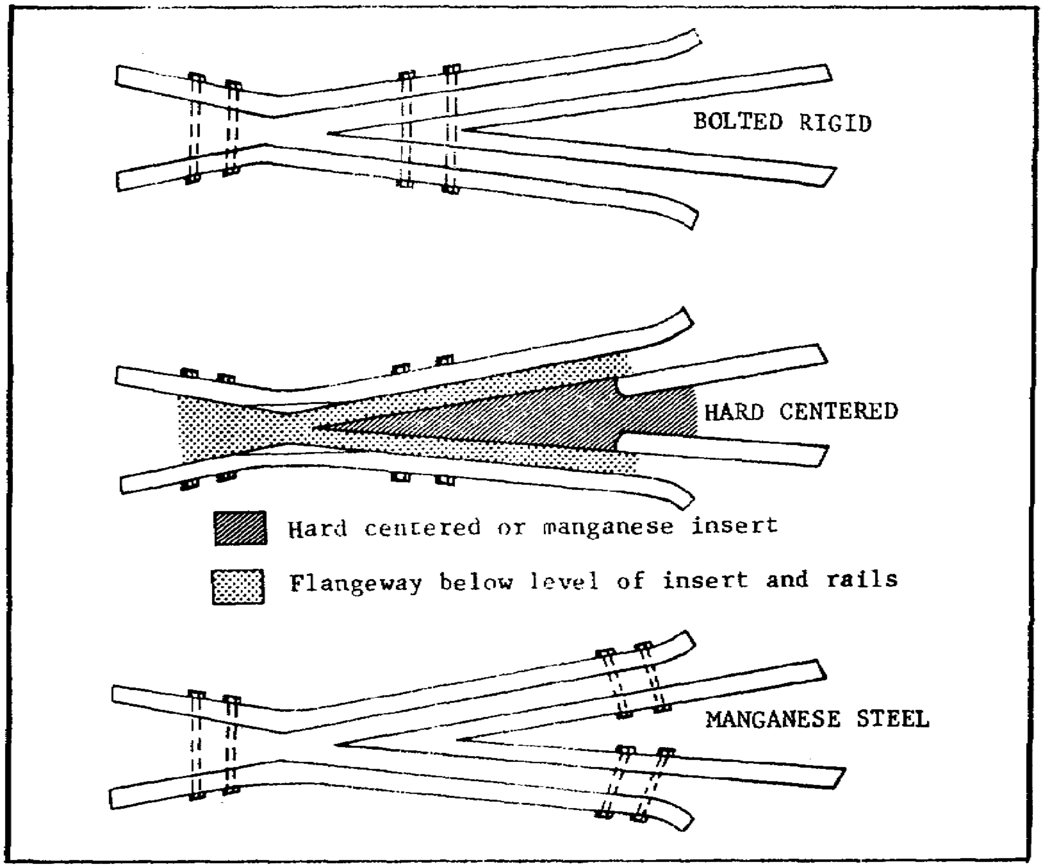


Figure 2.9. Types of Rigid Frogs.

Figure 2.10. Rigid Frog in Track.

may be used on light traffic lines and in relatively unimportant yards, or when other types are not on hand.

2.6. PATH THROUGH A FROG

The path through a frog that the train wheels take can be followed more easily if you refer to figure 2.11 as you read the remainder of the paragraph. If a locomotive were moving from left to right and were to be diverted to the left, the wheels moving over the left-hand rail would roll on it just as if it were ordinary track. The wheels moving over the right-hand rail would pass over the frog. The flanges would follow path C-D, while the treads would move along path A-B. Note that the wheels are unsupported as they pass the junction where the dotted line E-F crosses the dotted line C-D, at the throat of the frog. The gap is necessary for the movement of a train not being diverted by the switch, because it permits the flanges of the left-hand wheels to cross the rail A-B as it proceeds along path G-H. Any train passing through the turnout, regardless of direction, has the wheels on one or the other side pass through the frog. Wheels passing over the frog from left to right deliver a blow to the point of frog at X.

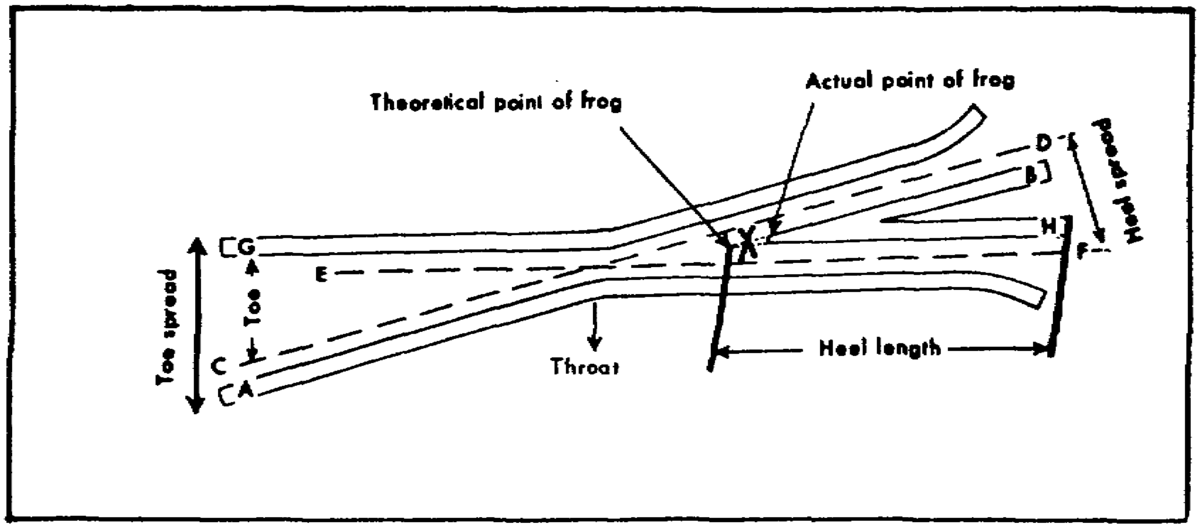


Figure 2.11. Movement Through a Frog.

2.7. FACING- AND TRAILING-POINT MOVEMENTS

Facing and trailing-point movements are the terms describing the prevailing moves through a turnout. They are designated in part by the direction from which the train is traveling when it reaches the frog. A train entering a turnout so that it faces the switch points and passes over them before it comes to the frog is said to be making a facing-point move. If the prevailing movement is facing point, the switch is called a facing-point switch. A train passing through the turnout so that it gets to the frog before reaching the switch points is making a trailing-point move. If most of the trains make trailing movements over the switch, it is called a trailing-point switch. The arrows in the diagram of a switch in figure 2.12 indicate facing- and trailing-point movements.

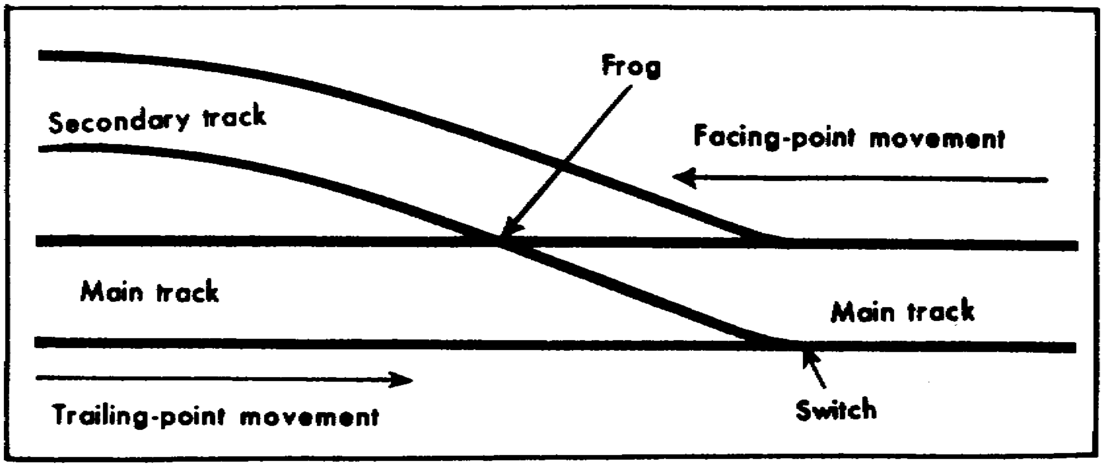


Figure 2.12. Facing- and Trailing-Point Movements.

2.8. RAILS

Three types of rails are to be found in a turnout. They are the guard; closure, and stock rails. Each performs a different job, as the subparagraphs following explain. The location of each type is noted in figure 2.13.

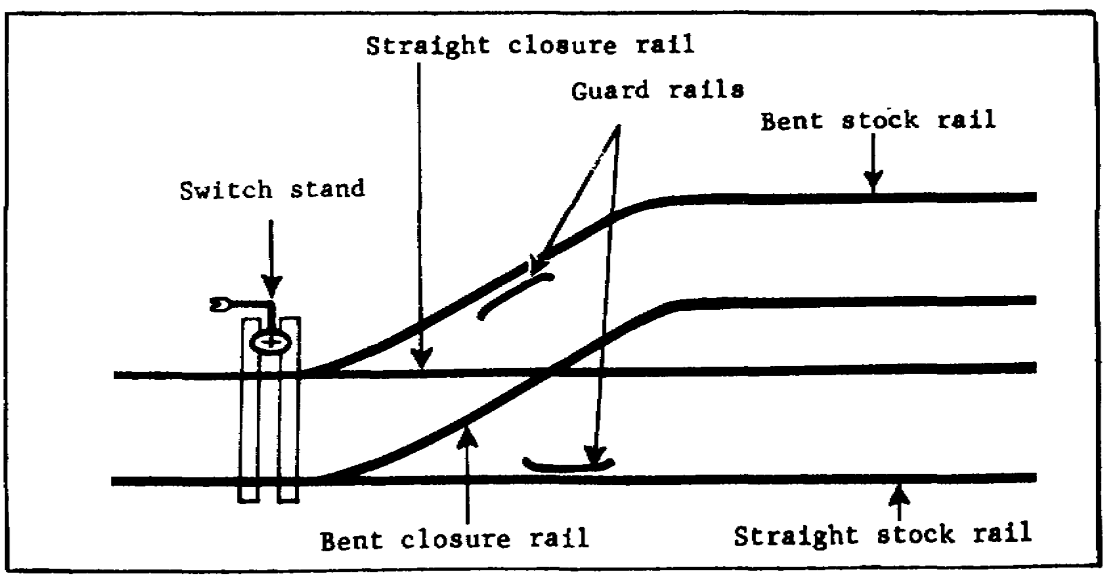
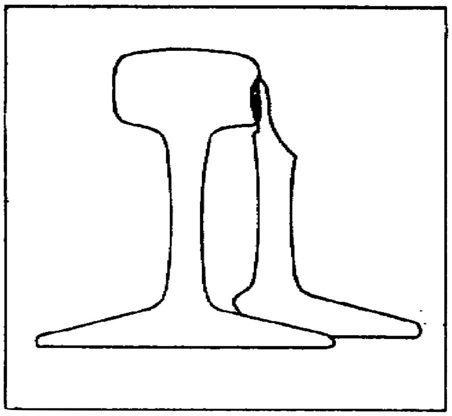


Figure 2.13. Location of Guard, Closure, and Stock Rails.

a. Guard rails are located opposite the frog on both mainline and turnout sides. They force the wheel flanges close to the running rails so that the opposite flanges will not strike direct blows on the frog point or pass down the wrong side of the point. Using guard rails in turnouts prevents excessive frog wear and reduces derailment hazards.

b. Straight and curved closure (lead) rails join the switch rails to the frog. The latter are joined together near the points by switch rods so that they are moved as a unit. The number used depends on the length of the switch rails. The rods closest to the points extend under the stock rails to the switch-throwing mechanism, as shown by the dotted line in figure 2.13.

c. The straight and bent stock rails are the two rails against which the switch points bear. The straight stock rail may also be called the through rail or the through running rail. The curve in the bent stock rail is at the theoretical point of the switch rather than at the actual one, to protect the switch points from batter. Turnouts designed for high-speed traffic often have indentations cut in the stock rail to further protect the switch points and to help in preventing derailments. The indentation is a 10-to 12-inch groove ground along the gage side of the head of the rail. The shaded area in the sketch points out the general area of the groove. Approximately one-quarter inch deep at its beginning opposite the switch points, the groove tapers to nothing at the other end.



2.9. SWITCH PLATES

The switch points rest on switch slide plates that are planed to provide a smooth surface on which the bottom of the points can slide. These plates extend under the stock rails and are graduated in thickness so that the top of the point is kept slightly above the top of the stock rail. Usually, the plates have fixed or adjustable rail braces to support the stock rails, which are subjected to the heavy lateral forces exerted by trains passing through the turnout. Long, narrow tie plates, so-called heel plates, are used to fasten both main-line and turnout rails to the switch ties. The heel plates are located beyond the heels of the switch points, that is, beyond the ends of the switch rails away from the points. Switch plates are used until the turnout and main-line rails have diverged far enough to permit use of separate tie plates.

2.10. SWITCH TIES

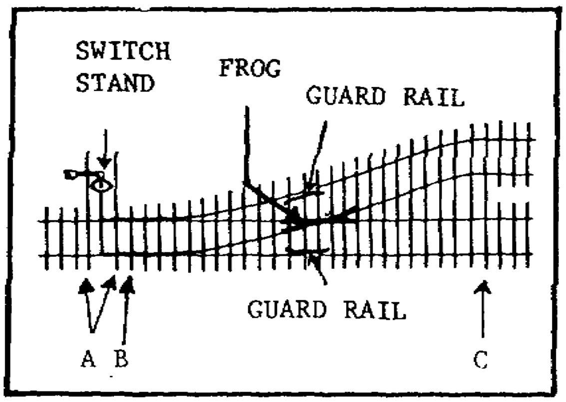


Figure 2.14. Arrangement and Location of Switch Ties.

The entire turnout is supported on switch ties. Look now at figure 2.14. Notice at point A that the two ties supporting the switch points also support the switch-throwing mechanism. They are referred to as headblock timbers and are 15 feet long. The succeeding ties, the actual switch ties, gradually become longer toward the frog end of the turnout, as shown in figure 2.14 between points B and C. For a No. 8 turnout, for example, tie lengths vary from 8 1/2 feet just beyond the switch points to 15 1/2 feet beyond the heel of the frog.

2.11. SWITCH-THROWING MECHANISM

Several references to the switch-throwing mechanism are made in earlier paragraphs. Just what is it? What does it do?

a. What the mechanism is. The switch-throwing mechanism consists essentially of a switch stand with a throw lever and a connecting rod. The switch stand is located on two 15-foot headblock timbers, shown at A in figure 2.14 opposite the switch points and usually on the right side of the track with respect to the normal direction of traffic. The center of the stand is approximately 6 feet 6 inches from the centerline of the track. The mechanism may be operated manually or electrically. Hand-thrown switches are thrown by the operators of small stations, yard switchmen, or traincrews. Electrically powered switches are thrown by remote control by operators stationed at towers or interlocking plants.

A typical manually operated switch stand is shown in figure 2.15. The targets (1) are painted panels to show the direction or the track for which the switch is lined--green, switch normal or set for main-line operation; red, switch reversed or set for turnout.

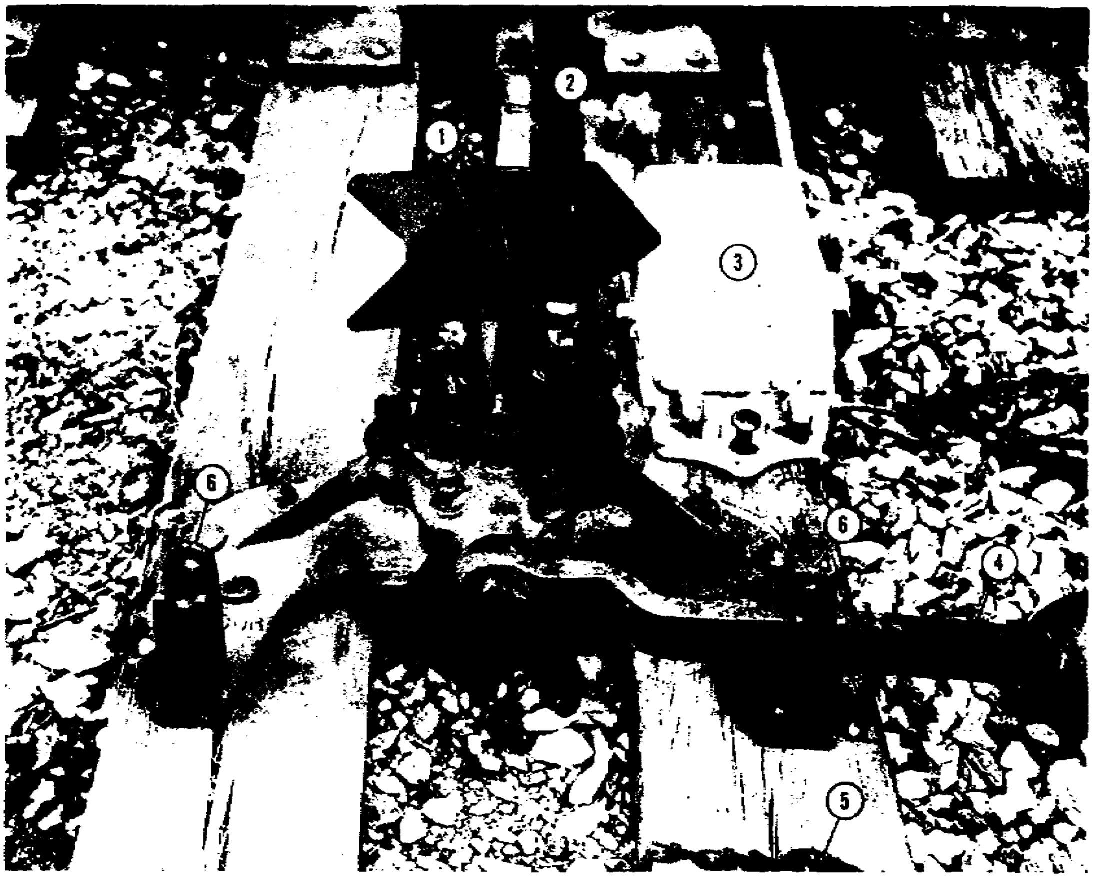


Figure 2.15. Manually Operated Switch Stand.

The switch rod (2) runs to the movable rails of the turnout and enables the operator to throw them. A control box (3) automatically activates downtrack signals when the throw lever (4) is moved, to show that the switch is either normal or reversed. To prevent the throw lever from being thrown accidentally or by unauthorized persons, a lock, a portion of which is seen at (5), is run through either of the latches shown at (6).

Main-line switch stands are always equipped with lights. They are mounted above the stand to indicate by color the direction or track for which the switch is lined. Green indicates that the movement is set for the main track; red, for the turnout.

b. What the switch does. As you have already gathered, the switch-throwing mechanism plays an essential part in turnout operation. It enables the switch points to be changed from mainline to turnout movement and back to main-line again. The switch stand is operated by the throw lever being moved from one latch to the other. Note in figure 2.15 that the lever is placed so that it is parallel to the track. As the lever is operated, the movable rails slide away from their accompanying stock rails a minimum of 4 3/4 inches; however, the throw can bc adjusted from 4 1/2 to 5 1/2 inches. When the lever is thrown back to the original latch, the movable rails again slide back against the stock rails. Look again at figures 2.3 and 2.4. Figure 2.3 shows a split switch closed for main-line movement, and figure 2.4 shows it thrown for turnout.

2.12. SUMMARY

Turnouts make it possible for a train to leave one track and enter another. A turnout is a combination of five components: a switch, a frog, guard rails, closure rails, and switch ties. A turnout is either left- or right-handed. The sharpness of a turnout is determined by the acuteness of the frog angle.

The two designs of switches are stub and split. Although economical and adaptable to light, slow traffic, the stub switch is quite unsafe and difficult to maintain. Its rails are connected by tie rods, and both of the main-line rails move. The split, or point, switch is more common than the stub switch and is safer and more satisfactory. Split-switch rails are fastened to crossties. In the split switch, one main-line and one turnout rail move.

A frog is installed at the intersection of the running rails, to provide a channel for the wheel flanges to move from one rail to the other and to provide a continuous bearing for the tread of the wheel. A frog has a toe, a throat, and a heel, and both an actual and a theoretical point--all of which are names of its parts. Both spring and rigid frogs are manufactured. Rigid frogs are of three types: bolted-rigid--the military standard, hard-centered, and manganese steel. Regardless of direction, a train going through a turnout has its wheels, on one side or the other, pass through the frog. Facing and trailing-point movements describe the directions the train travels through the turnout.

Two guard rails are installed opposite the frog, one on the main-line side and the other on the turnout side. Closure, or lead, rails connect the switch rails to the frog. These in turn are joined by switch rods so that the switch rails can be moved as a unit.

The two stock rails, one bent and the other straight, are the ones that the switch points beat against. The bent stock rail is curved at the theoretical point of the switch to protect the switch points from batter. Switch slide plates placed under the stock rails act as their tie plates and provide a smooth surface for the points to move on. The turnout is supported on switch ties varying in length from 8 1/2 to 15 1/2 feet.

The switch-throwing mechanism, or switch stand, enables an operator, either by hand or by remote control, to move the switch points for either main-line or turnout movement. Painted panels show the direction or the track for which the switch is lined--green for normal, red for reversed. The switch rod connects with the movable rails to enable them to be thrown. A latch with a lock through it prevents the switch from being thrown accidentally or by unauthorized persons.

Section II. Location

2.13. GENERAL

Turnouts are used to divert traffic from main track, branches or sidings, crossovers, and ladders (switching leads). The location of a turnout is affected by space limitations, speed requirements, volume and distribution of traffic, direction of traffic, and type of installation, and whether both freight and passenger equipment are to operate over them.

The track supervisor plans to brief his foreman and men on these points: turnouts in yards, crossovers and sidings, and permissible speeds through turnouts. His notes follow in the remaining paragraphs of section II.

2.14. IN YARDS

In most yards, turnouts are usually sharp and switches are manually operated. The restricted space in yards requires the sharp turnouts; the low speed limits found there permit them. Figure 2.16 illustrates typical yard turnouts. To control track routing, terminals often have interlocking plants that require a common operating point and remote control of switches. Interlocking is a system in which turnouts and signals are so connected and controlled that conflicting or incorrect routes cannot be set up by a tower operator. Yard turnouts and turnouts to sidings and running tracks have the same characteristics.

Figure 2.16. Yard Turnouts.

2.15. CROSSOVERS AND SIDINGS

To divert trains on multiple-track main lines, a crossover is provided. To permit opposing trains to pass or to allow a faster train to pass a slower one on a single-track line, a siding is provided. Although the purposes of these two types of turnouts are similar, their designs differ, as the following subparagraphs point out.

a. Crossovers. On multiple-track main lines, it is often necessary to provide routes so that trains may be diverted from one parallel track to another for passing, reaching station platforms, and getting off the main line. Two turnouts with a track between them, known collectively as a crossover, provide the means for moving trains from one track to another. Figure 2.17 depicts a typical crossover. Sharp turnouts must not be used in crossovers unless mainline speeds can be restricted. The turnouts should, if possible, be of the same size. And to avoid too many compromise joints, turnouts should be of the same rail section as the track they join whenever possible. Crossovers are generally remotely controlled and must be if a group of them is interlocked.

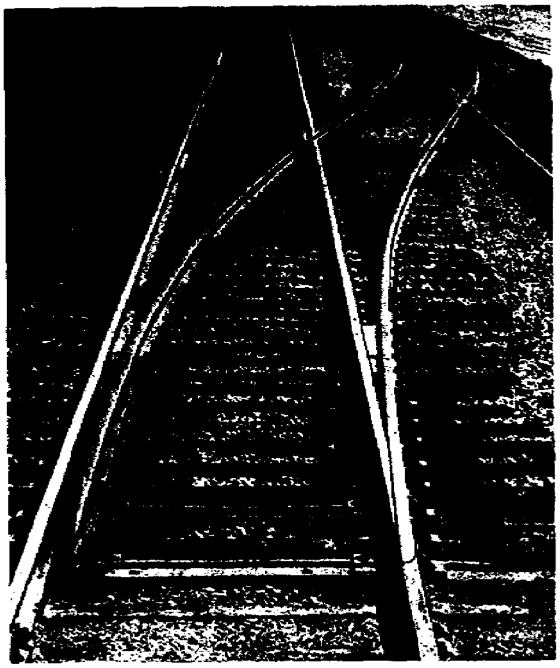


Figure 2.17. Typical Crossover.

b. Single-track sidings. To allow passing of trains when they are running in opposite directions or moving at different speeds in the same direction on single-track lines, sidings are used. Their turnouts may be sharp and need not be remotely controlled, since one of the trains must ordinarily stop before entering or leaving the siding.

2.16. PERMISSIBLE SPEEDS THROUGH TURNOUTS

The speed requirement to be met on a particular track determines the number of the frog and the length of the switch rail used in a turnout. On a military railroad, the No. 8 frog and the 16 1/2-foot switch rail are standard. On civilian railroads, Nos. 7, 8, and 9 frogs are used for yard movements; Nos. 10, 11, and 12 for slow-speed main and branch lines; and Nos. 12, 15, and 20 for high-speed main-line movements. A rule of thumb gives maximum permissible speed in miles per hour through a conventional turnout as equal to twice the frog number. In table I are

Table I. Permissible Speeds Through Various Turnouts

Frog No.	Switch-rail length, ft	Permissible speed, MPH*
20	45	45
20	30	35
15	30	30
10	20	15
10	18	15
8	20	10 to 15
8	18	10 to 15

*To convert miles per hour to kilometers per hour, multiply the mph figure by 1.61. Example: 45 x 1.61 = 72.45 or approximately 72 kmph.

listed the permissible speeds at which trains may pass through turn-outs having certain frog numbers and switch-rail lengths.

2.17. SUMMARY

Yard turnouts are usually sharp, and manually operated switches are used because of the limited space in yards and the low speeds required in them. Remote-control interlocking plants usually control track routing in passenger terminals.

A crossover is used for diverting trains from one parallel track to another, passing, reaching station platforms, and getting off the main track. A crossover requires two turnouts with a track between them, but sharp ones are not desirable because they restrict the speed of the trains using them. If possible, the turnouts should be the same size and use the same rail section as the tracks they join. Single-track sidings permit passing of trains running in opposite directions or at different speeds in the same direction. Turnouts to these sidings may be sharp and manually controlled. "Twice the frog number" is the rule of thumb applied to find the permissible speed through a turnout. But the speed is also controlled by the length of the switch rail.

Section III. Construction

2.18. GENERAL

Plans and data for installing a turnout must be worked out by an engineer or a skilled turnout technician, because a knowledge of trigonometry is needed. The computations for locating the parts of a turnout can be complicated, especially if curves are involved. However, standard plans and data tables are obtainable. In addition, civil engineering handbooks contain exhaustive treatments of various design problems which may occur.

When briefing the track foreman and men, the track supervisor should be able to give them the when, why, where, and how of turnout construction. His notes in answer to these questions follow in the remaining paragraphs of this section.

2.19. WHEN, WHY, AND WHERE

Turnouts are installed during new construction and during out-of-face renewal of track, and when existing ones are no longer satisfactory, because of increased speed requirements or changes in locomotive design. Turnouts may lead from one tangent track to

another at an angle or into a curve, or they may lead from a curve into a tangent or another curve. Because of increased wear, turn-outs should not ordinarily be located on curves.

2.20. PRELIMINARIES

Certain decisions and arrangements must be made before construction can begin. The track supervisor has been notified that the turnout from the westbound track to the new installation north of Burton Division's main line is to be constructed before the crossover from the eastbound. Coordination has been made with the dispatcher to take the westbound main track out of service until the job is completed. The foreman must determine the proper length of rails to use so that no rail joints will fall between the ends of either guard or switch rails. He will see to it that all the rails are cut to the correct lengths with a rail saw, such as the one shown in figure 1.19. None of them are to be cut with a torch, because this leads to early rail failure, as paragraph 3.29.c (2) of RT 670 explains. Now that the construction preliminaries have been taken care of, go on to the first and subsequent steps in turnout construction, described in paragraphs 2.21 and 2.22.

2.21. ESTABLISHING TURNOUT POSITION

The first step in installing a turnout is to locate the actual point of frog (PF), as shown in figure 2.18A, and set a stake to mark the position. From the PF, you can locate the other parts of the turnout. The first one you establish is the point of switch (PS). Again refer to figure 2.18A. To decide on the locations, you refer to a turnout plan, such as the one given in figure 2.2, or to a table of data, such as table II.

2.22. REMAINING STEPS

The turnout position has been established and the point of frog and point of switch have been located. What are the other steps in turnout construction? They are given in the remainder of this paragraph and illustrated in parts B through F of figure 2.18. Although there are several satisfactory methods of turnout installation, only one is outlined here.

The next step is for the gang to remove the old rails, ballast, and ties between the point of frog and point of switch, as shown in figure 2.18B. After the old ballast has been cleaned and replaced or new ballast substituted, new switch ties and switch and tie plates

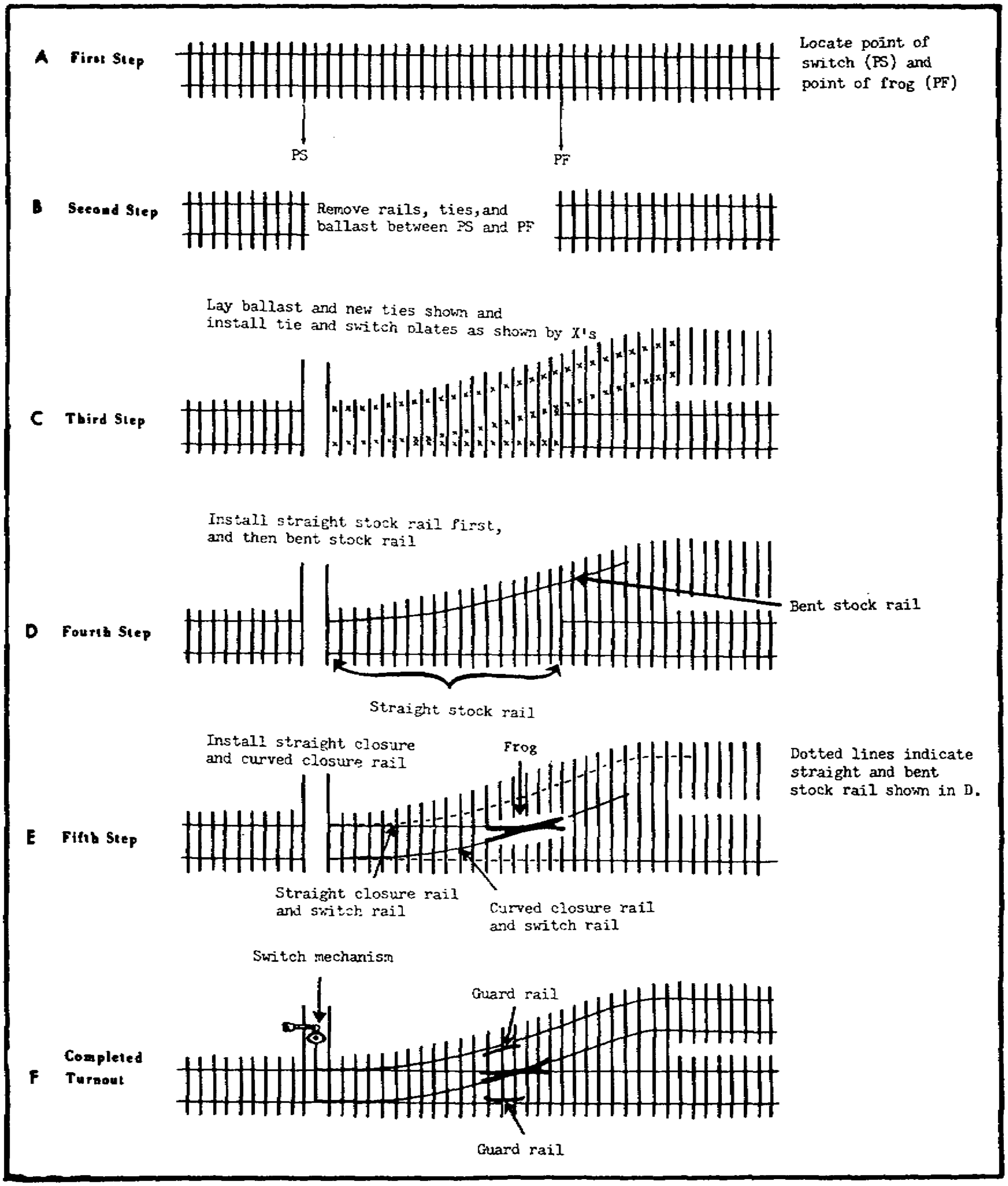


Figure 2.18. Steps in Turnout Construction.

are positioned, as shown in figure 2.18C. At this point, the straight stock rail is placed, lined, and spiked. The bent stock rail is next set in its approximate position and held in place by a few spikes to prevent its springing, as shown in figure 2.18D.

Table II. Turnout Crossover Data for Straight Switches

Point of switch to point intersection	Point of intersection to point opposite point of frog (1½")	Col 1: Frog number	Properties of switches — Col 2: Length of switch rail (ft. in.)	Properties of switches — Col 3: Switch angle (de mi sec)	Col 4: Actual lead (ft. in.)	Closure distance — Col 5: Straight closure rail (ft. in.)	Closure distance — Col 6: Curved closure rail (ft. in.)	Lead curve — Col 7: Radius of center line (feet)	Lead curve — Col 8: Degree of curve (de mi sec)	Gauge line offsets — Col 9 (ft. in.)	Gauge line offsets — Col 10 (ft. in.)	Gauge line offsets — Col 11 (ft. in.)	Gauge line offsets — Col 12 (inches)	Gauge line offsets — Col 13 (inches)	Gauge line offsets — Col 14 (ft. in.)
		5	11 0	2 39 34	42 6 1/2	28 0	28 4	177.80	32 39 56	18 0	25 0	32 0	11 13/16	20 5/8	2 8 3/4
		6	11 0	2 39 34	47 6	32 9	33 0	258.57	22 17 58	19 2 1/4	27 4 1/2	35 6 3/4	42 1/8	21 5/8	2 10
		7	16 6	1 46 22	62 1	40 10 1/2	41 1 1/4	365.59	15 43 16	26 2 1/4	35 10 1/2	45 6 1/4	11 3/4	19 9/16	2 6 7/8
30-0	38-0	8	16 6	1 46 22	68 0	46 5	46 7 1/2	487.28	11 46 44	27 7 3/4	38 8 1/2	49 9 3/4	11 7/8	20 9/16	2 8 5/16
		9	16 6	1 46 22	72 3 1/2	49 5	49 7 1/4	615.12	9 19 30	28 10 3/4	41 2 1/2	53 6 3/4	12 5/16	21 3/8	2 9 7/16
		10	16 6	1 46 22	78 9	55 10	56 0	779.39	7 21 24	29 11 3/4	43 5 1/2	56 11 1/4	12 1/4	21	2 8 5/8
		11	22 0	1 19 46	91 10 1/4	62 10 3/4	63 0	927.27	6 10 56	37 8 1/2	53 5	69 1 1/2	12 1/4	21 3/8	2 9 3/4
		12	22 0	1 19 46	96 8	66 10 1/2	67 0	1,104.63	5 11 20	38 8 1/2	55 5	72 1 1/2	12 7/16	21 5/8	2 9 7/8
		14	22 0	1 19 46	107 0 3/4	76 5 1/4	76 6 3/4	1,581.20	3 37 28	41 1 3/4	60 2 1/2	79 3 3/4	12 7/8	22 5/16	2 10 1/2
		15	30 0	0 58 30	126 4 1/2	86 11 1/2	87 0 3/4	1,720.77	3 19 48	51 9	73 6	95 3	12 1/8	21 3/4	2 9 3/4
		16	30 0	0 58 30	131 4	91 11	92 0	2,007.12	2 51 18	53 0	76 0	99 0	12 7/16	21 13/16	2 10 5/16
		18	30 0	0 58 30	140 11 1/2	99 11	100 0	2,578.79	2 13 20	55 0	80 0	105 0	12 3/4	22 1/8	2 10 7/16
		20	30 0	0 58 30	151 11 1/2	110 11	111 0	3,289.29	1 44 32	57 9	85 6	113 3	13 1/16	22 11/16	2 11 3/16

Col 1: Frog number	Col 15: Tangent adjacent to switch rail (feet)	Col 16: Tangent adjacent to toe of frog (feet)	Properties of frogs — Col 1: Frog number	Properties of frogs — Col 17: Frog angle (de mi sec)	Properties of frogs — Col 18: Over-all length (ft. in.)	Properties of frogs — Col 19: Toe length (ft. in.)	Properties of frogs — Col 20: Heel length (ft. in.)	Properties of frogs — Col 21: Toe spread (inches)	Properties of frogs — Col 22: Heel spread (inches)	Date of cross-overs, 13' 0" track centers — Col 23: Straight track (ft. in.)	Date of cross-overs, 13' 0" track centers — Col 24: Cross-over track (ft. in.)	For change of 1' 0" in track centers — Straight track (ft. in.)	For change of 1' 0" in track centers — Cross-over track (ft. in.)
5	0.00	0.78	5	11 25 16	9 0	3 6 1/2	5 5 1/2	7 15/16	13 9/16	16 10 5/16	18 1 7/8	4 11 7/16	5 0 1/8
6	0.00	1.75	6	9 31 38	10 0	3 9	6 3	7	13	20 5 1/2	21 6 1/2	5 11 1/2	6 0 1/2
7	0.01	0.00	7	8 10 16	12 0	4 8 1/2	7 3 1/2	7 9/16	13	24 0 3/8	24 11 5/8	6 11 9/16	7 0 7/16
8	0.64	0.00	8	7 09 10	13 0	5 1	7 11	7 1/8	12 3/4	27 7 1/4	28 4 3/8	7 11 5/8	8 0 3/8
9	0.00	0.17	9	6 21 35	16 0	6 4 1/2	9 7 1/2	8	13 5/16	31 1 5/8	31 10 3/8	8 11 11/16	9 0 5/16
10	2.08	0.00	10	5 43 29	16 6	6 5	10 1	7 3/16	12 5/8	34 8 1/8	35 3 7/8	9 11 11/16	10 0 5/16
11	0.00	0.13	11	5 12 18	18 8 1/2	7 0	11 8 1/2	7 1/8	13 1/4	38 2 1/2	38 9 1/2	10 11 3/4	11 0 1/4
12	0.00	0.50	12	4 46 19	20 4	7 9 1/2	12 6 1/2	7 5/16	13 1/16	41 8 3/4	42 3 1/4	11 11 3/4	12 0 1/4
14	0.24	0.00	14	4 05 27	23 7	8 7 1/2	14 11 1/2	6 7/8	13 5/16	48 9 1/4	49 2 13/16	13 11 13/16	14 0 3/16
15	1.56	0.00	15	3 49 06	24 4 1/2	9 3	14 11 1/2	7	12 7/16	52 3 7/16	52 8 3/8	14 11 13/16	15 0 3/16
16	0.66	0.00	16	3 34 47	26 0	9 5	16 7	6 9/16	12 15/16	55 9 3/8	56 2 1/2	15 11 13/16	16 0 3/16
18	0.57	0.00	18	3 10 56	29 3	11 0 1/2	18 2 1/2	6 7/8	12 5/8	62 9 3/8	63 2 3/16	17 11 13/16	18 0 3/16
20	2.47	0.00	20	2 51 51	30 10 1/2	11 0 1/2	19 10	6 1/4	12 3/8	69 10	70 2	19 11 7/8	20 0 1/8

NOTES

Data shown are computed for turnouts out of straight standard 56 1/2-inch gage track. If wheelbase of equipment used requires wider gage for switch alinement or curvature shown, maintain lead and alinement of curved closure rail and move inside stock and curved rails out the required amount. Increase gage of straight track through switch, and bend the straight closure rail to true alinement ahead of toe of frog.

Next, the frog and the straight closure rail with its accompanying switch rail are assembled on the ties, between the stock rails, adjacent to their final positions. This assembly is gaged from the straight stock rail, with the point of frog coinciding with the staked position of the PF, and spiked in place. The point of switch is spiked temporarily. The curved closure rail and turnout point of switch are then spiked in place, as figure 2.18E shows. Now the bent stock rail can be gaged from the turnout point of switch and the curved closure rail and then spiked in its final location. The two guard rails are assembled and spiked opposite the frog and adjacent to the running rails. Next, the spikes are removed from the through point of switch; it is then moved to the open position, 4 3/4 inches from the bearing surface of the curved stock rail, and joined to the opposite point of switch with the switch rods. Then the switch-throwing mechanism is installed. The turnout is now ready for use. The completed turnout is shown in figure 2.18F.

2.23. SUMMARY

It takes an engineer or a skilled turnout technician to draw up the plans and data needed for turnout construction. A knowledge of trigonometry is essential. Turnouts are installed during new construction and out-of-face track renewal, or when the present ones have become unsatisfactory.

Before construction can begin, the dispatcher must take the track out of service until the work is completed. The foreman must determine the proper lengths of rails so that placing them will not interfere with either guard or switch rails. Having the rails properly cut is also his responsibility.

The first step in turnout construction is to locate the point of frog and point of switch. The other steps include removing and relaying rails, ties, and ballast; installing the straight and bent stock rails, followed by the straight and curved closure rails and the frog. When the guard rails and the switch-throwing mechanism are in place, the construction is complete.

Section IV. Maintenance

2.24. GENERAL

Turnout maintenance, like any other, really involves three things: inspection, repair, and prevention. The first and foremost step in turnout maintenance is frequent inspections. The stock rails, switch points, guard rails, and frogs must come under the closest scrutiny for signs of excessive wear. All bolts and spikes are checked for tightness, ties examined for signs of pumping, and gage and surface checked frequently. After inspections, the faults discovered must be studied to find out their causes and prevention. Your personal experience is valuable in this work. In the remaining paragraphs of the section, examples show the approach to and prevention of typical problems with frog points, switch points, and switch ties.

2.25. FROG POINTS

Following an inspection of the tracks near the Griffin cutoff, the frog point of a turnout in the eastbound main line was reportedly badly chipped. Wheel flanges have been striking the point. This dangerous condition could result in a derailment; immediate correction is required. The point can be repaired by building up the chipped area with weld. If, however, this is the only action taken, the cause will still exist and the point will be damaged again. Only one thing could cause the chipping: the gage between the guard rail and frog point is too narrow and the guard rail opposite the point doesn't hold the wheels against the rail. However, investigation may show that the running and the guard rails are improperly located and that the frog is poorly lined even though they all seem to be well spiked.

Further investigation may show that several good-looking ties under the frog, guard rail, and running rail are "spike killed." This means that the ties have been destroyed internally by repeated spikings and can no longer give the spike support needed for proper gage. In addition to building up the frog point, the bad ties must be replaced and the rails gaged to keep the point from being damaged again. Whenever possible, damaged frogs should be repaired without being removed from track. When this cannot be done, they are sent to a central repair shop for rebuilding.

2.26. SWITCH POINTS

During an inspection of switch points, a lip was found on the stock rail that interferes with the point's bearing properly against the stock rail. During another inspection later, it was discovered that the switch points have dropped below the top of the stock rail. When a lip, or fin, on the switch-rail side of the stock rail is found that interferes with the point's proper bearing against that rail, it must be removed by grinding or filing. The grinder being used in figure 1.17 to remove excess weld at a rail joint or the files pictured in figure 1.7 may be used for removing a lip. When operating the grinder, the operator must be sure to wear the safety goggles shown in figure 1.7.

If the point is not bearing properly against the stock rail, a wheel flange could "pick the point," that is, force its way into the small opening between the point and the rail, throw the switch, and derail equipment. To further check the bearing of switch points against stock rails, the switch points are thrown to expose their bearing surfaces next to the stock rails. The area of wear will show whether the points have full bearing against the stock rails. If full contact is not found, it can be corrected by grinding or by adjusting the rods on the switch-throwing mechanism.

When investigating a turnout, the inspector may find that the switch points are lower than the stock rail. He is immediately aware of the danger of the wheel treads riding up on the stock rail so that the switch rail cannot redirect the flange. It will then fall on the switch rail and probably cause chipping. If this continues, the switch rail becomes so badly chipped that it may be easily "picked," or a wheel may fall on the wrong side of the switch rail. Either can cause a derailment. A badly worn switch point can be built up by weld.

2.27. SWITCH TIES

If, when a train passes through the turnout, the switch ties at the point are pumping, it is certain that low switch points are to blame. The rigidity of the stock rail maintains its normal elevation above the tie. The remedy is to tamp the ties or to correct any existing water pocket (RT 670, par. 2.10). If the switch points are severely chipped, they have to be replaced or at least repaired. When a point is replaced, usually its accompanying stock rail is also.

2.28. SUMMARY

Inspection, repair, and prevention are the keywords of turnout maintenance. Inspect turnouts frequently for excessive wear, loose bolts and spikes, pumping ties, and improper gage and surface. Study the faults found to determine their causes and prevention. Among the faults that may be found are chipped frog points, the switch point bearing improperly against the stock rail, low switch points, and pumping ties.

Section V. Special Switches and Track Constructions

2.29. GENERAL

Switches without frogs, frogs without switches, and stock rails that go nowhere--all of these and more, more switches, that is, constitute most of the subject matter of section V. This section shows how the now-familiar switches and frogs have been adapted to suit special purposes. It tells more about stub switches and introduces spring switches, derails, crossings, and slip switches. Also, this section discusses gantlet tracks, a special type of track construction, and track bumpers that may be installed on spurs and sidings.

2.30. STUB SWITCHES OVERSEAS

Although the stub switch is practically obsolete in this country, as paragraph 2.4a explains, it is of interest to military track supervisors because it may be found in many oversea areas. Its disadvantages are, first, that high temperature may cause sufficient rail expansion to bind the movable rails in one position, preventing the switch from being thrown to the alternate path. Second, the slightest maladjustment of the switch rails can result in derailments. However, because of the urgent need for rail transportation and the scarcity of supply parts in a theater of operations, this switch may be used in spite of its poor design. All that is necessary to construct such a turnout are switch ties and a suitable frog; the switch itself can be made of standard rail.

2.31. SPRING SWITCHES

A spring switch is actually a split switch incorporating a throwing mechanism that permits a train to make a trailing-point move no matter for which direction the switch is lined. This is done by having the switch points held in normal position, that is, set for main line, by springs mounted in cylinders and attached to the switch-rod assembly. The wheel flanges of a train passing on to the main track from the turnout side force the switch point over against spring tension without damaging the switch stand or operating mechanism. After the train has passed, the springs return the switch points to normal position. An oil cylinder and a buffer-plate assembly prevent the switch from returning to normal position too quickly, which would be damaging to the entire mechanism. The switch is usually constructed so that it can also be manually thrown for facing-point traffic to enter the turnout side. It is then set for the turnout.

Trailing moves for the main-line side now force the points against spring tension.

2.32. DERAILS

Derails are used to deliberately run a car or train off the rails to prevent its colliding with another or its going into an open, movable-span bridge. The only place they are used on a main line is at the approach to such a bridge. To prevent cars from running away or fouling a main track, derails are installed on storage tracks, industry or depot connections, and similar spurs, especially when such tracks descend toward the main line. Logically, equipment derailment is preferred to a locomotive's going into a river because of an open bridge or onto a main line when a through train is passing the junction.

Split-point and frog derails are the two designs commonly used. The split-point derail, illustrated in figure 2.19, a simple switch mechanism that leads the car off the track, could be described as a switch with no frog. Only one switch point is necessary, and the curved stock rail leads nowhere. A derail may be operated either manually or by remote control. The arrow in figure 2.19 points to the switch rod connected to the manually controlled switch-throwing mechanism. The derail frog, shown in figure 2.20, fits over one rail. Its grooved contour guides the wheel flange up, over, and away from the rail.

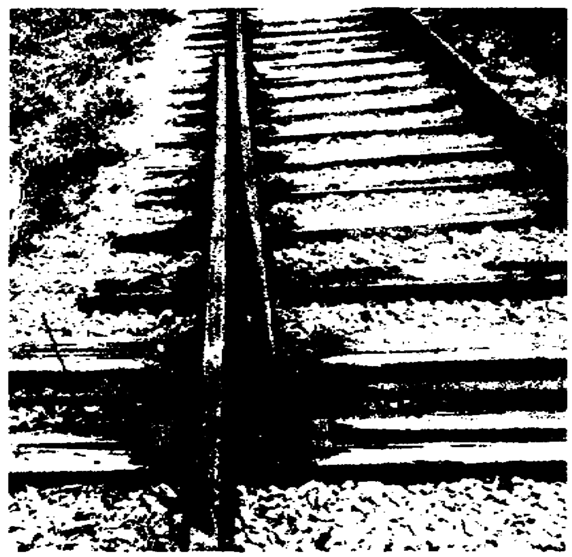


Figure 2.19. Split-Point Derail.

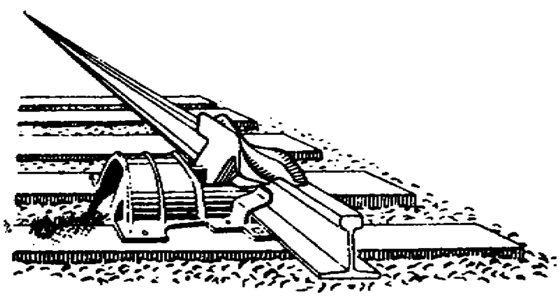


Figure 2.20. Derail Frog.

2.33. TRACK CROSSINGS

Although crossings with other tracks should be avoided, they are sometimes necessary. Such track crossings are either cast solid or made of built-up rail sections. Normally, built-up ones are used on military railroads.

Except for right-angled crossings, each one is designed for a particular location.

A frog is needed at each intersection to enable the wheel flanges to pass along both tracks. For flat-angled crossings, conventional frogs are used at the ends but specially designed ones in the center. In figure 2.21, the end frogs are lettered (A) and the center ones (B). The end frogs in the crossing shown in figure 2.21 are the rigid type. But when they are used in such a wide-angled crossing, the flangeway openings are also necessarily wide. These are dangerous and cause a rough ride and increased point damage. To avoid these bad features, crossings are usually built with movable-point frogs. A track crossing with such frogs is illustrated in figure 2.22. The movable points consist of two knuckle--angled--rails against which rails mitered to the crossing angle and its supplement are moved to form a solid wheel support or opened to provide the flangeway needed for moving over opposing routes. In figure 2.22, the knuckle rails are labeled and the crossing angles are marked (A). Movable-point frogs act somewhat like switches in that they must be set for one track or the other.

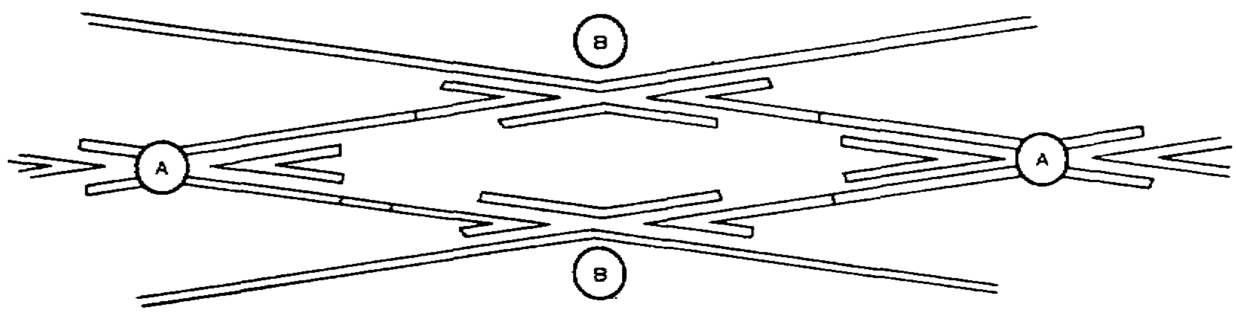


Figure 2.21. Track Crossing With Rigid Frogs.

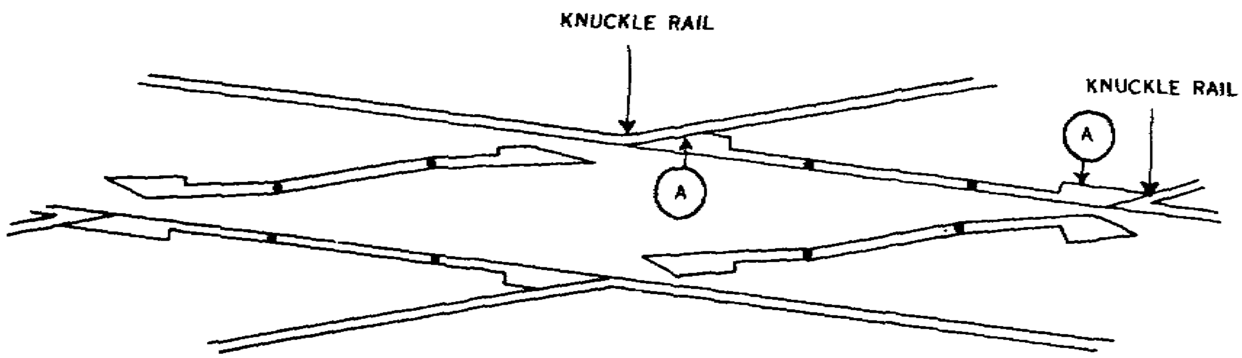


Figure 2.22. Track Crossing With Movable-Point Frogs.

2.34. SLIP SWITCHES

Adding switch rails to a movable-point frog crossing results in a double slip switch, shown in figure 2.23. A train entering it on either track can be diverted to either of the tracks at the opposite end. Slip switches provide flexibility of train movements and take up much less space than the combination of simple turnouts that would be required to obtain the same result. They have the disadvantage of difficult and expensive maintenance. Their use is also discouraged because their parts must be individually designed and built to fit a particular location. They are most often seen in passenger terminals and old yards where space does not permit additional turnouts to meet modern requirements. Slip switches are not to be built nor rehabilitated in a theater of operations. These switches are popularly known as "puzzle" switches, probably because it is extremely difficult to look at them and determine immediately for which route of travel they are set.

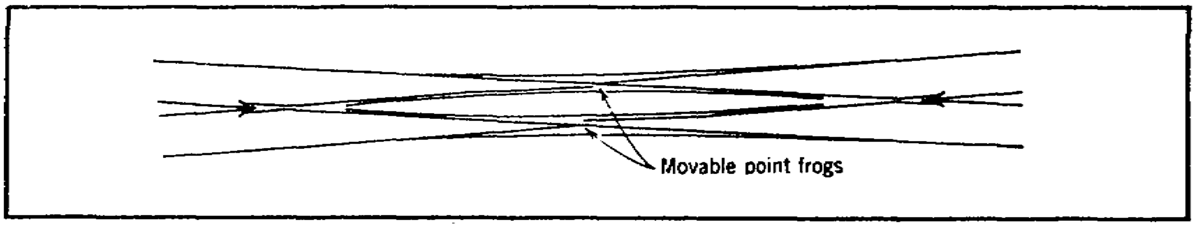


Figure 2.23. Double Slip Switch.

2.35. GANTLET TRACKS

Gantlet tracks have two frogs but no switch rails, as illustrated in figure 2.24. They are used to converge double-track lines into less space for short distances. A typical use might be to run a double-track line over a bridge too narrow for two tracks. The same thing could be done with two turnouts, but the gantlet track arrangement does not require switch points nor is setting the turnout necessary. However, signal protection is required since trains running in opposing directions cannot pass each other on the gantlet track.

2.36. TRACK BUMPERS

Track bumpers are installed at the end of dead-end tracks to prevent equipment from being derailed and to protect surrounding structures, etc. Typical locations are industrial spurs, blind sidings,

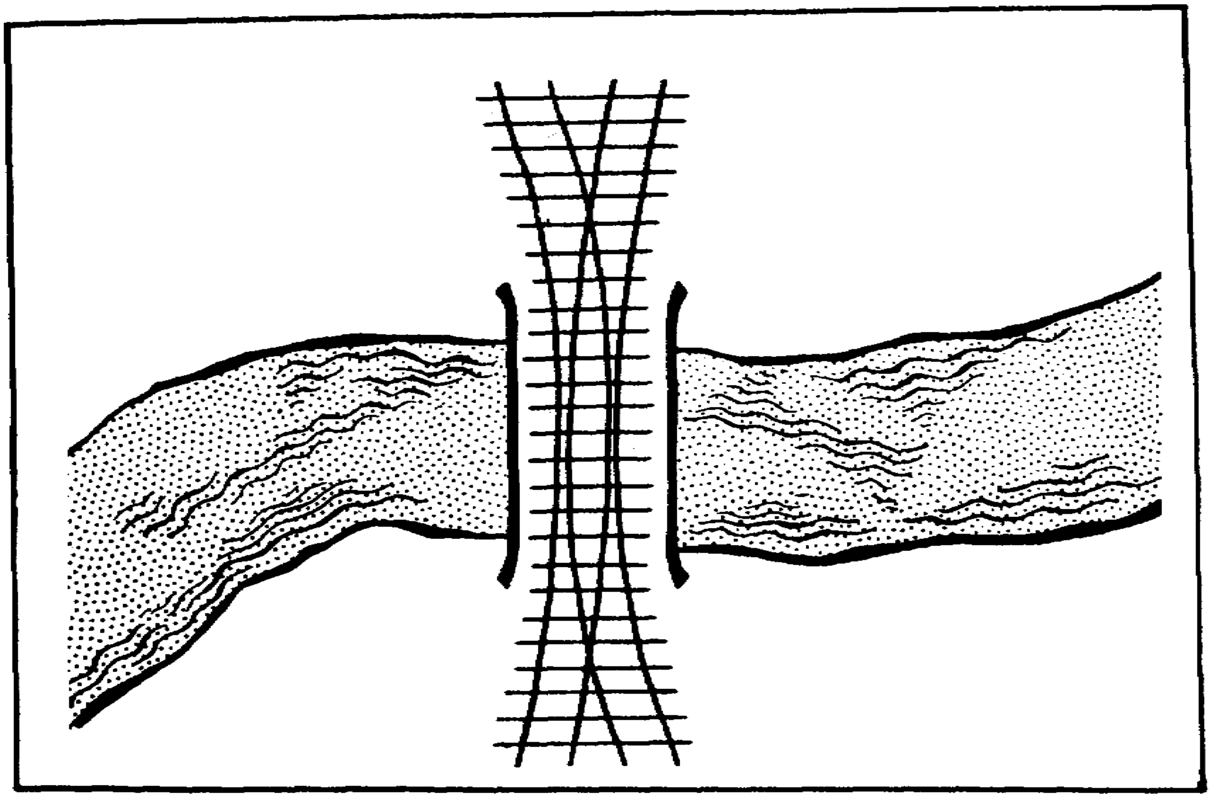


Figure 2.24. Gantlet Track Over Narrow Bridge.

passenger terminals, freight stations, and team tracks.* Several types of bumpers are available, two of which are shown in figures 2.25 and 2.26. However, all have the same purpose: to receive the initial impact from the rolling stock and transmit it to the ground or track structure. Commercial designs made of manganese steel bolted to the rails receive and pass the load to the rails and ties. Concrete blocks of sufficient bulk may be able to absorb most of the shock. Wooden posts may be driven in the ground at the end of the track. Although simple to install, they offer little resistance. Mounds of earth, easy to build and the cause of little damage to equipment, are frequently used in a theater for temporary installations where commercial bumpers are unavailable. Wheel stops, such as steel members shaped to receive the wheel tread, are bolted to the rails, but their resistance to impact is limited. Timbers bolted or strapped to the rails may be used when other devices are not available.

*A team track is one on which freight is transferred directly between rail cars and highway vehicles.

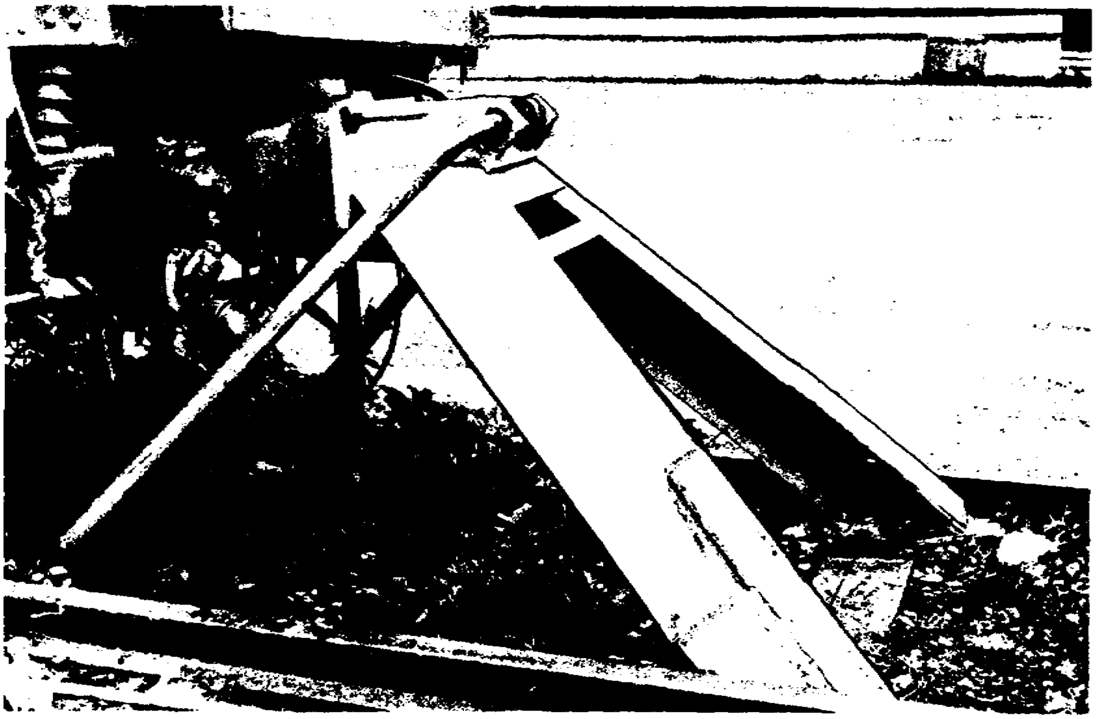


Figure 2.25. Track Bumper Bolted to Ties.

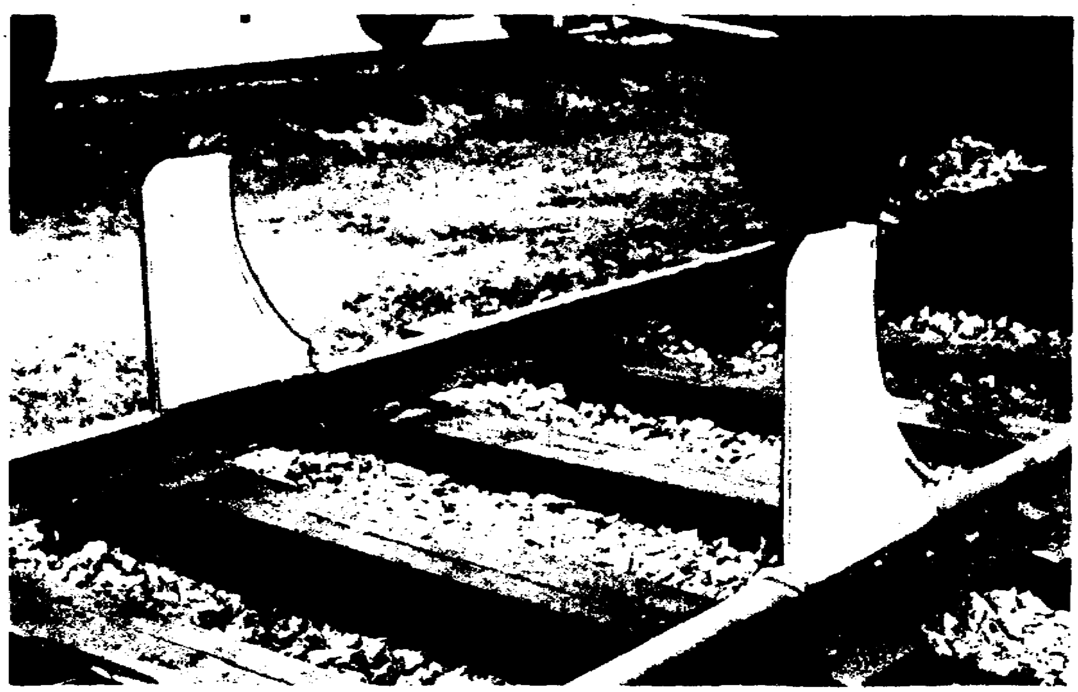


Figure 2.26. Track Bumpers Welded to Rails.

2.37. SUMMARY

Although becoming obsolete in this country, stub switches may be found overseas. Expansion because of high temperature may cause binding of the stub switch's movable rails, thereby preventing their being thrown. Even a slight maladjustment of such a switch may cause a derailment. Switch ties, a suitable frog, and standard rail are all that are needed to construct a stub switch.

A spring switch is nothing more than a split switch designed to allow a trailing-point move through it, even though it may be lined for facing point. A derail runs equipment off the rails to prevent collisions, cars from running away, and fouling of a main track. Both split-point and frog derails may be used. A split-point derail has no frog and only one switch point. The frog derail fits over one rail and guides the wheel flange up, over, and away from the rail.

When two tracks cross at grade, frogs must be installed to allow the wheel flanges to pass along both tracks. The end frogs are usually the conventional rigid and movable-point ones; those in the center are specially designed. Rigid frogs give a rough ride and are more dangerous than movable-point ones in a wide-angled crossing.

With switch rails added to a movable-point frog, it becomes a double slip switch. When entering it from either direction, a train can be diverted to either track at the other end of the switch. Although it saves space and provides train-movement flexibility, the switch is difficult and expensive to maintain.

Gantlet tracks, which provide a double track in a space where ordinarily only one track would be found, have two frogs but no switch rails. Track bumpers are used at the end of dead-end tracks to forestall derailment and to safeguard structures. Such tracks are found on industrial spurs and blind sidings among other locations. Track bumpers may consist of commercially designed manganese steel bumpers, concrete blocks, earthen mounds, or timbers.

Up to this point, the discussion of railway track maintenance has been confined to straight or tangent track and the switches, frogs, and other equipment used to permit a train to go from one track to another. Next, the railway curve, used to change the direction of a rail line, is discussed.

Chapter 3

CURVES

3.1. INTRODUCTION

Several noteworthy curves are to be found on the railroads of the United States. The longest, where the Illinois Central railroad rounds Lake Pontchartrain in Louisiana, is 9.45 miles. This is only a slight curve, but its sharpness varies throughout its length. Another is the famous Horseshoe Curve of the Penn Central Railroad near Altoona, which achieves its fame not from its length but from its shape. The curve is more than a semicircle and is used to lengthen the line as the track climbs over the Allegheny Mountains. The grade on this curve is a steep 1.8 percent, but if a tangent were constructed connecting the lower and higher ends, its grade would be over 8 percent.

Most railway curves, however, are not as spectacular as these. They are less sharp and shorter, although most are longer than 100 feet. And they are scarcely noticed by anyone except maintenance-of-way workers to whom they represent extra work. Railway curves are quite numerous and represent approximately one-seventh of all the rail trackage in the United States.

The distinctive characteristics of curved track and its highly technical layout and maintenance are vitally important to track maintenance men. Consequently, the material in this chapter requires close and careful reading. The chapter is divided into five sections: section I deals with the characteristics of curves; section II discusses superelevation; section III explains spirals; section IV describes stringlining; and section V details the lining of curves.

Section I. Characteristics

3.2. GENERAL

Railway curves are needed to change the direction of rail lines. Such changing is necessary to join tangents, bypass obstructions, reach points not on the tangents, and gain elevation. This section describes the general types of curves and their lining and measurement.

3.3. CURVES AND THEIR LINING

Curves may be classified as simple or circular, compound, or reverse. Study figure 3.1 as you read the definitions to follow. A simple or circular curve is one with uniform radius; compound and reverse curves are merely combinations of simple ones. A compound curve consists of two simple curves of different radii, both bending in the same direction. A reverse curve is made up of two curves going in opposite directions, one following on the other; the letter S is an example. Reverse curves require a tangent between them at least the length of a locomotive. But a tangent of at least 300 feet makes construction and maintenance as well as train movements easier.

The rail on the outside of a railway curve is arbitrarily de -fined as the line rail, as paragraphs 1.25 and 1.26 explain. This is the rail that must first be correctly lined. The inner one is then lined by gaging it from the outer rail.

3.4. EFFECT OF CURVATURE ON EQUIPMENT

The sharpness of curves is of extreme importance. Locomotives and rolling stock must be designed to operate on those over which they are to travel. For example, a locomotive with a long, rigid wheelbase is unable to negotiate sharp curves without spreading the track gage. Curvature adds additional resistance to a train's normal resistance to movement. Naturally, this reduces the normal tonnage capability of a locomotive just as a grade does. Where curves occur on grades, this resistance is further increased. If a locomotive's maximum capability is the hauling of a 4,000-ton train up a 1.2 percent grade, it will stall if the resistance of a sharp curve is superimposed on the grade. To enable this type of locomotive to haul

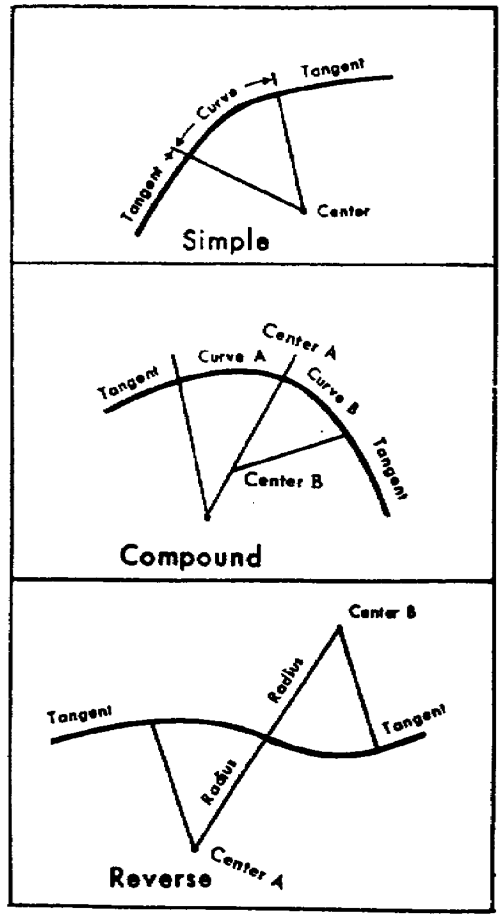
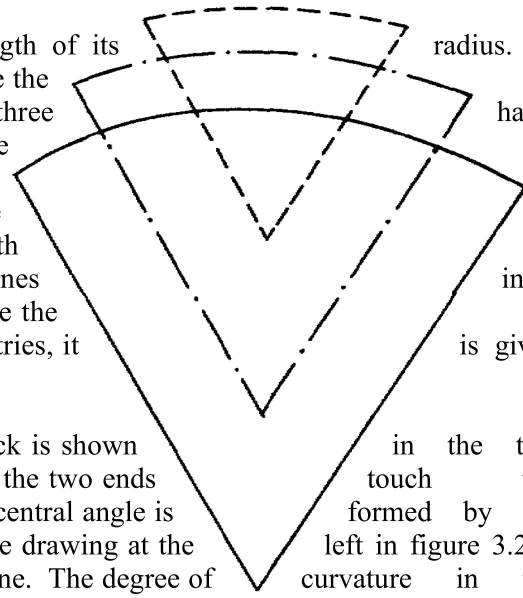


Figure 3.1. Simple, Compound, and Reverse Curves.

4,000-ton trains around the curve, the grade throughout the length of the curve must be decreased. The amount to reduce it is a problem of engineering beyond the scope of this text. Curves located on grades that have been reduced in this way are said to be compensated.

3.5. COMPUTING CURVATURE



The sharpness of a curve depends directly on the length of its radius. Long radii result in light curvature; short radii, in sharp. Compare the sharpness of the curves in the accompanying sketch. Each of the three has the same number of degrees; that is, each represents the same portion of an entire circle. However, the curve with the short, broken line radii is much sharper than the other two. At the same time, the curve with the dot-dash radii is sharper than the one with the long, solid-line radii. Most railroads, subways, and elevated lines in countries other than the United States and Great Britain designate the sharpness of a curve by specifying the radius. In those two countries, it is given in degree of curvature.

The method of computing the degree of curvature of track is shown in the two drawings in figure 3.2. A chord, 100 feet long, is placed so that the two ends touch the curved track, on the inner side of the outside rail, at points A. A central angle is formed by the two radii running to the center, C. The degree of curvature in the drawing at the left in figure 3.2 is 9 degrees, a much sharper curve than would be found on a main line. The degree of curvature in the drawing at the right is 20 degrees, a much sharper curve than the 9-degree one. The dotted lines at d represent the same portion of a circle as does the arc representing the track between points A. Since there are 360 degrees in a circle, the 9-degree curvature illustrated represents 1/40th of a circle $\left(\frac{360}{9}\right)$ and the 20-degree curvature illustrated represents 1/18 of a circle $\left(\frac{360}{20}\right)$.

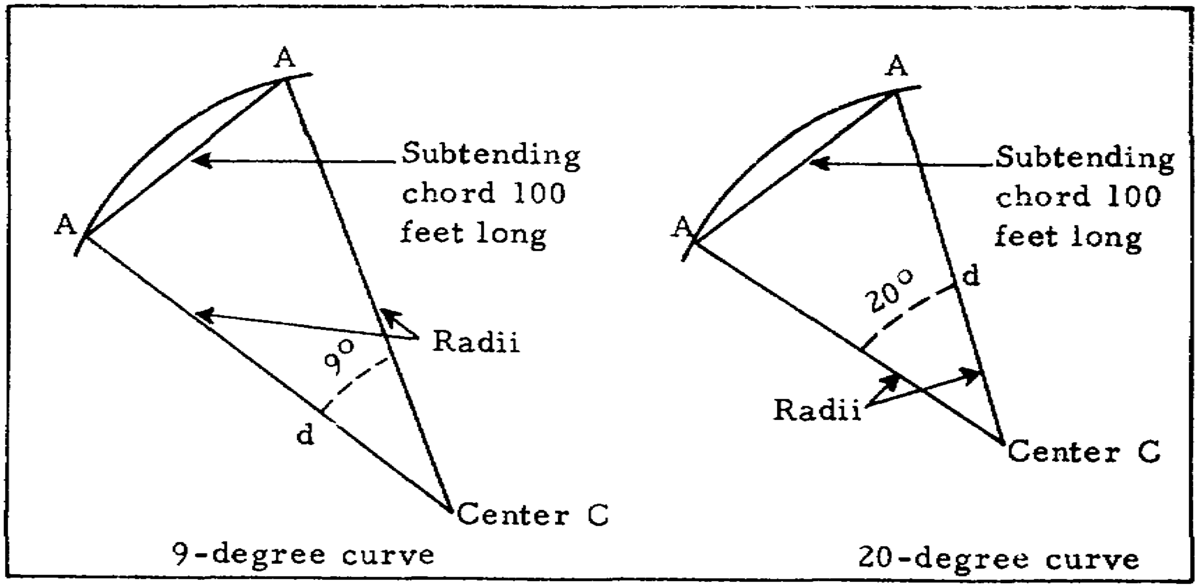
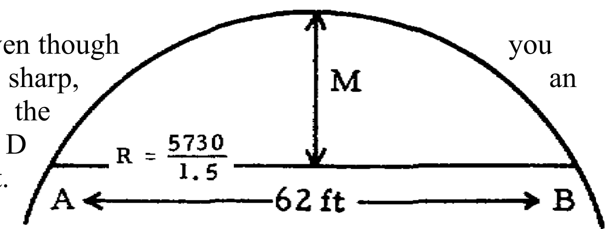


Figure 3.2. Determining Track Curvature.

You can also quickly determine the approximate degree of curvature with a standard 62-foot stringline cord. This is accurate enough for formula computations of superelevation, discussed in section II. Stretch the 62-foot cord between two points on the inner side of the outside rail--the same method used for the 100-foot chord in the preceding paragraph and in figure 3.2. The distance measured at the halfway point of the stringline cord, the 31-foot mark, to the head of the rail in inches is equal to the degree of curvature. The sketch to the right shows how the measurement is made.



Often, you may need to know the radius of a curve even though you already know the degree of curvature. If the curve is not too sharp, an approximate value of the radius can be determined by the following formula in which R represents the radius in feet, D represents the degree of curvature, and 5730 is a constant. Thus: $R = \frac{5730}{D}$. For example, a curve of 1.5 degrees has a radius of or 3,820 feet.

3.6. SUMMARY

The three types of curves used to change the direction of a rail line are the simple or circular, the compound, and the reverse. They increase the amount of resistance to the pulling power of locomotives and cause additional maintenance on rail equipment and curved trunk itself. The sharper the curve the more resistance it offers to the locomotive and the more maintenance it requires. Track maintenance men can easily find how sharp a curve is with a 62-foot stringline cord. They simply stretch it between two points on the inner side of the outside rail and measure from its center to the head of the rail. The number of inches measured equals the degree of curvature. Most countries designate a curve's sharpness by its radius, but the United States and Great Britain designate it by degree of curvature. If you know the radius length, you can find the degree of curvature, and vice versa, by using the formula $R = \frac{5730}{D}$ where R equals the radius, D equals the degree of curvature, and 5730 is a constant.

Section II. Superelevation

3.7. GENERAL

While driving a car around a sharp turn, you have probably felt as if an invisible force were pulling you toward the outside of the curve. Similarly, in riding a bicycle around a curve, you lean to the center of the curve to keep your balance. These phenomena are a result of a characteristic associated with all moving bodies. It is explained by the physical law which says that any body in motion tends to remain in motion at the speed and in the direction it is going at any one instant. Bodies, whether automobiles, bicycles, or railroad cars, tend to move in a straight line even though they are being steered or pulled around a curve. This tendency is known as inertia. The combination of inertia and turning force has the effect of causing the body to roll over. Naturally, this must be prevented.

The bicycle rider compensates for inertia by leaning to the inside of the curve; automobiles are protected from rolling over by their springs, and, sometimes, by the banking of the highway toward the center of the curve. All motorists know how much easier it is to drive around a banked curve than a flat one. Railroads provide the same protection for trains by raising, or superelevating, the outside rail on curves. Raising the rail, or superelevation, is done to overcome the effects of centrifugal force. That's the physical force that pushes a body traveling in a circular path away from the center or axis of that circle.

How is superelevation used? What are the problems associated with it? What is the maximum that can be used? These are the questions answered in the remaining paragraphs of this section.

3.8. USE

The amount of superelevation to be built into a railway curve depends upon the kind of curve, the sharpness of the curve, the gage of the track, and the speed of trains. On a simple curve, full superelevation is given throughout the entire length and the runoff is made on tangents, as shown in table III. On a compound curve other than a spiraled one, discussed in section III, full superelevation is given the curve of greatest degree throughout its length; the superelevation is then reduced, as shown in table IV, until the proper superelevation is attained for the curve of lesser degree. On a reverse curve, tile track is level at the point of reverse, and full superelevation is obtained each way by raising the outside rails.

Table III. Length and Elevation of Runoffs Required at Various Train Speeds*

Speed, mph	Elevation, in.						
	1	1 1/2	2	2 1/2	3	3 1/2	4
	Required length, ft						
10	10	15	20	25	30	35	40
15	18	27	35	44	53	62	70
20	25	38	50	63	75	88	100
25	30	45	60	75	90	105	120
30	35	53	70	88	105	123	140
35	40	60	80	100	120	140	160
40	45	68	90	113	135	158	180
45	53	80	106	131	158	185	210
50	60	90	120	150	180	210	240
55	65	98	130	163	195	228	260
60	70	105	140	175	210	245	280
65	75	113	150	188	225	263	300
70	80	120	160	200	240	280	320
75	88	132	175	220	263	308	350
80	95	143	190	238	285	333	380
85	100	150	200	250	300	350	400
90	105	158	210	263	315	368	420

*Use the following table when converting inches, feet, and miles to their metric equivalents:

To convert--	Multiply by--
Inches to centimeters	2.54
Feet to centimeters	30.48
Miles to kilometers	1.61

Table IV. Permissible Speeds at Various Superelevations and Degrees of Curvature, MPH*

Se=Speed at equilibrium elevation.
Sp=Speed at 3" unbalanced elevation.

Curves	Elevations	¼"	½"	¾"	1"	1¼"	1½"	1¾"	2"	2¼"	2½"	2¾"	3"	3¼"	3½"	3¾"	4"
0° 30′	Se	30	40	50	55	60	65	70	75	80	85	90	95	100		105	110
	Sp	100		105	110												
1° 00′	Se	20	25	35		40	45	50	55		60	65		70		75	
	Sp	70		75		80		85			90		95			100	
1° 30′	Se			25	30	35		40	45		50		55			60	
	Sp	55		60		65			70			75			80		
2° 00′	Se		20		25	30		35		40		45		50			55
	Sp	50			55			60			65				70		
2° 30′	Se						30			35		40			45		
	Sp	45				50			55				60				65
3° 00′	Se			20		25		30			35			40			45
	Sp	40			45				50				55				
3° 30′	Se						25			30			35			40	
	Sp			40				45					50				55
4° 00′	Se				20			25			30			35			
	Sp	35				40					45					50	
4° 30′	Se											30				35	
	Sp			35				40						45			
5° 00′	Se					20			25				30				35
	Sp				35					40						45	
5° 30′	Se						20			25				30			
	Sp						35						40				
6° 00′	Se							20			25				30		
	Sp	30							35						40		
7° 00′	Se								20				25				
	Sp					30						35					
8° 00′	Se									20				25			
	Sp	25						30							35		
9° 00′	Se										20					25	
	Sp			25							30						
10° 00′	Se											20					
	Sp					25							30				
11° 00′	Se												20				
	Sp						25								30		
12° 00′	Se												20				
	Sp	20							25								

***To convert miles per hour to kilometers per hour, multiply the mph figure by 1.61. Example: 55 x 1.61 = 88.55 or approximately 88 kmph.**

For standard-gage track, the amount of superelevation is represented by $e = 0.00066\ DV^2$, where D is the curvature in degrees and V the train speed in miles per hour. This formula gives the height of superelevation that will give the train equilibrium, that is, will permit it to bear equally on both rails. This amount of raise is known as the equilibrium superelevation. It means the height in inches that the high or outside rail must be raised to compensate for the side thrust and overturning action of centrifugal force.

For example, if a train is to operate around a 2-degree curve at 55 miles per hour, the equilibrium superelevation would be calculated as follows:

$$
\begin{aligned}
e &= .00066 \times D \times V^2 \\
&= .00066 \times 2 \times (55)^2 \\
&= .00066 \times 2 \times (55 \times 55) \\
&= .00066 \times 2 \times 3025 \\
&= 3.99300 \text{ or } 4 \text{ inches}
\end{aligned}
$$

If a train exceeds the speed for which the equilibrium superelevation was determined, a greater force bears on the high or outside rail than on the low or inside rail. If the speed is lower than that for which the equilibrium superelevation was calculated, a greater force is exerted on the low rail.

Railway engineers generally agree that a train can travel over a curve with 3 inches less superelevation than the equilibrium superelevation calculated for the train's speed. In the example just given, the equilibrium superelevation is 4 inches; but if the elevation were 3 inches less, or 1 inch, the train could still pass around it at 55 mph (88 kmph) without endangering safety or comfort. A superelevation where the high rail is 3 inches lower than the equilibrium superelevation is said to have 3-inch unbalanced elevation. Such-curves are commonly used where both slow and fast trains use the same track.

3.9. PROBLEMS

Determining the proper superelevation is a simple matter when all trains operate at approximately the same speed, but this is seldom true. It is most closely approximated on multiple-track lines having separate tracks in each direction for freight and passenger trains. Double-track railroads usually assign the tracks by direction rather than by speed or service. Single-track lines create a greater problem than multiple tracks, especially where curves occur on grades. Because both passenger and freight trains operate over the same track in both directions, the expected train speed for a curve will vary between that of passenger trains descending the grade and that of heavy freights climbing the grade. Use of the 3-inch unbalanced elevation is then necessary. Quite often this is not enough compensation for such a wide differential in speed; restricting the speed of the faster trains is then necessary.

3.10. MAXIMUM SUPERELEVATION

Military engineers specify that 4 inches of superelevation is the maximum to be used. If this amount of superelevation is not enough for the speeds expected, speed limits have to be imposed. Again refer to table IV; it shows permissible speeds at various super-elevations when the degree of curvature is as shown in the left column of that table.

3.11. SUMMARY

Raising the outside rail of a curved track vertically is known as superelevating the track. Superelevation counteracts the lateral thrust and centrifugal force exerted by locomotives and rolling stock. The amount of superelevation depends on the kind of curves, the sharpness of the curve, the gage of track, and the speed of trains. On a military railroad, the maximum amount of superelevation recommended for any curve is 4 inches.

Section III. Spirals

3.12. GENERAL

The history of railroading is marked by a continuous increase in train speeds. Gradually, it became evident that mere arcs of circles could not serve satisfactorily as complete curves. Locomotives traveling at increased speeds exerted great force on the outside rail of a curve at the point where the locomotive entered the curve from the tangent, and struck another blow to the next tangent on leaving the curve. Since it was impossible to superelevate the entire curve without disturbing the level surface of the tangents at either end, speed had to be reduced while traveling around the curve, passengers were subjected to discomfort, and an element of danger was introduced. Including a spiral, or easement curve, between the tangent and the circular curve eliminated the difficulties.

A spiral, although a curve, differs from a circular, or simple, curve in that the curvature as well as the radii of the spiral vary uniformly throughout its length. Starting from the open end of the spiral, the curvature becomes sharper toward the closed end. A simple geometric spiral, a circular curve, and a spiraled curve are shown in figure 3.3. The way in which spirals are used and designed is explained in the next two paragraphs.

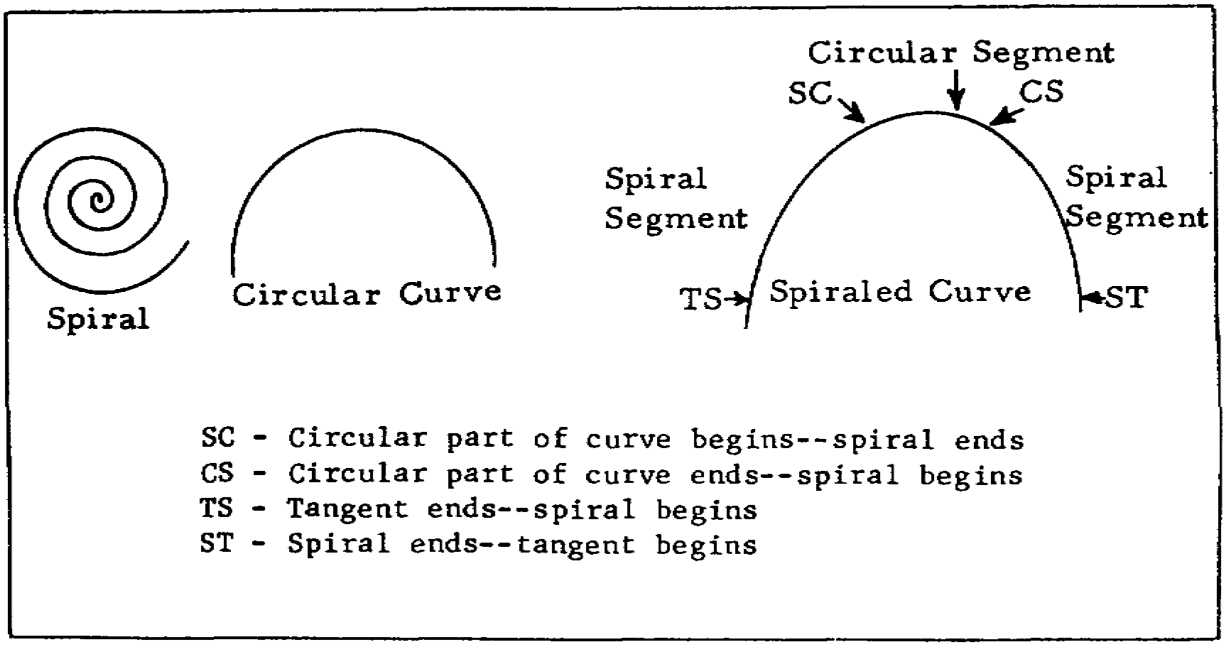


Figure 3.3. Geometric Spiral and Circular and Spiraled Curves.

3.13. USE

Spirals are used to ease trains into and out of curves and are thus correctly called easement curves. In brief, that is how spirals are used, but more details are needed. As you read the following explanation, study the diagram of the spiraled curve in figure 3.3, beginning with TS at the lower left; the pairs of letters identified here also appear on the diagram. Straight track joins a spiral at a point where both are tangent--TS. Then the spiral continues, getting sharper until it is as sharp as the circular curve--SC. From this point, the track follows the circular curve to the place where another spiral begins--CS, from which point it becomes less sharp until it joins the next tangent--ST.

Since the curvature of the spiral increases throughout its length, the superelevation of the outside rail can be gradually increased from zero at the end of the tangent to the calculated maximum at the beginning of the circular curve. On the spiral at the other end of the circular curve, the superelevation decreases from the amount used in the circular curve to zero at the next tangent. The spiral therefore provides the proper amount of superelevation for a train's speed without a sudden change in the banking.

3.14. DESIGN

The job of designing spirals is one for qualified engineers. In general, however, the length of spirals depends upon the amount of superelevation of the circular curve and, to an extent, on the general train speed. These relationships are tabulated in table V. Spiral design depends on the amount of increase in superelevation to which a train is subjected per second. Therefore, trains which approach the curve at a high rate of speed require long spirals. Similarly, a curve with less superelevation needs a shorter spiral than a curve with greater superelevation.

Table V. Spiral Lengths on Curves for Various Elevations and Speeds

Elevation, inches	Speed, mph*											
	15	20	25	30	35	40	45	50	55	60	65	70
	Length of spirals, ft**											
1	18	23	29	35	41	47	53	59	64	70	76	82
1 1/2	26	35	44	53	62	70	79	88	97	106	114	123
2		47	59	70	82	94	106	117	129	141	152	164
2 1/2		59	73	88	103	117	132	147	161	176	191	205
3		70	88	106	123	141	158	176	193	211	229	246
3 1/2			103	123	144	164	185	205	226	246	267	288
4			117	141	164	188	211	235	258	282	305	
4 1/2			132	158	185	211	238	264	290	317	343	
5				176	205	235			322		381	
5 1/2				194	225						419	

*To convert to kmph, multiply by 1.61.
**To convert to centimeters, multiply by 30.48.

In a theater, time is usually all important, and constructing proper spirals takes a great deal of time. Therefore, the Corps of Engineers has specified that railway curves of 2 degrees or less constructed in theaters are not to include spirals. However, they are not to be disregarded entirely, because there may be some already built and in operation.

3.15. SUMMARY

The spiral curve differs from the circular curve in that the curvature of the spiral varies uniformly throughout its length. It is used to connect tangent track and a circular curve so that a train moves from tangent track through a spiral into the circular curve, through another spiral, and on to tangent track. Because of the great length of time required to properly construct spirals, military engineers have specified that spirals are not to be included in constructing curves in a theater when the degree of curvature is 2 degrees or less.

Section IV. Stringlining

3.16. GENERAL

The requirements for well-maintained curved track are the same as those for straight track, but many maintenance jobs are more difficult to perform on curves, and some faults of curved track must be corrected more frequently than the same ones on tangents. For instance, rails wear faster on curves. And while both curves and tangents require proper lining, you can line a straight stretch of track by eye but must calculate corrections in detail to line a curve properly.

Although the design and construction of curved track are intended to counterbalance the forces applied by trains rounding curves, they can never compensate for them entirely. Sooner or later the continual passage of trains results in track movement, and the lining is disturbed. First, the ride becomes uncomfortable and the rails suffer great wear; eventually, the curve becomes unsafe for scheduled speeds. Constant watchfulness by maintenance men, however, can prevent this happening. Curves are checked frequently, and when one becomes distorted, it is lined promptly to avoid further damage.

Engineers use surveying equipment to lay out railway curves; in the past they were lined in the same way. Now, however, they are almost always lined by a comparatively simple method known as stringlining. When poor riding qualities or visual inspections indicate that a curve is poorly lined, a stringlining job is required.

The first six paragraphs of thus section cover the basis of stringlining, the equipment the fieldwork requires, the marking off of stations, the measuring of ordinates, the evaluation of the figures, and the calculations involved. The next paragraph discusses the marking of the ends of tangents, spirals, etc. The last two paragraphs discuss some problems you may encounter in stringlining.

3.17. BASIS

When a string is stretched tautly between two points on the inside or gage side of the outside rail of a curve, the distance between the midpoint of the string and a point five-eighths of an inch from the very top of the rail is proportional to the degree of curvature. This is the basis of stringlining. A longer distance between the midpoint and the rail signifies a sharper curve than does a shorter one. This distance is known as an ordinate, though some railroaders call it an offset. The measurements marked m in figure 3.4 are ordinates.

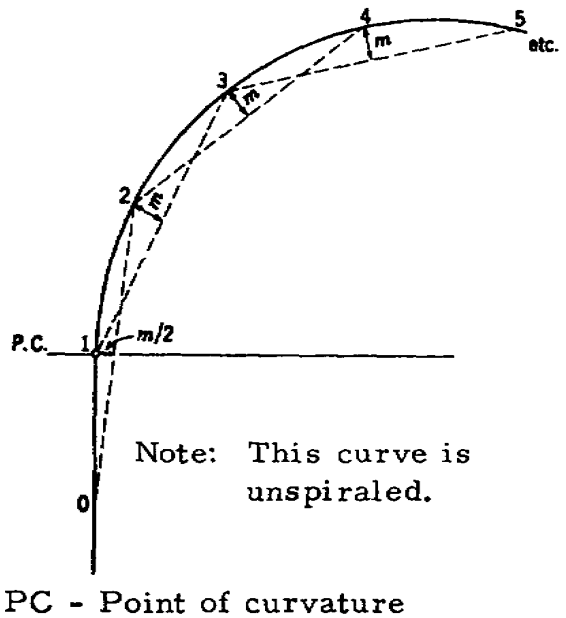


Figure 3.4. Ordinates on a Simple Curve.

When the string used is 62 feet long, the ordinate in inches equals the degree of curvature. For example, if a 62-foot string is stretched between two points on the inside of a rail on the simple portion of a curve and the ordinate measures 2 inches, then it is a 2-degree curve. If the ordinate were 3 1/2 inches, it would be a curve of 3 degrees 30 minutes. For this reason, a 62-foot string is usually used in stringlining.

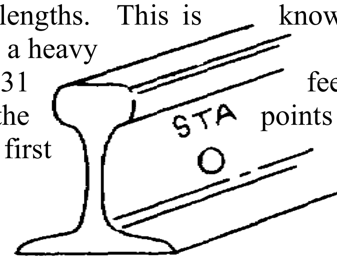
On a smooth or properly lined simple curve, the degree of curvature is the same at all points. Since measured ordinates are equal to curvature, all those in such a curve should be of equal length. If they are not, the curve is out of line. Similarly, on a properly lined spiral, curvature changes at an even rate. Therefore, ordinates on a spiral measured at equal distances should vary an even amount from one to the next.

3.18. EQUIPMENT

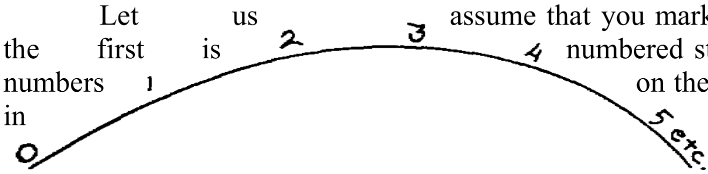
What equipment do you need to put stringlining into actual practice in the field? To mark off the stations and measure the ordinates, you need a tape at least 31 feet long, graduated in feet. Any such tape will do, provided the same tape is used to measure all the stations on a curve. You also need a strong string, 62 feet long or longer, marked at the 62-foot point. A ruler, graduated in inches and eighths of an inch, is required for measuring ordinates. One graduated in inches and tenths will do, if a similar rule is used for all lining of a particular curve. However, in this discussion, all ordinates are expressed in eighths of an inch. You also need a notebook, a pencil, and a heavy crayon. A pair of wooden blocks, 1 by 1 by 2 inches, known as offset blocks, are helpful. To mark the distance the track is to be moved, you need wooden stakes, surveyor's tacks, and a ruler or tape.

3.19. MARKING OFF STATIONS

The first step in stringlining is to divide the entire curve into 31-foot lengths. This is known as marking off the stations. You start at some point on the tangent, marking it with a heavy crayon on the web of the outside rail, as shown in the sketch. Then you measure 31 feet toward the curve with the tape and mark this point in the same way. Each of the points you mark is known as a station, and you number them consecutively from the first point to the end of the curve, as shown in the sketch.

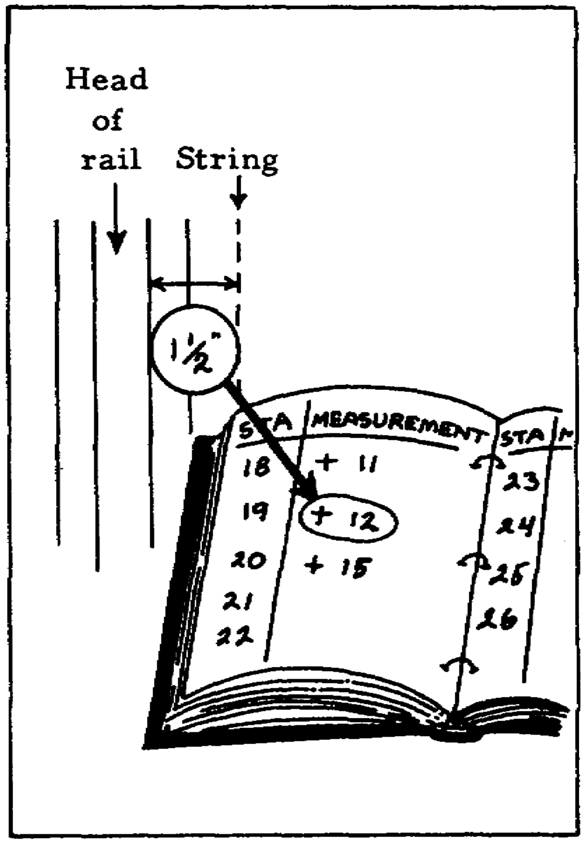


Let us assume that you marked two stations the first time you stretched the tape; the first is numbered station 0 or Sta. 0, and the second Sta. 1. Mark their numbers on the web at the station marks, and enter them in a column in the left margin of your notebook. Now measure 31 feet beyond Sta. 1, and mark and record Sta. 2. Continue this all around the curve, until you are out on the other tangent. In practice, it is a good idea to start far enough down the tangent to have 10 or 15 stations on the tangent, and to have 10 or 15 more beyond the curve on the other tangent. Why? Because the straight track at the approaches to a curve is likely to be disturbed by the passage of trains around the curve, and its lining should be checked.



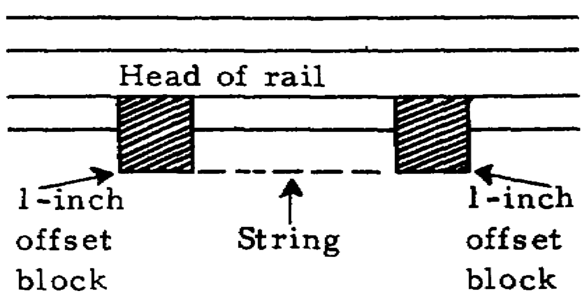
3.20. MEASURING ORDINATES

After the curve is divided into stations, you begin to measure the ordinates. Take the string and stretch it from Sta. 0 to Sta. 2, holding it on the inside of the head of the rail. The midpoint of the string will be opposite Sta. 1. Measure with the ruler between the head of the rail and the string at Sta. 1, and enter the distance in eighths of an inch in your notebook beside the station number. If there is no distance, write down 0. Next stretch the string between Sta. 1 and Sta. 3, measure at Sta. 2--the midpoint of the string, and record the result. Continue to measure at each station all around the curve until the far end of the string is at the last station you have laid off. Record the result at each station.



When you are on the curve itself, you will get some result at each station. Say, for instance that at Sta. 19 you measured 1 1/2 inches between the string and the head of the rail. Since 1 1/2 inches is 12/8 inches, you would enter +12 in your notebook. Inches and eighths should be converted to eighths of an inch and recorded in that way, as the sketch illustrates.

If you find that the string at its midpoint is pressed against the rail, especially on or near tangents, this shows either that the rail is absolutely straight or that it has curved inward at that point. Here the offset blocks are used, as shown in the sketch. Use one block at each end of the string, and place it between the string and the head of the rail. This keeps each end of the string exactly 1 inch from the rail. Now measure at the midpoint of the string. If you measure 1 inch, the track is absolutely straight, and you enter 0 in your



notebook. But if you measure only 1/2 inch, it means that the rail curves inward there. The midpoint of the string is 1 inch minus 1/2 inch, or 1/2 inch, or 4/8 inch nearer the rail than are the ends of the string. Therefore, you would enter -4 in your notebook, indicating a reverse bend of 1/2 inch.

Now that you have measured and recorded the ordinate at each station, you have finished the first phase of your fieldwork. Next, you must take your notebook home or to the office and calculate how much you need to move the track at each station to achieve a smooth curve. Columns 1 and 2 of figure 3.5 show the station numbers and measured ordinates of a short curve.

3.21. EVALUATING FIGURES

For instructional purposes, the curve described in figure 3.5 has been purposely shortened and simplified; in practice, you would rarely see one like it. A railway curve usually contains dozens if not hundreds of stations. Remember, the longest in the United States is over 9 miles! A curve may be compound, that is, consisting of two or more joined circular curves of different degree; or it may be reverse, curving first in one direction and then in another. But the principles discussed apply to them all. With this method, you can line any curve if you work carefully, check your figures at every opportunity, and adjust your results as often as necessary. The following subparagraphs and annex A explain generally the use and evaluation of figures.

a. Annex A. The curve calculated in figure 3.5 is diagramed in annex A, sheet 1. Study that sheet as you read the explanation of it. The solid line represents the track itself, while the broken lines are the 62-foot string stretched from station to station. The curvature in the diagram is greatly increased, so that you can easily see and compare the ordinates at each station, and so that the distortion of the curve is obvious. The actual curve is so gentle that the largest measured ordinate is only 9/8 inch. However, a 200-ton locomotive at 60 mph (96 kmph) would slam into such a stretch with a great deal of force. Even such minor deviations in high-speed track would cause an uncomfortable ride and high maintenance costs; therefore, the curve should be relined.

b. Analysis. You can see from the diagram that the curve should make a continuous turn to the right. However, at Sta. 1 there is a slight bend to the left. In column 2 of figure 3.5, you see a negative ordinate listed for that station, while all the others are positive. A negative ordinate always indicates such a wrong or

1	2	3	4	5	6	7
STATION	MEASURED ORDINATE (Eighths of an inch)	PROPOSED ORDINATE (Eighths of an inch)	ERROR (Col 2 figure minus col. 3 figure)	SUM OF ERRORS (Col. 5 figure for previous station plus col. 4 figure for this station)	HALF THROW (Col. 5 figure for previous station plus col. 6 figure for previous station)	FULL THROW (Twice col.6 figure for this station)
0	0	0	0	0	0	0
1	-1	+2	-3	-3	0	0
2	+5	+4	+1	-2	-3	-6
3	+7	+6	+1	-1	-5	-10
4	+7	+6	+1	0	-6	-12
5	+9	+6	+3	+3	-6	-12
6	+6	+6	0	+3	-3	-6
7	+1	+4	-3	0	0	0
8	+2	+2	0	0	0	0
9	0	0	0	0	0	0
	36	36	0			

Figure 3.5. Stringline Calculation.

reverse bend. When it is not designed into a curve, it is called a dogleg. At Sta. 8, the diagram shows another dogleg. In column 2, the measured ordinates decrease from Sta. 5 through Sta. 7, increase at Sta. 8, and then continue to decrease. If these faults were corrected, it would be a fairly smooth curve. The stringline calculation shows you how to correct them.

c. Selecting new ordinates. Next, you must select an ordinate for each station of the new curve. Since the ordinates are smaller near each tangent, it should be a spiraled curve. This means that the new ordinates should increase by regular amounts to a maximum, remain constant for several stations on the circular part of the curve, and then decrease to zero at about the same rate they increased. One thing limits you at this point: the sum of the proposed ordinates must always equal the sum of the measured ordinates. Note that columns 2 and 3 of figure 3.5 each total 36. This principle gives you a chance to check your work; if they are not equal, the proposed ordinates must be revised. By looking at the measured ordinates, you can see that there are 10 stations on the curve, but that stations 0 and 9 are on the tangents and can have no ordinates, while stations 1 and 8 are at the ends of the tangents and will have very small ordinates. If the curve is spiraled, the ordinates at stations 2 and 7 will be less than those on the circular part of the curve. Therefore, most of the curvature will be at stations 3 through 6 where the curve is circular.

You may have a track chart, similar to the one in annex C, which shows what the curvature should be. If you do, you can simply change degrees to inches--1 degree equals 1 inch, convert the inches to eighths, and enter the result at each of those stations. If you don't, you usually take the average ordinate on the circular part of the curve. Here, for stations 3 through 6, the ordinates are 7, 7, 9, and 6, a total of 29 and an average of more than 7. But if you use an ordinate of 7 at each of the four stations, they total 28, while the sum of proposed ordinates can be only 36. This leaves only 8, or 4 for each of the two spirals located on either end of the curve. So perhaps 7 is too large; try 6 for each of the ordinates on the curve. Then the total is 24, and the spirals have 6 each. Since there are two stations on each spiral, values of 2 and 4 provide a regularly increasing curve to full curvature of 6. Therefore, in column 3 of figure 3.5, you enter these figures--2, 4, 6, 6, 6, 6, 4, 2. Sometimes, on long curves, it is necessary to try three or four different spirals before you get one that fits, but here it was easy.

d. Calculating errors. The difference between the measured and the proposed ordinate is the error at a station. If the proposed ordinate is larger than the measured ordinate, the error is entered as minus, such as that at Sta. 7. If the measured ordinate is the larger of the two, the error is plus, as at Sta. 5. If the measured ordinate is minus, the error is the sum of the measured and proposed ordinates, and is minus, as at Sta. 1. Calculate the error at each station and enter it in column 4. The sum of the entries in this column must be zero.

3.22. CALCULATIONS

Making the calculations for columns 5, 6, and 7 of figure 3.5 gives you the distance the track must be moved or "thrown" at each station. They consist of rounding out the ordinate readings by borrowing from the high ones and lending to the low. Properly done, the calculations provide you with uniform curvature, the result you wish to obtain. The remainder of the paragraph takes you through the steps.

You first figure out the sum of errors up to and including each station, and enter it in column 5. At Sta. 0 where there is no error and no previous error, the sum of errors is 0. At Sta. 1, the error is -3, but there is no previous error. As the zigzag arrow shows, 0 is added to -3, and the result is -3. At Sta. 2, previous errors add up to -3, and the error is +1; -3 +1 equals -2. This calculation is made at each station to the end of the curve. The total of this column must also be zero. This leads you to where you can figure half of the necessary throw.

For each station, you add the sum of errors at the previous station--column 5, and the half throw there--column 6, as the arrows between those columns indicate. At Sta. 0, there is no previous error and no previous half throw so that the half throw is 0. The same thing is true at Sta. 1, but at Sta. 1 there is an error and this will affect Sta. 2. To find the half throw at Sta. 2, add the sum of the errors at Sta. 1 to the half throw there. Here -3 +0 equals -3, so that figure is entered. At Sta. 3, the figures for Sta. 2 are added; -2 and -3 equal -5, which is the half throw for the station.

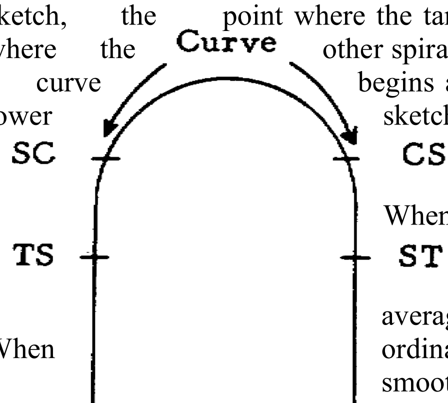
This process is repeated at each station to the end of the curve. Note that the figures in this column need not add up to 0; however, the last entry in the column, the half throw at the last station, must be 0. If it is not, it must be adjusted by the method discussed in paragraph 3.24.

The half throw at each station is doubled and entered in column 7. This is the full throw, the amount the track must be moved or "thrown" at each station, expressed in eighths of an inch. If the throw is negative or minus, the track must be moved in, that is, toward the low or inside rail. If the throw is positive or plus, the track must be moved out, that is, toward the high or outside rail. When the full throws for all stations have been calculated, the paperwork of stringlining is complete. Remember, there must never be any throw at the last station.

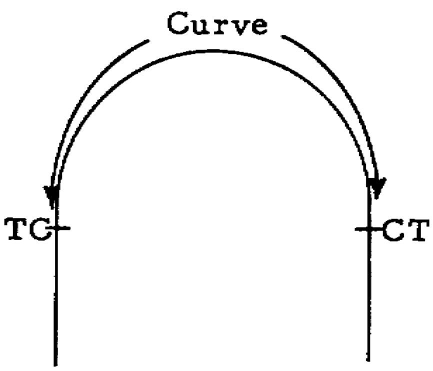
Sheet 2 of annex A is an overlay showing the same curve after the throws calculated in figure 3.5 have been made. Place it over sheet 1, annex A, so that stations 0 and 9 coincide on the two sheets. You can then see that the throwing results in a smooth curve, as intended.

3.23. MARKED POINTS

Many railway curves are marked with stakes to show where the tangents end, the spirals end, and so forth. These points are shown in drawings, and may be marked in the field, by letters. As shown in the upper sketch, the point where the tangent ends and the spiral begins is TS--tangent to spiral, while the point where the other spiral ends and the tangent begins is ST--spiral to tangent. The circular part of a curve begins at SC--spiral to curve, and ends at CS--curve to spiral. As shown in the lower sketch, if there are no spirals, the curve begins at TC--tangent to curve--and ends at CT--curve to tangent.



When these points are marked by stakes, they help greatly in choosing proposed ordinates. For example, the curvature between SC and CS is constant. The correct proposed ordinate for this stretch is almost certainly the average measured ordinate, to the nearest whole number, for the same distance. When ordinates have been assigned to the circular part of the curve, it is easy to set up smooth spirals between TS and SC and between CS and ST. Remember, though, that the sum of the proposed ordinates must always equal the sum of the measured ordinates. You can adjust your curve



to arrive at this by changing the ordinate by one unit, either plus or minus, at one or more stations.

3.24. ADJUSTING FINAL THROW

If the ordinate at any station deviates by one-eighth inch from a smooth curve, the riding quality of the track is not affected because the variation is too slight to be noticed. This fact makes it possible to adjust a curve slightly to make it come out right. Often you measure and calculate a curve, only to find that a throw is required at the last station. Since the rule says that there can be no throw there, you have to adjust your proposed curve. You do this by changing the proposed ordinates at two of the preceding stations, one +1 and one -1, so that the total still equals the sum of the measured ordinates.

Here are the calculations for the last few stations on a spiral of a typical curve. At the last station--Sta. 22, there is a half throw of +3, as shown in part A of table VI in which the proposed ordinates for stations 16 and 19 are circled. It is these two that you are to change. Since the last throw is plus, you increase the proposed ordinate at Sta. 16 by 1 and decrease that at Sta. 19 by 1. Note that the stations chosen are three stations apart; this is because the final half throw is 3. Also note that the proposed ordinate at the earlier or lower numbered station was increased, because the final half throw is plus. Now the proposed ordinate at Sta. 16 is 10, and that at Sta. 19 is 2, as shown in part B of table VI in which all the corrected numbers are outlined in heavy black lines. Note particularly that all full throws from Sta. 17 through Sta. 22 decreased.

The rules to follow in adjusting a final half throw are given below. However, remember this one precaution: it is usually easier and produces a better curve if the stations chosen are on the circular part of the curve rather than on a spiral.

(1) Choose a pair of stations on the curve, whose numbers differ by the amount of the final half throw.

(2) If the final half throw is plus, add 1 to the proposed ordinate at the earlier station, and take 1 away at the later station.

(3) If the final half throw is minus, take 1 away from the proposed ordinate at the earlier station, and add 1 at the later.

(4) Recalculate the curve from the earlier station.

Table VI. Adjusting Proposed Ordinates to Eliminate a Throw at Last Station

Part A - Figures Before Correction

Sta. No.	Measured Ordinate	Proposed Ordinate	Error	Sum of Errors	Half Throw	Full Throw
14	15	14	+1	-4	+19	+38
15	13	12	+1	-3	+15	+30
16	10	9	+1	-2	+12	+24
17	6	7	-1	-3	+10	+20
18	5	5	0	-3	+7	+14
19	5	3	+2	-1	+4	+8
20	2	1	+1	0	+3	+6
21	0	0	0	0	+3	+6
22	0	0	0	0	+3	+6

Part B - Figures After Correction

Sta. No.	Measured Ordinate	Proposed Ordinate	Error	Sum of Errors	Half Throw	Full Throw
14	15	14	+1	-4	+19	+38
15	13	12	+1	-3	+15	+30
16	10	10	0	-3	+12	+24
17	6	7	-1	-4	+9	+18
18	5	5	0	-4	+5	+10
19	5	2	+3	-1	+1	+2
20	2	1	+1	0	0	0
21	0	0	0	0	0	0
22	0	0	0	0	0	0

3.25. ADJUSTING OTHER THROWS

Sometimes a curve includes a point at which the track cannot be moved, such as a bridge, a turnout, or a restricted clearance. At such a point, the throw or throws must be zero. You must adjust the curve by the method given in paragraph 3.24 so that they are zero.

At other times, a series of throws may be very large; they can be reduced by the same method. Assume that you have six half throws that come out to +24, +31, +37, +34, +29, +26. All you have to do is reduce the third half throw to +25 by choosing a pair of stations 12 numbers apart; the others will become proportionally smaller. However, when you adjust throws on a curve, always remember to recalculate from the adjustment on to the end of the curve and to make sure that the last throw is zero.

3.26. SUMMARY

Stringlining is a method of determining the curvature of a rail. By stretching a string tautly between two points on the inside of the outside rail on a curve, the distance, that is, the ordinate, from the midpoint of the string to a point five-eighths of an inch from the very top of the rail is equivalent to the degree of curvature. A long distance indicates a sharp curve; a short one, a light one.

When using a 62-foot string, the length of the ordinate in inches equals the degree of curvature. The curvature of a correctly lined simple, or circular, curve measures the same throughout. On a spiral, the curvature progresses evenly.

In the field, you use a tape 31 feet or longer, a string 62 feet or longer marked at the 62-foot mark, a ruler graduated in inches and eighths of inches, a notebook, a pencil, a crayon, offset blocks, wooden stakes, and surveyor's tacks.

Follow the steps given here to stringline a curve, including evaluation of the figures and the calculations involved. Mark and record stations at 31-foot intervals all around the curve. Stretch a 62-foot string tautly between each set of alternate stations, and measure and record the distance from the string's midpoint to the rail. Choose a new ordinate for each station so as to insure a smooth curve. <u>The total of new ordinates must equal the total of measured ordinates.</u> Find and record the difference between the measured and the new ordinates at each station. If the measured ordinate is greater, the difference is plus; if less, the difference is minus. Compute and record for each station the sum of errors at that station and at all previous stations. To do this, add each station's error to the sum of errors at the previous station. The sum of errors for the last station must be zero. Compute the necessary half throw for each station by adding the sum of errors and the half throw at the previous station. The half throw at the last station must be zero. If necessary, change ordinates to adjust the curve and recompute. Double the half throw at each station to find the full throw. Adjust the proposed ordinates if the final throw is other than zero and if restricted clearances, a bridge, or a turnout makes it impossible to move the track.

Section V. Lining an Actual Curve

3.27. GENERAL

For a long distance on tangent or straight track, a foreman with an "experienced eye" can sight kinks readily and have them corrected. But on curved track where his view is shortened to only a few feet and where he can see only outstanding kinks and discrepancies that need to be corrected, he would do well to forget about trying to line the curve by sighting and stick to a more reliable method. He should use either his track gage along with the centerline stakes placed by the engineers laying out the tracks or the stringline method discussed in section IV. To bring the track back into line, he will direct his gang to use their lining bars, or, if available, a track liner. This section discusses precautions that the track supervisor should heed, the computations of an actual curve, the marking and the throwing of the track, and the re-dressing of the ballast.

3.28. PRECAUTIONS

When making stringline computations, heed two important precautions: calculate accurately and keep throws short. Remembering these precautions will make the computations simpler and the work on the track itself easier.

a. Accurate calculations. When you make stringline calculations, be very careful of your arithmetic. Check your results every time you can. An error in addition or subtraction at any point will make your figures wrong from there on. It is often harder to find and correct a mistake than it is to make the whole computation in the first place.

b. Size of throws. Keep the throws as small as possible when men are to move the track with lining bars. Since the entire track--both rails, the accompanying ties, and the tie plates and other hardware--is moved as a unit, this involves a great deal of work. In addition, after the track is thrown, the ballast must be re-dressed; the shorter the throws the less ballast work required. Extremely long throws might even make it necessary to widen the ballast section.

It is difficult to set a limit on the size of throws, since so many different things may affect them. However, the usual half throw should not be more than 24/8, or 3 inches; the full throw would then be 6 inches. If throws exceed the limit set by policy, the curve should be adjusted. This can be done by the method discussed in section IV or by adopting a new set of ordinates for the spirals. Usually throws are at a minimum when the total plus throws are approximately equal to the total minus throws, and neither plus nor minus throws are bunched in one stretch of track. The conscientious stringliner always tries to achieve this, sometimes revising his calculations for a curve time and again, until he finally arrives at a smooth curve with small throws.

3.29. AN ACTUAL CURVE

One actual railway curve was divided into 36 stations; 22 of them were on the curve itself. The calculations are shown in figure 3.6. Both tangents were badly out of line while the circular curve varied as much as 3/4 inch between stations, for example, between stations 7 and 8. Remember, the figures given in the calculations as well as in the discussion following are in eighths of an inch.

The curve was first computed in the columns headed A in the figure. A smooth curve resulted but the final station, Sta. 28, required a half throw of +14. The proposed ordinates at stations 4 and 18 were adjusted, circled in column B under PROPOSED ORDINATE. The B series of computations produced no throw at the final station but left too large a throw, -31, at Sta. 12, circled in column B under HALF THROW.

The proposed ordinates were adjusted at stations 3, 10, 13, and 19; the new values are circled in column C under PROPOSED ORDINATE. This change did the job; the half throw at Sta. 12 was reduced from +31 to +24. The third computation produced a satisfactory curve with reasonable throws so that its results were used.

DIVISION : Burton

SUBDIVISION : No. 2

TRACK : Eastbound

CURVE : 2d curve East KP 45 Near Rhodesburg

DATE ORDINATES MEASURED : 5 Feb 71

CALCULATIONS BY : [illegible]

DATE STAKED OUT : 11 Feb 71

STAKED OUT BY : [illegible]

MAXIMUM SPEED 60 MPH 96 KMPH

REMARKS	STATION	MEASURED ORDINATE	PROPOSED ORDINATE				ERROR				SUM OF ERRORS				HALF THROW			
			A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
	-7	0	0				0				0				0			
	-6	-2	0				-2				-2				0			
	-5	0	0				0				-2				-2			
tangent	-4	1	0				+1				-1				-4			
	-3	0	0				0				-1				-5			
	-2	0	0				0				-1				-6			
	-1	-2	0				-2				-3				-7			
TS	0	-1	0				-1				-4				-10			
	1	3	1				+2				-2				-14			
	2	3	4				-1				-3				-16			
spiral	3	12	7	7	8		+5	+5	+4		+2	+2	+1		-19	-19	-19	
	4	10	10	11	11		0	-1	-1		+2	+1	0		-17	-17	-18	
	5	17	13	13	13		+4	+4	+4		+6	+5	+4		-15	-16	-18	
SC	6	20	15	15	15		+5	+5	+5		+11	+10	+9		-9	-11	-14	
	7	17	15	15	15		+2	+2	+2		+13	+12	+11		+2	-1	-5	
	8	11	15	15	15		-4	4	-4		+9	+8	+7		+15	+11	+6	
	9	14	16	16	16		-2	-2	-2		+7	+6	+5		+24	+19	+13	
circular curve	10	14	16	16	15		-2	-2	-1		+5	+4	+4		+31	+25	+18	
	11	14	16	16	16		-2	-2	-2		+3	+2	+2		+36	+29	+22	
	12	11	16	16	15		-5	-5	-4		-2	-3	-2		+39	+31	+24	
CS	13	14	16	16	16		-2	-2	-2		-4	-5	-4		+37	+28	+22	
	14	15	15	15	15		0	0	0		-4	-5	-4		+33	+23	+18	
	15	13	12	12	12		+1	+1	+1		-3	-4	-3		+29	+18	+14	
	16	10	9	9	9		+1	+1	+1		-2	-3	-2		+26	+14	+11	
	17	6	7	7	7		-1	-1	-1		-3	-4	-3		+24	+11	+9.	
spiral	18	5	5	4	4		0	+1	+1		-3	-3	-2		+21	+7	+6	
	19	4	2	2	3		+2	+2	+1		-1	-1	-1		+18	+4	+4	
	20	2	1	1	1		+1	+1	+1		0	0	0		+17	+3	+3	
ST	21	0	0	0	0		0	0	0		0	0	0		+17	+3	+3	
	22	0	0	0	0		0	0	0		0	0	0		+17	+3	+3	
	23	-1	0	0	0		-1	-1	-1		-1	-1	-1		+17	+3	+3	
	24	-2	0	0	0		-2	-2	-2		-3	-3	-3		+16	+2	+2	
tangent	25	3	0	0	0		+3	+3	+3		0	0	0		+13	-1	-1	
	26	1	0	0	0		+1	+1	+1		+1	+1	+1		+13	-1	-1	
	27	-1	0	0	0		-1	-1	-1		0	0	0		+14	0	0	
	28	0	0	0	0		0	0	0		0	0	0		+14	0	0	
		211	211				0											

Figure 3.6. Stringline Calculations of an Actual Curve.

3.30. MARKING AND THROWING TRACK

After the stringline calculations are complete, the track is marked or staked so that the track maintenance gang will know how large a throw to make at each station. This should be done soon after the ordinates are measured, within a week or so if possible. Likewise, the track should be thrown as soon as possible after the stakes are set or the marks are made. The more time the whole process of measuring, calculating, marking, and throwing takes, the likelier it is that the track will go farther out of line or that the stakes or marks will be disturbed by passing trains. Marking and throwing the track are discussed in the following subparagraphs.

a. Marking. Track may be marked for throwing in one of two ways. One is used for marking double track; the second is for either single or double track.

(1) Double track. A scratch board is used to mark one of two parallel tracks for throwing, as shown in figure 3.7. The

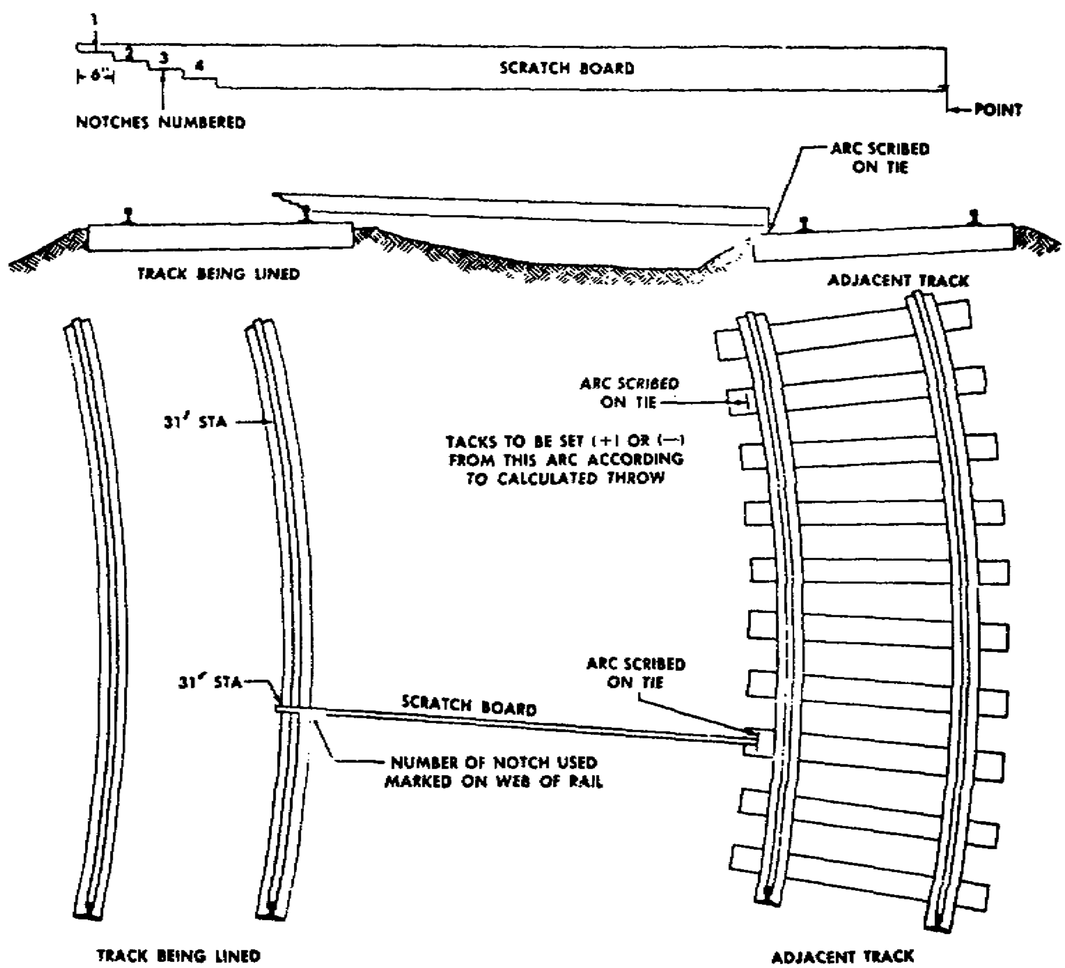


Figure 3.7. Use of Scratch Board in Lining Curves.

board is placed on one rail of the track with the rail fitted into one of the numbered notches on one end of the scratch board. The point on the other end of the board is then used to scratch a mark on the nearest tie of the other track. Then a surveyor's tack is driven into the tie, either inside or outside the mark, depending on whether the throw is plus or minus, and the full throw away from it. The board is then moved to the next station. When the maintenance gang comes along, they place the board on the same rail at the same spot in the same numbered notch, and move the track either in, for a minus throw, or out, for a plus throw, until the point of the board is above the tack. That station is then considered lined properly.

(2) Single track. Line stakes are used to mark single track for throwing and may also be used for double track. The stakes should be of straight-grain wood and long enough to be driven down through the ballast and well into the subgrade. They should be driven down until the top of the stake is level with the base of the rail. They are usually set between the two rails, on a line a constant distance from the track after it has been thrown. Some railroads place them on the future centerline of the track. Others use an imaginary line 12 inches from the base of the outside or high rail, the method illustrated in figure 3.8. One stake is driven at each station and a surveyor's tack driven into its head to show the exact point of reference.

Suppose you were setting your stakes 12 inches from the rail; you would calculate the exact location of the tacks in this way. At a station with a minus throw, you would add the full throw to 12 inches, place the stake approximately that distance from the high rail, and drive the tack exactly that distance from it. If the station required a plus throw, you would subtract it from 12 inches and use that figure. For example, if the full throw at a station is -28, or 3 1/2 inches, the tack would be 12 + 3 1/2 or 15 1/2 inches from the base of the rail. Or if the throw were +22, or 2 3/4 inches, the tack would be 12 – 2 3/4, or 9 1/4 inches from the rail. If different weight rails are used on the curve, be sure to add or subtract the differences in the widths of the rail bases.

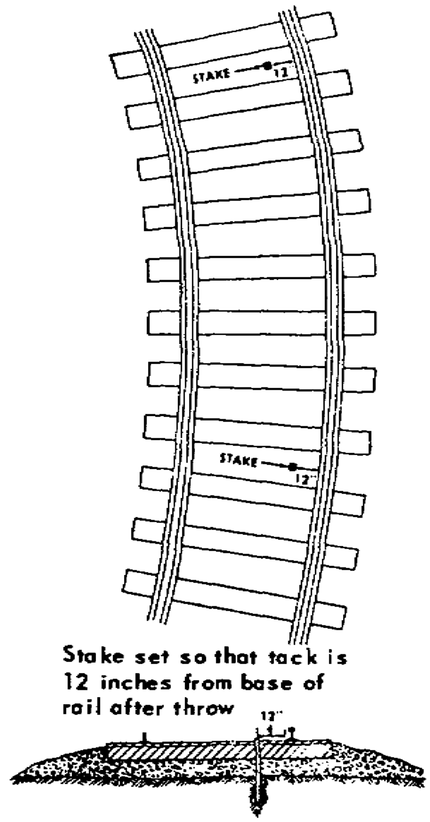


Figure 3.8. Setting Line Stakes on Single Track.

b. Throwing. Track may be thrown or moved manually by men using lining bars, such as the one shown in figure 1.7, or by a machine, such as the track liner pictured in figure 1.22. By either method, the track is moved the proper distance from the tacks on the line stakes or the ties. When a track gang equipped with lining bars is to throw the track, part of it works on each rail. They move the entire track as a unit at each station. Figure 3.9

shows how the men and bars are positioned. To make the throw easier, ballast may be removed from around the ties. The track liner does the same work as the track gang equipped with lining bars. Only one operator is needed where three to eight men with bars would be required on each rail.

Figure 3.9. Throwing Track With Lining Bars.

3.31. RE-DRESSING BALLAST

After the track has been thrown, the original ballast section must be restored, and the ballast must be tamped. If a station requires an extremely long throw, the ballast section may have to be widened. The outer rail must also be raised to proper superelevation. Usually when a curve is out of line, its superelevation has changed and is no longer correct. Most railroads publish tables showing the superelevation to be used for various curvatures and speed limits.

3.32. SUMMARY

Make your stringline calculations carefully and keep them accurate. Make your final throws as small as possible--no more than 6 inches, especially when the gang has to move the tracks with lining bars. Revise your proposed ordinates, several times if necessary, to arrive at a smooth curve with short throws.

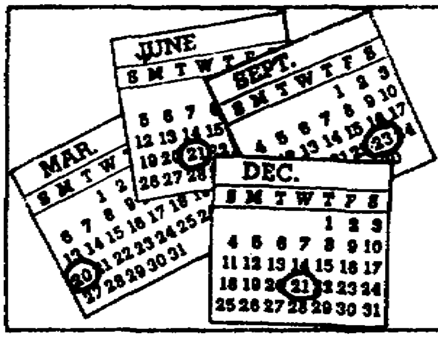
Mark or stake the track after you make your calculations, to show the gang how far to throw the track at each station. On a double track, use a scratch board to mark one of the tracks. Place the board on one of the rails and scratch a mark on the nearest tie of the

other track. Drive a surveyor's tack into the tie the distance away from the mark that the track is to be thrown.

To mark the throws on a single track, drive wooden line stakes at each station through the ballast and into the subgrade, level with the rail base. Drive them between the rails at points on a line a preset distance from the track after throwing. Show the exact point of reference by nailing a tack in the head of the stake.

Men equipped with lining bars or an operator on a track liner throws the track--the entire track as a unit at each station needing alteration. Complete the job by re-dressing the ballast, widening the ballast section under an extremely long throw, and restoring proper superelevation.

The next chapter brings three more elements in track construction and maintenance--highway grade crossings, guard rails, and the effects of weather.



Chapter 4

GRADE CROSSINGS, GUARD RAILS, AND SEASONAL MAINTENANCE

4.1. INTRODUCTION

As a railroad is constructed across country, it intersects highways. Crossings are built at these locations to enable automobiles to cross the railroad's right of way. The crossings require special construction and maintenance as do the guard rails used to prevent derailed equipment from extensive damage. Track maintenance and the problems associated with it are affected by the weather resulting from seasonal changes. Each of these three elements of track maintenance, highway crossings, guard rails, and seasonal changes, is discussed in a separate section of this chapter.

Section I. Crossings at Grade

4.2. GENERAL

Highway, safety, and railroad right-of-way engineers have long recognized that as long as grade crossings exist some motorists are going to be killed. In addition, crossings have always been the source of numerous other forms of aggravation and of expense. They include whistle warnings that often conflict with antinoise ordinances, reduced train speeds, and heavy maintenance costs. In the interest of good public relations, and often at the direction of legislative bodies, railroads have eliminated many grade crossings by constructing overpasses or underpasses. Nevertheless, some still remain and, likewise, the many difficulties associated with their maintenance. In a theater of operations, it is not practical to eliminate such crossings. In fact, it may frequently be necessary to construct new ones. This section discusses the construction of highway crossings, their maintenance, and the difficulties encountered in it.

4.3. CONSTRUCTION

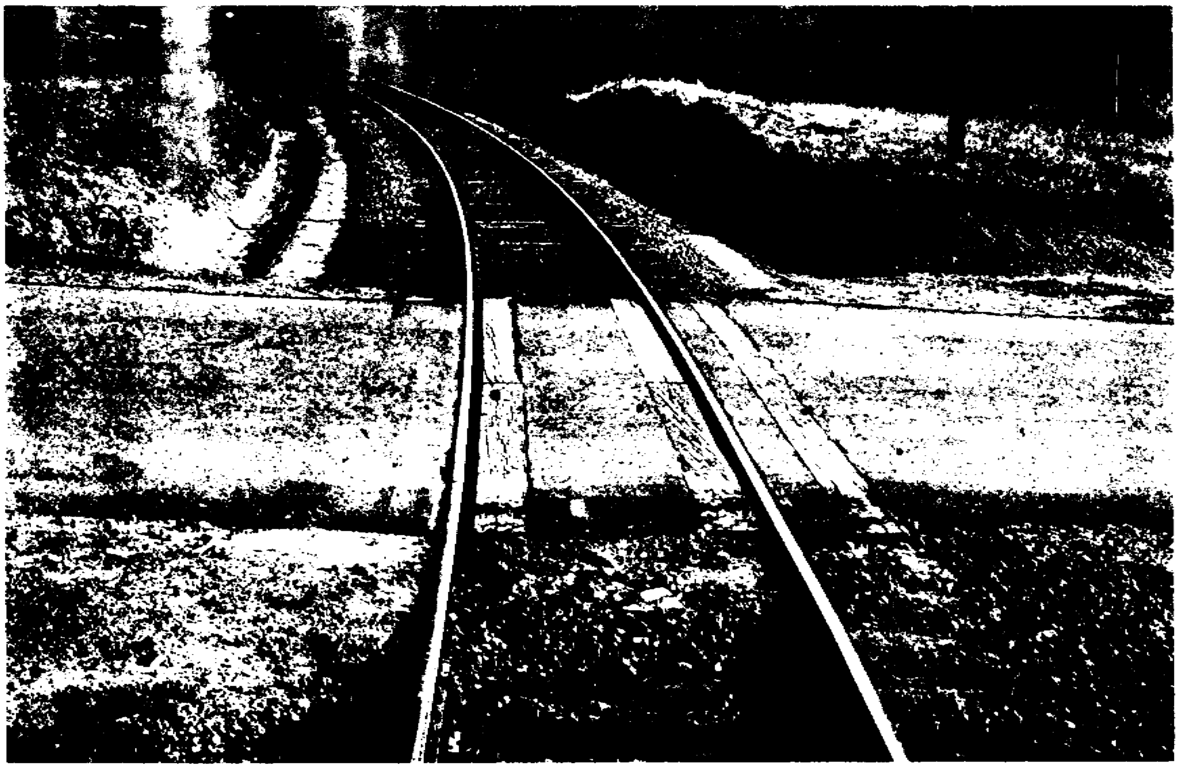
Roadways should cross railroad tracks in such a way that they can be clearly sighted from the highway. The surface of the roadway where it crosses the tracks should be level with the top of the rails. For a distance of 30 feet on each side of the crossing, the highway approach should be no more than 9 inches below nor more than 3 inches above the level of the rails. This insures that approaches are on a smooth grade so that vehicles with low road clearance may pass over the crossing without their undercarriages touching either the rails or road surface, and no vehicles are jolted in making the crossing. Flangeways, or passageways for the wheel flanges, 2 1/2 inches wide between the gage side of rails (RT 670, par. 1.6a) and the roadway must be provided, unless curvature of the railroad is more than 8 degrees. If more than 8, the flangeways should be 2 3/4 inches across. For both, the minimum depth of the flangeway should be 2 1/2 inches. The crossing should be about 4 feet wider than the road itself.

Crossings may be constructed of various materials and in different designs; the choice depends upon the amount and kind of highway traffic and the materials available. Materials include rails, wooden planks, asphalt, concrete, precast concrete slab, or prefabricated metal planks. Figure 4.1 illustrates two types of highway grade crossings, one with wooden planks and asphalt and the other with wooden planks only.

A simple crossing may use 3-inch wooden planks spiked to blocks on both sides of each rail. The outside ones are placed flush against the head of the rail, while those inside are set to provide the necessary flangeway between the planks and the gage side of the head of the rail. The space between the inside planks may be filled with cinders, gravel, concrete, planks, or asphalt. A similar crossing uses rails instead of planks inside the running rails. The ends of the inside rails are bent toward the center of the track to provide a 4-inch flangeway opening. The rails may be placed on their sides with their heads against the web of the running rails, or they may be placed on their bases with separators to maintain the proper flangeways.

4.4. MAINTENANCE

Good drainage is especially important to the proper maintenance of highway grade crossings. The culverts substituted for main side ditches under the highway approaches must be kept clean and free flowing. Cross lateral drains may be necessary, and water flowing on the highway should be diverted before it reaches the railroad roadbed.



A. With wooden planks and asphalt.

Figure 4.1. Typical Grade Crossings.

Holes in the road surface at the crossing must be filled with gravel or patching compounds, and broken planks must be renewed. When the highway material between the rails needs to be replaced, it is wise to put in new ties at the same time so that the crossing need not be torn up for tie renewals alone. When important highway grade crossings are repaired, the work should be done on only half the road at a time, leaving the other half open to highway traffic.

Flangeways must be kept clear of dirt, stones, ice, snow, and other foreign material to avoid derailment hazards. Frequent inspections should be made to insure that the road material has not been forced up by mud, stones, and other debris to a point where the clearance between the road and railway car underframes is too small.

4.5. MAINTENANCE DIFFICULTIES

The big difficulty in maintaining highway crossings is that the roadway covers the track structure up to the tops of the rails. Consequently, the road material must be removed before surfacing, gaging, lining, and tie or rail replacement work can be done. Another problem is the increased danger of derailment, because the flangeways left between the gage side of the rails and the road material often fill and thereby force the wheels off the track.

When highway grade crossings are constructed, the road material used should be easily removable to simplify track maintenance. If no rail joints occur within the crossing and if it is located on straight track, the frequency and difficulty of maintenance operations are reduced.

4.6. SUMMARY

The great danger and maintenance expense of highway grade crossings have caused many of them to be eliminated and overpasses and underpasses substituted. However, they are not practical in a theater of operations. Instead, it may be necessary to construct new highway grade crossings there.

Maintenance of these crossings is difficult because the road materials used to enable automobiles to cross the right of way must be removed before repair work can be done. The amount of maintenance and the danger associated with highway crossings can be decreased if provisions are made for draining water flowing on the highway away from the railroad roadbed and if highway crossings can be located on straight track rather than on curves.

Section II. Guard Rails

4.7. GENERAL

When a train is derailed, the danger of more serious consequences, such as the train's falling off a bridge or crashing into a station platform or building, is ever present. To reduce the chances of such occurrences, guard rails are used to keep derailed rolling stock from leaving the ties. They are placed between the running rails to catch derailed wheels and prevent the equipment from overturning or leaving the ties at critical locations. This section explains the location of guard rails and their sizes and sources.

4.8. LOCATION

Although guard rails are useful when properly placed, they should not be installed indiscriminately. The presence of guard rails complicates maintenance work, making their overuse undesirable. Their most frequent and important location is on bridges, although they may be placed beside running rail near station platforms where such tracks are on extremely sharp curves or where train speeds are high. They are often placed at tunnel entrances, especially if the tracks leading into the tunnels are curved. The guard rails may extend throughout the length of the tunnel if it is shored with timber or steel. They lessen the chance of derailed equipment damaging shoring and causing a tunnel to cave in on the engine or cars. In theaters of operations, when rail is in short supply, guard rails are not to be used on main-line curves unless the curvature is 15 degrees or more.

Guard rails are installed on trestles 40 feet or more in length and on all open-floor deck bridges. On these bridges, the track structure is fastened directly without ballast, and there is no supporting structure above track level. For shorter bridges, guard rails are installed only if the track over the span is on a curve greater than 4 degrees. Look ahead to figure 5.2 where these bridges are illustrated.

On a single-track bridge, two guard rails are installed, each 10 inches from the gage side of its adjacent running rail. Figure 4.2 shows the proper location of guard rails on a single-track bridge. Double-track bridges require only one guard rail per track, placed adjacent to and 10 inches from the rail most distant from the edge of the bridge. Only two guard rails are needed on multiple-track bridges, one on each of the outside tracks, because the running rails of adjacent tracks act as guard rails for the inside track or tracks.

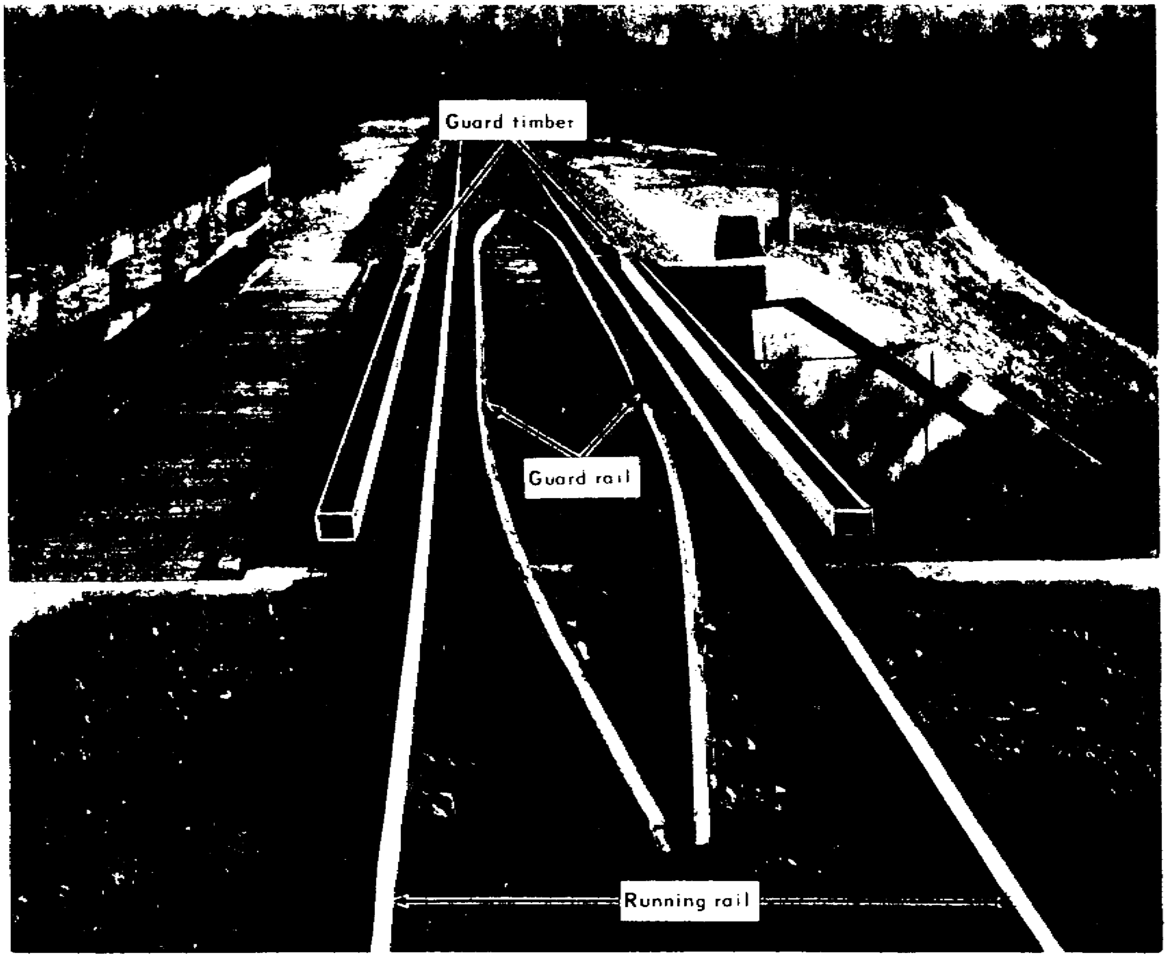


Figure 4.2. Guard Rails on Single-Track Bridge.

The guard rails should extend some distance beyond each end of the bridge and converge toward the track center. The distance which they should extend varies. One rule of thumb says it should be as much as a rail length; another rule sets it at 50 feet or about a car length. However, the important dimension is the 10 inches given a few sentences back. It must be established before the guard rail reaches the bridge itself and remain constant throughout its length.

4.9. SIZES AND SOURCES

Reconditioned running rails are often used as guard rails, but only if they are no larger in section than their adjacent traffic rails; it is generally desirable that they be smaller. The following are good combinations:

Traffic rail, lb per yd	Guard rail, lb per yd
130	100
100	85
85	70
75	60

4.10. SUMMARY

Guard rails are placed between the running rails to catch derailed wheels, thereby preventing equipment from overturning or leaving the ties. They are used most frequently on bridges and at tunnel entrances. Because guard rails complicate maintenance, they should not be used unless absolutely necessary. They should never be larger in section than their adjacent traffic rails.

Section III. Seasonal Problems

4.11. GENERAL

Many serious maintenance problems affect railroads only seasonally. Winter and summer provide violent extremes of weather which often damage the right of way and track structures. The first two paragraphs of this section cover the main summer maintenance problems and their solutions. Most of the remaining paragraphs cover the problems encountered in the winter in cold climates and their solutions. The last paragraph explains how to preserve the safety and comfort of the maintenance gang in cold climates during the winter.

4.12. WEED GROWTH

Probably the most obvious result of summer weather is a great increase in plant growth. Weeds of all varieties burst forth in an apparent attempt to completely conceal the railroad right of way. Given the chance, weeds will overrun seldom used tracks, fill drainage ditches, and create an unsightly condition.

Weeds growing in the roadbed hold water, contaminate ballast, and cut off drainage. Ties then become rotted, and line and surface are lost. Figure 4.3 illustrates excessive growth of weeds in track; figure 4.4 shows the effect of such growth after the weeds are removed; and figure 4.5 is an example of good weed control. These pictures show why it is essential to fight weed growth before it gets a good start. It is not necessary to explain here the danger of

Figure 4.3. Excessive Weed Growth in Track.

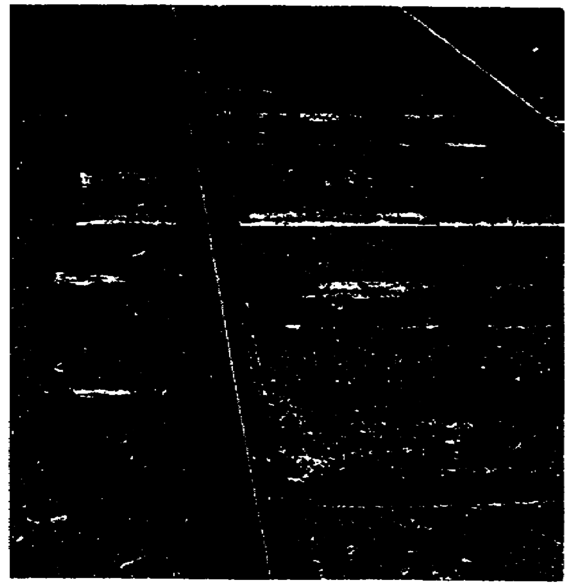


Figure 4.4. Effect of Weeds on Ballast and Ties.

Figure 4.5. Good Weed Control.

excessive plant growth in drainage ditches since the importance of clean ditches is pointed out in chapter 2 of Reference Text 670.

Weed control should begin before the growth has a chance to get a good start and before the weeds have seeded. The work has two phases: elimination of weeds, first from the track and then from the rest of the right of way. These phases are discussed in the subparagraphs that follow but before that discussion begins, it should be pointed out that a distinction must be made between good and bad plant growth along the right of way. Plant life which protects against slope erosion must be preserved. That which interferes with drainage and creates a poor appearance should be destroyed, including weeds that foul ditches, interfere with drainage, and serve no useful purpose.

a. Eliminating weeds from the track is generally done with chemical sprayers or weed burners, although hand mowing is necessary if other equipment is not available. The sprayers or burners are often mounted on a car and the whole unit moved by a locomotive, so that the work progresses quickly and is done thoroughly. When burners are used, firefighting equipment should be carried with the unit to extinguish any fires which might start in the ties or in the vegetation beside the right of way.

b. To eliminate weeds from the test of the right of way, scythes and brush hooks are most often used. However, mechanical mowers and sickles of both the on-and off-track types are frequently used because they save time and labor. One type of rail-mounted mowing machine is shown in figure 4.6. It is being moved by a railway motor car.

4.13. RAIL JOINTS IN SUMMER

Rail joints are designed and assembled to provide freedom for rail expansion during hot weather. Occasionally, however, a joint becomes “frozen”; that is, the rail cannot expand within the joint. If this happens, the rail may buckle under the great stress of restricted expansion. If a joint is working, that is, is not frozen, an area of shiny metal is visible under the head of the rail where it has worn against the joint bar. If track inspection shows gaps between rails that should have closed because of high temperature, it is wise to see if the joint is working. If not, the joint bars should be loosened or removed, slushed with oil, and replaced with proper bolt tension. Special attention should be given insulated joints in the summer to insure they are separating track circuits as is their purpose.

4.14. SNOW AND ICE

During a severe winter, snow and ice increase the maintenance workload, may disrupt service, and may endanger lives and equipment. Large snowdrifts can completely obstruct service. Ice in flangeways of frogs, crossings, or station areas can derail trains. Snow and ice on station and loading platforms endanger passengers

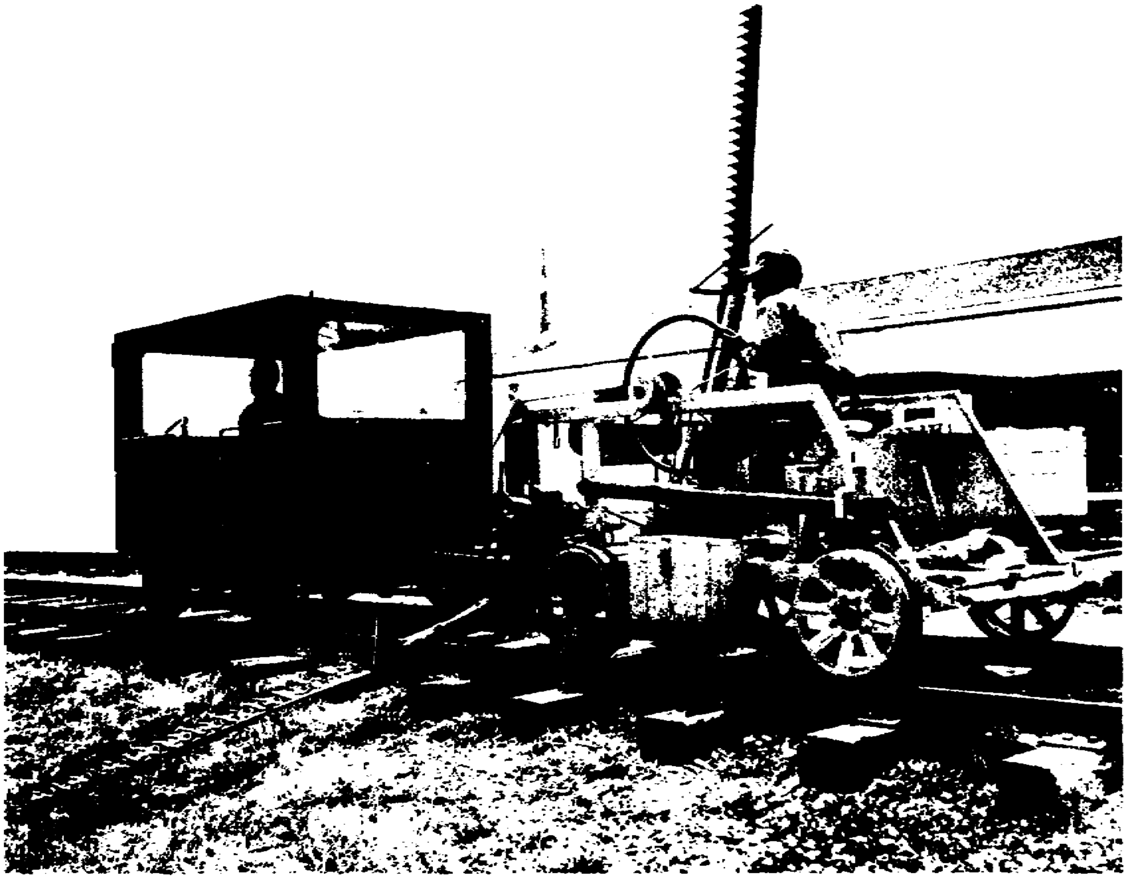


Figure 4.6. Rail-Mounted Mowing Machine Towed by Railway Motor Car.

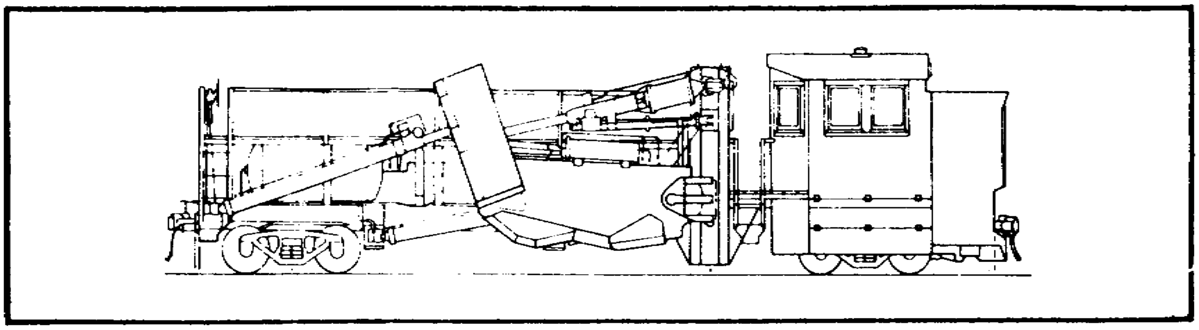
and increase the difficulty of loading freight cars. Snow and ice often freeze or block switch points, preventing their movement and virtually stopping train movement by tying up terminals. To provide dependable transportation, railroads must prevent these conditions. That's why a large percentage of the winter work hours in cold climates is spent in preventing or solving snow and ice problems. Paragraphs 4.15 through 4.21 discuss the methods and equipment used and the work involved in keeping railroads operating under such conditions.

4.15. SNOW PLOWING

The cardinal rule in snowplowing is to start early and keep plowing--the only way lines can be kept open in heavy snowfalls. Snow plows are generally used to remove large quantities of snow from lung stretches of track. They may be of several types, each of which has a particular purpose.

a. Flangers are used to clear snow from between the rails, especially from the gage side of the rails. Their blades must be power operated so that they may be raised to permit passage over crossings and switches. Flangers may be mounted on special cars, on locomotives, or on other types of plows.

b. Spreader plows may be ordinary spreader ditchers used for snow removal as shown in the sketch; or they may be specially designed equipment meant only for that purpose. Both are widely used. These plows have "wings" reaching out from their sides that shove the snow a considerable distance from

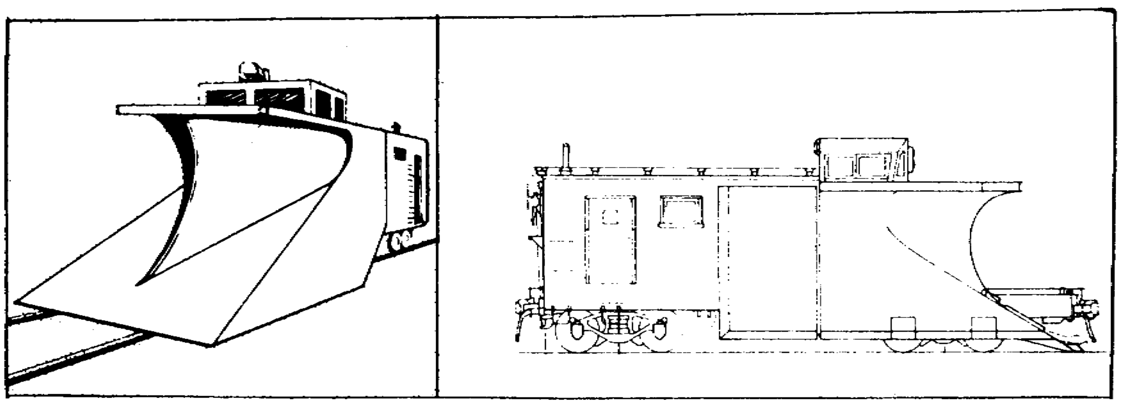


the track. This feature makes them especially desirable for clearing yards and multiple-track lines. They may be used in moderate snowfalls or to clear the ridges of snow left near the track by flangers or by push or rotary plows.

c. Push plows are used on heavier snowfalls. They may be wedge shaped to distribute snow on both sides of the track or sloped to throw the snow on one side only. The sloped type is used on double-track lines in preference to the wedge-shaped one. Simple push plows may be mounted on flatcars, as shown in figure 4.7. But they are more often attached to ballast-filled gondola cars, which are heavier and less likely to derail.

A more elaborate push plow is shown in figure 4.8. Here the plow is a fixed part of a special car. It is equipped with wings, to spread the snow out to the side, as well as a flanger attachment not visible in these views. An operator's compartment contains controls by which the wings and flanger are operated. This plow is operated at high speeds, up to 30 mph or 48 kmph. It may be used to clear medium-sized drifts, although several passes may be needed for complete removal.

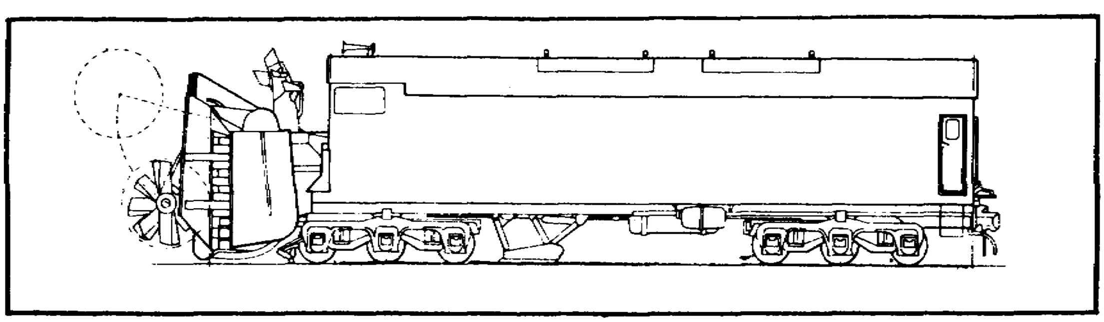
Figure 4.7. Snowplow Blade Attached to Flatcar.



Part A. Front-Side View Part B. Profile

Figure 4.8. Push-Type Snowplow.

d. Rotary plows have large rotating blades that cut into high and tightly packed snow and throw it through a large nozzle away from the track. The dotted lines in the sketch show the action. The blades are operated by steam or diesel power plants. Rotary plows



must be used when snow is deeply drifted and tightly packed. However, they pile snow close to the track, making it difficult to plow later snowfalls. They also require considerable maintenance.

4.16. SNOWSLIDES AND SNOWDRIFTS

Snowslides are much worse than plain snowdrifts because they may be filled with trees and rocks. The amount of snow in a slide usually rules out using any plows except the rotary type. However, if a snowslide is suspected of containing rocks and trees, the rotary plow cannot be used because its blades may be damaged. Handtools, dynamite, or bulldozers or other excavators must be used.

4.17. SNOW FENCES AND SHEDS

Snow fences and snow sheds are often used to protect sections of a railroad that are continually subjected to drifts and slides because of peculiar terrain features.

a. Snow fences are used to prevent drifts from piling up on the track. One type is made of light wood slats wired together and looks something like a long venetian blind set on edge. It comes in sections of various lengths and can be rolled up for easy carrying or storage. In use, it is set up with the slats sticking up from the ground, parallel to and some distance away from the track on the side from which the wind is expected. The wind velocity is reduced as it passes through the slats. As a result of the decreased velocity, the snow drops and piles up forming a drift around the fence before it can reach and obstruct the track. Several other types of either metal or wood for temporary or permanent construction as well as hedges and stone fences may also be used.

b. Snow sheds protect against slides in side hill cuts and against drifts and slides in through cuts. They provide direct shelter for the track so that a tunnel under the snow is open for traffic. They are permanent and most often constructed of timber.

4.18. PROBLEMS WITH SWITCHES AND MOVABLE POINT FROGS

The points of switches and movable point frogs and the car retarders in automatic hump yards may be frozen or blocked in place by ice or snow. Restriction of their movement blocks sidings and terminals, often tying up whole divisions or even systems. Several ways of meeting the problem are discussed in the subparagraphs that follow. However, during severe snowfalls, these procedures may not suffice. It is then necessary to use crews equipped with brooms and shovels to keep switches operating.

a. The first steps in preparing to fight winter's attack on switches are to dig out crib ballast from between the ties under the switch points to provide space for falling or cleared snow, and to distribute snow brooms to switch locations so that the points can be swept clear.

b. Some sort of heating devices should be provided to melt snow and ice before they accumulate at switches, movable point frogs, and car retarders. Electric or gas heaters may be permanently installed and often used in terminals subject to long, severe winters. However, these devices are too elaborate and expensive to install in theaters of operations or where winters are mild.

The snow-melting pot, shown in figure 4.9, is a commonly used substitute for the electric or gas heater. It is placed in the dugout crib at the beginning of the winter season, kept filled with kerosene or similar fuel throughout the winter, and lighted at the start of each storm or stretch of freezing weather. It has the disadvantages of requiring considerable attention, charring the ties, and creating a fire hazard when tank cars containing flammable liquids pass over it.

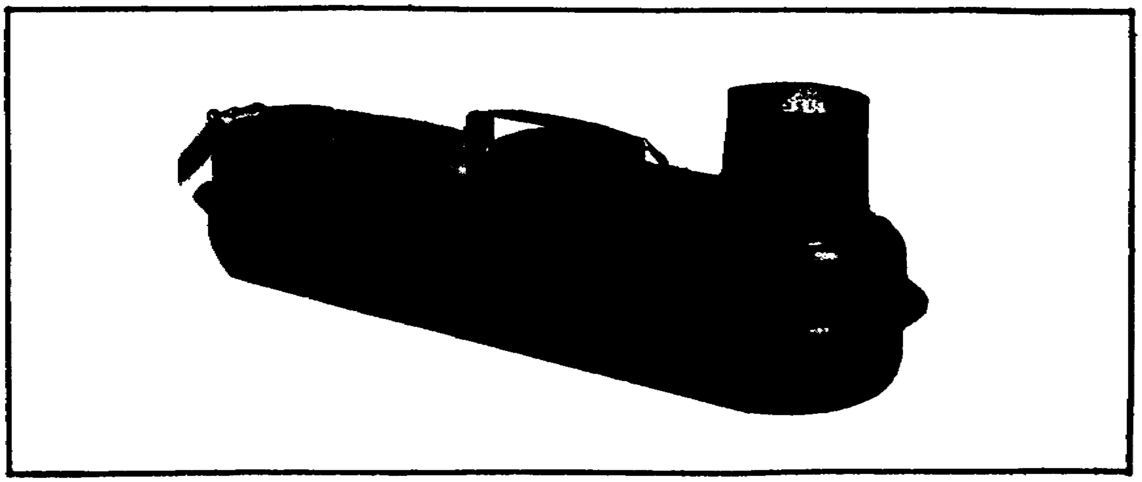


Figure 4.9. Snow-Melting Pot.

c. Weed burners may be adapted for clearing snow and ice by installing special nozzles in them which make flame direction adjustable and provide much more heat than is necessary for weed burning. This type of snow melter is used largely in terminals to free switches and car retarders.

4.19. FLANGEWAY PROBLEMS

If flangeways in frogs, crossings, or station platforms become filled with ice, danger of train derailment is present. While switch heaters may be used at frogs, they obviously cannot be used on highway crossings or station platforms. The usual remedy is to clean out the ice manually. Salt may be spread on highway crossings to melt ice but must not be used on turnouts because of the danger of corrosion. Adequate drainage of water lessens the problem and should be taken care of before the winter season begins.

4.20. ICE IN TUNNELS

Ice may become dangerous in wet tunnels, for it builds up in layers on the floors and walls, and heavy icicles hang from the tunnel roofs. If the icicles are allowed to form and remain, workers may be injured and equipment may be damaged. Extremely heavy accumulations of ice may derail locomotives and cars. Often it takes a large force of men to chop away such ice. Providing steep enough drainage ditches to keep water moving in the tunnel and blocking strong winds from blowing through the tunnel reduce the problem.

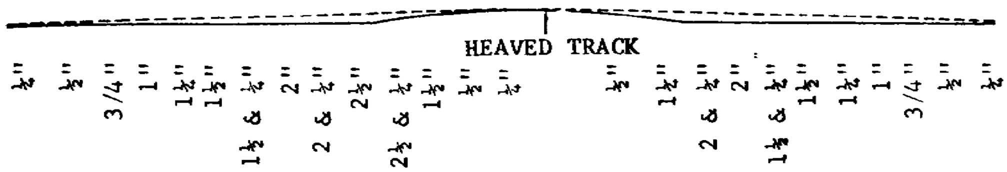
4.21. HEAVING TRACK

In cold winters, ballast freezes, making tamping impossible. Therefore, track must be in proper surface before winter begins. However, even when a satisfactory surface has been provided, poor drainage may allow ice to form in the roadbed at isolated points on the line. Water expands while freezing, disturbing the track surface and heaving the track. Since the track cannot be resurfaced by tamping, other means must be used. Subparagraphs a and b discuss these methods; subparagraph c. tells what happens after the thaw.

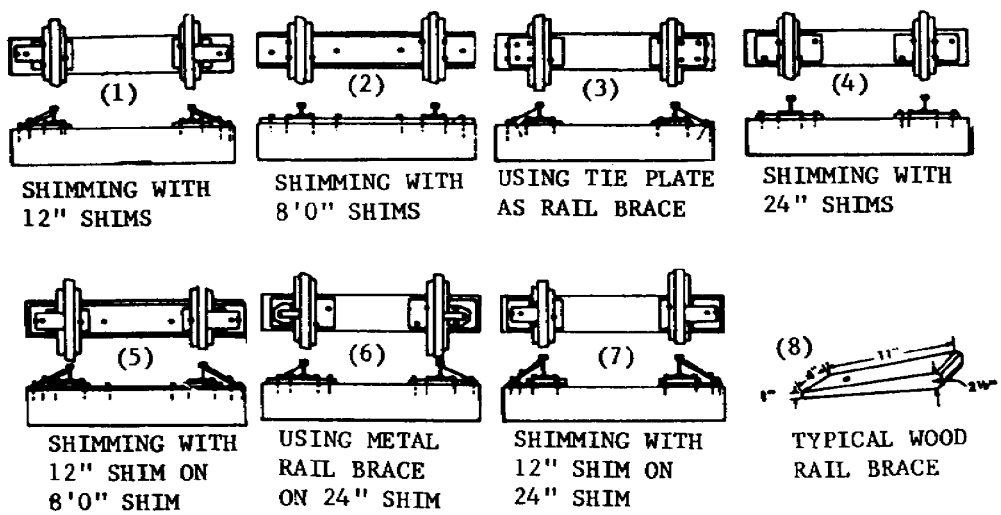
a. Spreading salt or salt water on the ballast lowers the freezing point of water and may help prevent heaving. But if salt comes in contact with switch points or frogs, it causes corrosion. If the heaved track is not too much higher than the surrounding track, it may be lowered by removing tie plates. In more severe cases, the high spots are lowered by digging away ballast; however, this is difficult and expensive.

b. Shimming raises the low areas on each side of the heaved track, providing a smooth surface runoff, as shown in part A of figure 4.10. The shims used to raise the track are placed between the rail or tie plate and its tie. The length of runoff depends on the speed

PART A



PART B



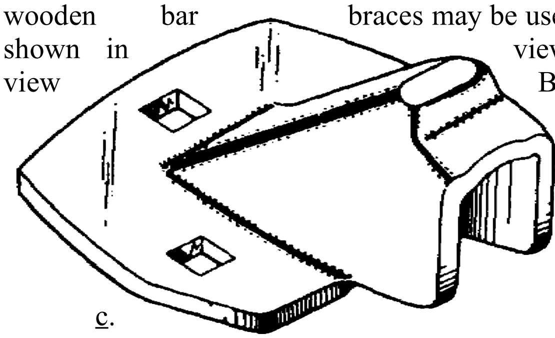
PART C

Dimensions of Standard Shims			
Width, in.	Length, in.	Thickness, in.	Optional length, ft
7	12	1/4	-
7	12	1/2	-
7	12	3/4	-
7	12	1	-
7	12	1 1/4	-
7	24	1 1/2	8
7	24	2	8
7	24	2 1/2	8
7	24	3	8

Figure 4.10. Sizes of Track Shims and Methods Used to Raise Heaved Track.

of trains operating over the track but must be long enough to prevent sudden jolts. Shims are available in varying thicknesses and materials; those made of oak are best. Part C of figure 4.10 lists the dimensions of standard shims. For thicknesses up to 1 inch, ordinary 5 1/2-inch spikes may be used to fasten the rail. For greater thicknesses, 6- or 6 1/2-inch spikes must be used. The maximum thickness recommended is 2 to 3 inches.

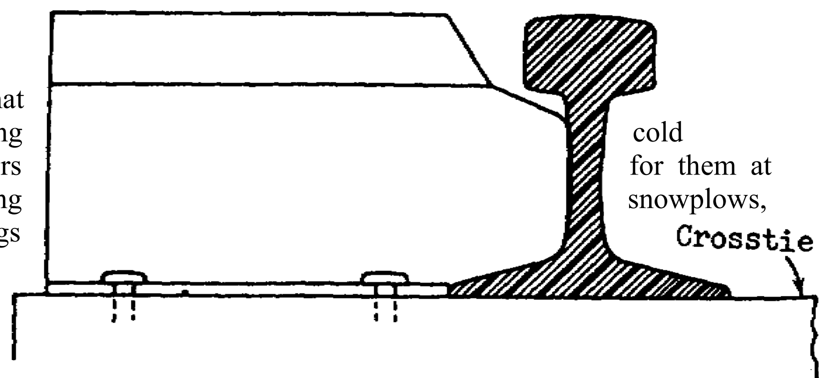
Part B of figure 4.10 illustrates seven ways to shim heaved track; overhead and vertical views of each method are given. Note the rail braces used with the shims in views B(1), B(5), and B(6). Either metal or wooden bar braces may be used. A metal one is shown in the sketch at the left; a wooden one is shown in view B(8) of figure 4.10. A tie plate may also be used as a brace, as view B(3) of figure 4.10 shows. When manufactured rail braces are not on hand, braces may be cut with a torch from rail sections. Then they are spiked to the tie so that they bear against the web of the rail. Such a brace is shown in the sketch at the right.



c. As soon as a spring thaw occurs, shims must be removed, tie plates must be replaced, or ballast must be replaced, depending upon the method used to compensate for heaved track. After that, the tracks must be resurfaced. The difficulty and expense of these operations are major reasons for taking every possible step to correct the poor drainage leading to heaved track.

4.22. CREW SAFETY AND COMFORT

For their safety and comfort, be sure that maintenance crews wear warm clothing during cold weather and, in severe climates, provide shelters for them at suitable locations on the line. When using snowplows, make certain that personnel are clear of wings and



blades before operation is begun. The men must be warned to be careful around slippery locations. A fall on or near a “live” track where trains are expected can result in serious injuries or death. Since hearing and visibility may be severely restricted by snow, watchmen and flagmen must be especially alert to warn the maintenance crew of approaching trains. Never allow anyone to work alone on or near the tracks in severe winter weather.

4.23. SUMMARY

The extreme changes between the summer and winter seasons vary the kind and amount of railway track maintenance required. During the summer, plants grow more rapidly on the roadbed. If this growth is not retarded, the roadbed becomes spongy because of lack of drainage. Rail joints also “freeze,” restricting the expansion of the rails and thereby causing the track to buckle.

In the winter, a large percentage of the increase in track maintenance is caused by snow and ice. The first problem in keeping the track open. The best way to keep it open is to prevent snow and ice from accumulating. Snow fences can be constructed to prevent snow from drifting over the track, and snow sheds can be built in cuts or against the sides of hills to keep the snow from sliding down on the track. If in spite of these extra precautions the track is covered with snow, snowplows must be used to remove it. All movable parts of the track, such as switches, movable point frogs, and car retarders, must also be cleared when the track has been covered with snow or ice. The second problem is protecting the track maintenance men from severe winter weather. Shelters should be built in suitable locations along the track to permit them to get in out of the cold, and they should not be permitted to work alone near the track in severe weather.

Other than the standard maintenance procedures discussed so far, some adaptations of them are necessary when special or unusual situations occur. Chapter 5 explains some of the possible variations as well as the management of maintenance-of-way activities.

Chapter 5

SPECIAL PROBLEMS AND MAINTENANCE-OF-WAY MANAGEMENT

5.1. INTRODUCTION

Bridges, tunnels, interlocking plants, and certain other rail-way structures pose special maintenance problems and alter normal maintenance procedures. And when demolition damages the track and structures of a railroad, rehabilitating them changes the usual maintenance procedures. The problems with structures and the rehabilitation of demolished rail lines are discussed in separate sections of this chapter. The third and final section explains the management of maintenance-of-way activities by track maintenance men.

Section I. Typical Examples

5.2. GENERAL

The track maintenance procedures most commonly used are those presented in the first four chapters. However, procedures must be changed or adapted when special or unusual problems occur. A common sense study of each new maintenance job usually suggests the needed variations and why they are necessary. Some typical examples of special problems follow.

5.3. IN TUNNELS

The minimum clearances which must be observed in tunnels limit the maintenance operations in them. No change in a minimum clearance can be made without approval from a higher authority (RT 670, par. 1.8). For instance, an out-of-face track raise could not be made in a tunnel without endangering the height clearance of trains passing through the tunnel. Similarly, if a track curves in a tunnel, it cannot be relined on a different curve since this would reduce side clearance. A close check must be maintained to insure that traffic has not disturbed track alinement to the point of endangering side clearance. These restrictions apply to bridges passing over railroad tracks and retaining walls near tracks as well as to tunnels.

Specific maintenance operations in tunnels are always made difficult by cramped working space. Out-of-face rail renewals, which usually employ rail-mounted cranes, are complicated by the difficulty of operating them in such close quarters. Ties are similarly difficult to replace in tunnels.

The many difficulties associated with track maintenance in tunnels necessitate taking every possible step to reduce such work to a minimum. For this reason, many railroads use welded rail in tunnels to eliminate joints and their constant maintenance problems. Some railroads have substituted concrete ties in tunnels to avoid the frequent replacement of timber ones. When tunnel maintenance is required, using out-of-face methods is a better policy than spot renewals or repairs. The entire job is completed at once; frequent small jobs that must be done under poor conditions are avoided.

5.4. ON BRIDGES

Track officials usually classify bridges as either ballasted-deck or open-floor. A ballasted-deck bridge has a solid flooring on which a conventional roadbed is placed, as shown in figure 5.1. On an open-floor bridge, the ties are fastened directly to the bridge structure without ballast, as you can see in figure 5.2A. This type is less satisfactory than the ballasted-deck bridge from the standpoint of track maintenance. However, an open-floor bridge is cheaper to build and easily converted to a highway bridge, and, for this reason, is more often constructed in a theater of operations. The top view of an open-floor bridge shown in figure 5.2B gives an idea of how easily this conversion could be made.

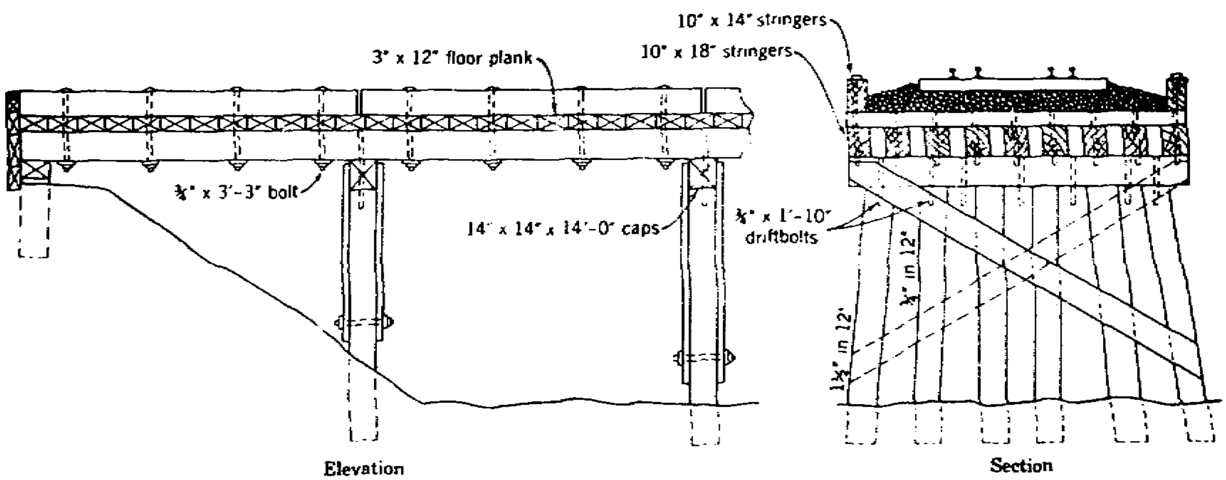


Figure 5.1. Ballasted-Deck Bridge.

A. Side View

B. Top View

Figure 5.2. Open-Floor Bridges.

Track over ballasted-deck bridges is surfaced and lined by tamping and with lining bars--the conventional methods. With open-floor bridges, such work is more difficult because there is no ballast to simplify moving the track either vertically or horizontally. The work must be done by shimming, changing tie size, notching, or elevating. Each tie must be custom made for its individual location.

For example, low spots may be corrected by placing ties of greater depth under the low rails. Such work requires considerable skill, time, and expense.

If the track approaching a ballasted-deck bridge is to be given an out-of-face raise, there is no problem because the raise may be carried across the bridge by the bridge ballast. But when the track leading to an open-deck bridge is given an out-of-face raise, a problem arises. The bridge track must be raised on shims, or the bridge ties must be replaced, or a suitable runoff must be provided at either end of the bridge to connect the lower bridge track with the higher track on either side. Runoffs are usually considered the best solution, since shimming is to be avoided as a general practice, and changing bridge ties is expensive and laborious. Rail anchors should not be used on track over open-floor bridges. (Rail anchors are discussed in RT 670, paragraph 3.22.) Ties are so well anchored when this type of bridge is constructed that tie movement is practically impossible, making rail anchors unnecessary. As a general practice, the surfacing of track over open-floor, but not ballasted-deck, bridges is done by bridge and building forces rather than by track maintenance men.

5.5. IN INTERLOCKING PLANTS AND SIGNAL TERRITORY

An interlocking plant is a network of remotely controlled turnouts and crossovers. It may also include crossings and always includes the mechanism controlling the switches and the signals governing trains passing through the installation. The plants are so constructed that conflicting movements cannot be set up by the operator, and the necessary signal indications are given automatically when any particular route is arranged. To carry out these functions, interlocking plants are necessarily complicated in construction and invariably involve detailed electric circuits. Much of the wiring is buried in the roadbed throughout the interlocking plant so that extreme care is necessary in any maintenance operation which disturbs the roadbed. Personnel of the communications and railway signal maintenance platoon should be called upon to locate this wiring when such jobs as ballast cleaning, ballast renewal, surfacing, or lateral drainage system maintenance are to be done within interlocking limits.

Repairing or replacing power-operated switches is another task requiring the assistance of signal personnel who have a direct interest in the effect these mechanisms have on signals and control machines. Similar assistance from the signal platoon is necessary when switches and rails in Centralized Traffic Control territory or automatic block territory are replaced or repaired.

5.6. DIFFERING GAGE

Problems resulting from junctions of railroads with tracks of different gage are minor in the United States where practically all lines are the standard 56 1/2-inch gage. It is probable, however, that such difficulties will arise in military operation of oversea railroads. Although these problems primarily affect the operating department, the solutions often affect the maintenance-of-way department. A yard located where tracks of different gage meet may have to serve both lines. Then it is necessary for all tracks to have three rails. One is commonly used by both types of rolling stock while each of the other two serves only one road. This solution is simple in ordinary track but becomes more involved in switches and crossings. Three-rail track is obviously a great deal more difficult to maintain, but the procedures, aside from being complicated, are similar to those for two-rail track.

5.7. ELECTRIFICATION

An electrified railway is one on which the locomotives do not carry with them the source of their power, such as coal or oil. Instead, they collect energy from an electric power line as they move along the track. The power may be supplied by a third rail alongside the track or by an overhead trolley wire.

On both military and civilian railroads, specially trained men are responsible for maintaining electric transmission equipment. They should always be informed or consulted if other maintenance work may affect power lines, trolley wires, or third rails. Examples of such work include major track raises under overhead trolley wires or along third rails, changes of alinement, or operation of odd-sized equipment that may extend to within a close clearance of electric conductors.

To insure the safety of track maintenance men working near third-rail or overhead lines, it is desirable and required by many railroads that electric transmission employees accompany them. Men working in electrified territory should know how to administer artificial respiration to revive victims of electric shock. When removing a victim from contact with energized conductors, no part of the victim's bare skin should be touched. The victim may be dragged away from the conductor by his dry clothing, or with rubber gloves, or he may be pushed or dragged away with a nonconducting material, such as dry wood or rope. In addition, both third rails and overhead trolley wires require special safety precautions by track forces.

a. Third rails are generally used to carry direct current at comparatively low voltages, about 600 volts, as well as high current. They are usually well shielded to prevent personnel from coming in contact with them. Third rails must be de-energized before any major track repair work is done near them. Minor work, such as raising a low joint, may be done with the power on if experienced crewmen do the job. Often, a set of electric lights is connected between the third rail and the running rail. While these lights are out, the power may be assumed to be disconnected.

b. Overhead trolley wires, supported by a catenary system,* may carry current similar to that carried by third rails, or they may carry high-voltage alternating current, approximately 11,000 volts. Such high voltage is extremely dangerous because it may jump through space--arc--as much as several feet. In addition, the mere de-energizing of such lines does not make them harmless, because they retain a residual charge. This makes it mandatory that they be grounded after being disconnected from the power source. Track maintenance men must not come within 3 feet of energized or ungrounded de-energized high-voltage overhead lines. Crane booms or other maintenance-of-way equipment must not be brought within 8 feet of such wires.

5.8. SUMMARY

Tunnels, bridges, interlocking plants, railroad junctions, and electrified railways create special maintenance problems. The limited space in tunnels makes track maintenance jobs difficult; everything possible should be done to reduce the amount of repair work needed in them. Welded rails eliminate joints and using concrete ties avoids the frequent replacement of wooden ones. Whenever track maintenance in a tunnel becomes necessary, out-of-face instead of the spot method should be used, allowing the entire job to be completed at one time. However, remember that out-of-face track maintenance can change the height clearance of the tunnel.

Maintenance on bridges is always difficult, particularly on open-floor bridges where there is no ballast. To simplify the vertical and horizontal movement of the track, each tie must be custom made for each individual replacement. Bridge and building personnel

*A catenary system is a method of supporting a trolley wire horizontally by suspending it by messenger wires from a catenary--a curve formed by a cord or cable hanging freely from two fixed points or supports.

rather than track maintenance men usually surface the track on open-floor bridges.

When maintenance work is done on roadbed controlled by an interlocking plant, track maintenance forces must be assisted by men from the communications and railway signal maintenance platoon. Their assistance is also required when power-operated switches are replaced or repaired.

When two railroads with different gages meet, three rails on each set of tracks are necessary. One of the three rails is used by locomotives and rolling stock of both gages and as a result it is more difficult to maintain.

Track maintenance men working on electrified railways must have special training and should be accompanied on any track maintenance job by electric transmission personnel. Until a qualified electric transmission worker has de-energized and grounded the high-voltage overhead transmission wires, track maintenance men must not approach within 3 feet of these lines, and track maintenance equipment must not be moved within 8 feet of them.

Section III. Demolition and Rehabilitation

5.9. GENERAL

In theaters of operations, track work differs considerably from that on commercial railroads. The exception, in the latter, where several hundred feet of track is torn up by a wreck, becomes the rule in a theater. Destruction by the enemy and deliberate destruction by our forces to keep serviceable lines from falling into enemy hands cause the increased work, and both are fairly common. Obviously, repairing a turnout or crossover is pretty much the same regardless of whether the enemy or our forces have deliberately caused the destruction. Likewise, damage to the rail plant or to a particular facility is similar if it has been caused by long-range artillery fire or aircraft bombing, no matter by which side. The most thorough damage is caused by deliberate destruction carried out by crews trained in such work who have demolition and special wrecking equipment. Moreover, the crews usually know railroad construction, operation, and maintenance; consequently, they know the most vulnerable spots where destruction can best hinder rehabilitating the line. This section explains large-scale rehabilitation of track, roadbed, tunnels, and bridges; demolitions and other methods of destruction; and theater rehabilitation and demolition practices.

5.10. LARGE-SCALE REHABILITATION

Heavy destruction of rail plants and facilities requires large construction and repair forces. When damage is extensive, the Corps of Engineers takes care of the new construction. Often, its forces are supplemented by local labor to do heavy and unskilled work.

a. Track. Where damage is confined to track, ties, and track fastenings, the principles and methods of repair outlined in previous chapters apply. Again, constructing a turnout or replacing rail and fastenings is the same regardless of what or who caused the need for it.

b. Roadbed. When the roadbed has been damaged, the instructions in Reference Text 670, dealing with subgrade, subballast, and ballast are to be followed. Members of a transportation rail unit may be required to assist engineer personnel in this work. Sometimes, engineer troops may not be immediately available to fill in a crater caused by a direct hit on the right of way. It may then be necessary for transportation forces to build a "shoo-fly"--bypass--track around the damaged section. All the previous track-laying instruction applies, although the urgency of the situation and the expected duration of the temporary track's use determine to what extent to go in subgrade, ballast, line, surface, and exact gage. A light train can operate safely over a comparatively poor section of track, if it travels at the slow speeds that may be necessary in a theater of operations.

c. Tunnels and bridges. Damage to tunnels and bridges can be an effective way of blocking a rail line. Special squads of bridge and tunnel personnel are required for repairing the structures before new track can be laid and service can be resumed. Figure 5.3 illustrates the way that four viaducts were repaired after being severely damaged. Figure 5.4 shows a method of tunnel repair used effectively in the Korean War in which rail sections were bent to fit tunnel-clearance requirements and then lashed or welded to longitudinal stringers, as part A shows. A heavy plank lining and a backfill of sand and stone completed the repairs as shown in part B.

5.11. DEMOLITION

Destruction and demolition to rail lines and facilities by our forces may be limited or extensive. Responsibility for ordering such destruction usually rests with higher authority. Vulnerable targets include rail yards, roundhouses, turntables, and interlocking

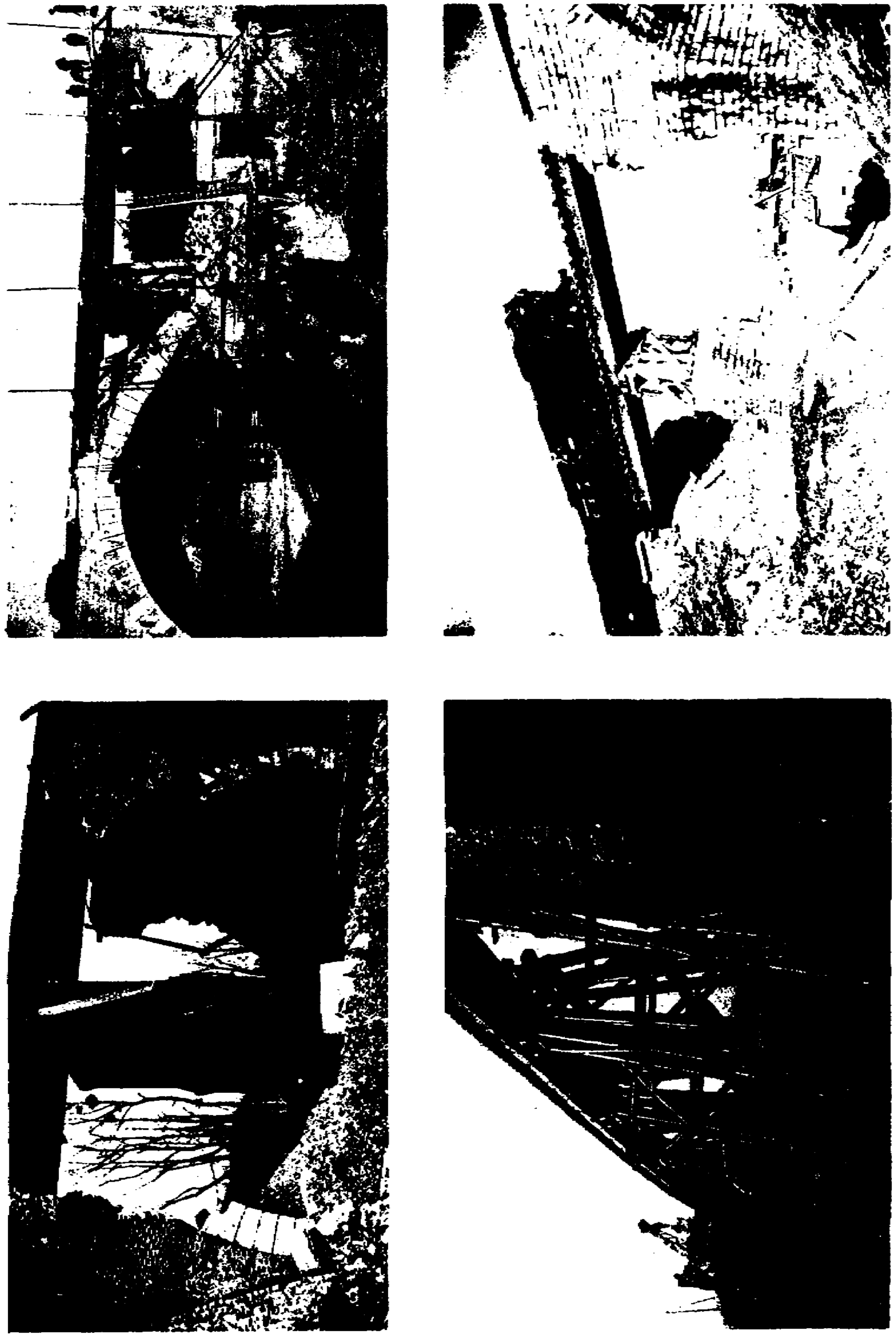
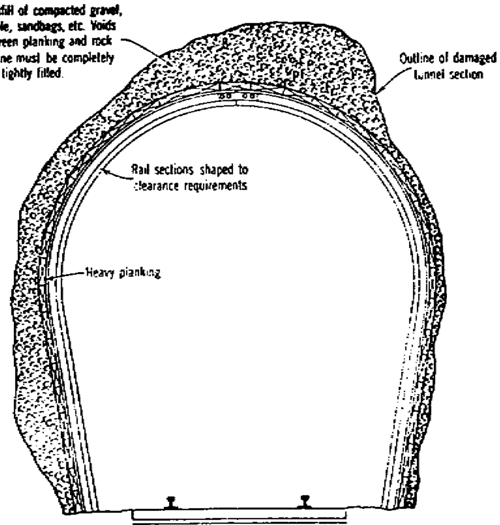
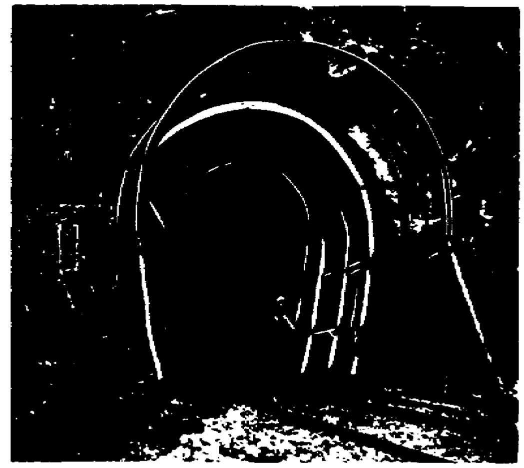


Figure 5.3. Temporary Repairs Made to Viaducts.



A. Detail of rail-frame tunnel lining



B. Rail-frame lining installed in damaged tunnel

Figure 5.4. Temporary Repair of Damaged Tunnel.

plants; water, power, and signal lines; piers, tunnels, and bridges; and other key spots along the track. In general, specially trained demolition crews are available for this work, but maintenance-of-way men may be required to assist them. On occasion, rail operating and track maintenance men may have to advise the crews as to the best points in the area to be demolished.

Rail, switches, frogs, and turnouts may easily be destroyed with small amounts of explosives in the hands of a few men. A detail of eight, for example, can do a hasty but effective job by placing 1-pound primed charges against the web of the rails on every other connection between rails on both tracks for several hundred yards, and then tamping the charges with sandbags. While tamping is not necessary to break the rails, it assures destruction of a longer portion of each section. The fuses are lighted by the last two men of the detail who follow about 250 yards behind the work car. This procedure should be repeated at intervals of 1 1/2 miles (2 1/2 km) to cause serious delay in track repair. About 20 pounds of explosives are needed for this spot destruction, as it is called, for an estimated 500 feet of single track. A frog may be destroyed by placing an explosive charge at the throat; switch points may be broken by discharging explosives at the points. By consistently destroying either the right- or left-hand points, both time and explosives can be saved. Turnouts may be mined, and switch and interlocking levers may be set with booby traps. Figure 5.5 shows the charge location for

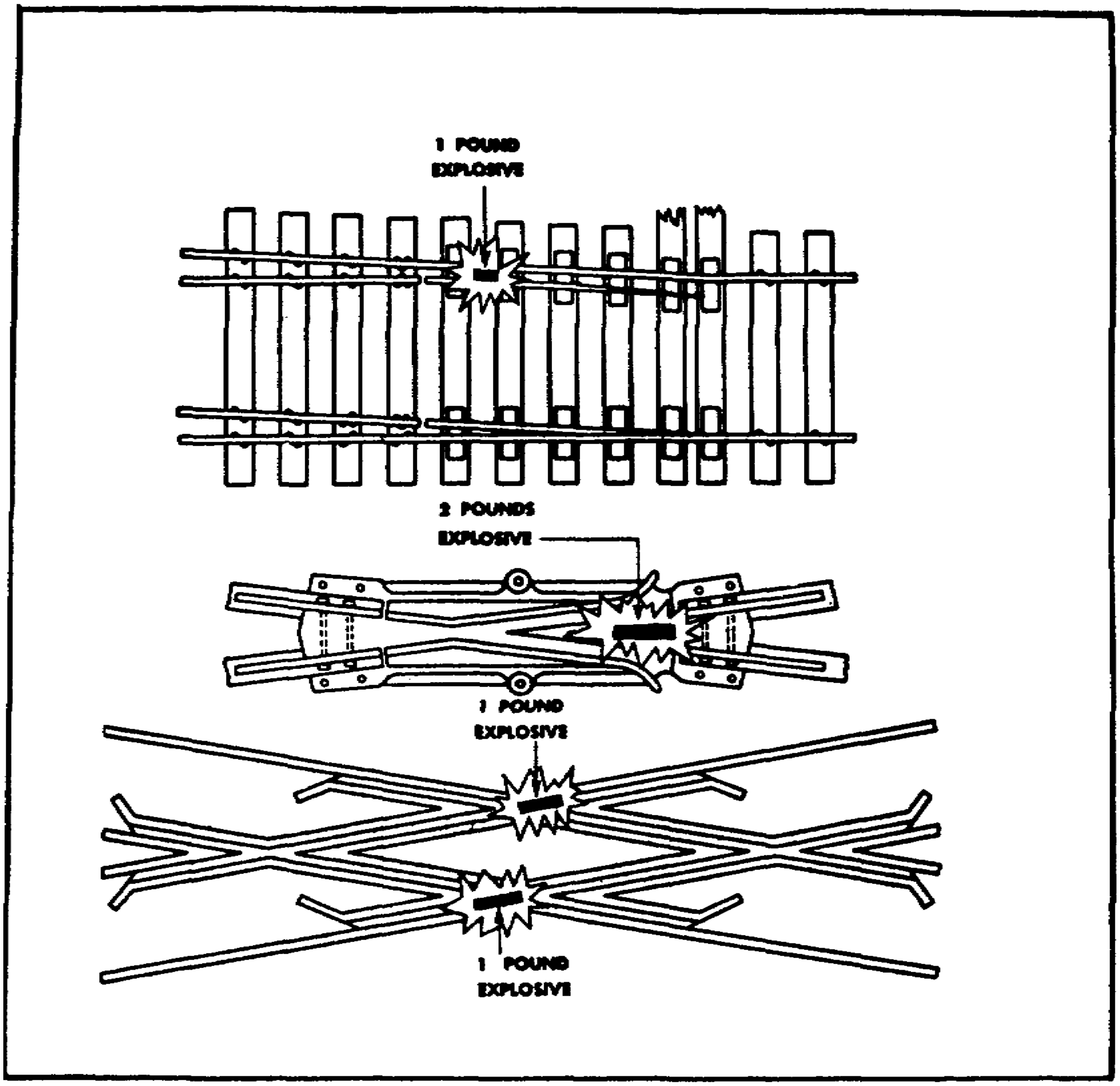


Figure 5.5. Charge Location for Switches, Frogs, and Crossings.

switches, frogs, and crossings; figure 5.6 shows the placing and results of hand charges against rails.

5.12. OTHER METHODS

In addition to explosives, fire, water, and mechanical means may be used to make rail lines and facilities unfit for use. They are discussed in the following subparagraphs.

a. Fire. A highly destructive fire may be set to ties and rails by spilling flammable liquid from a tank car along the tracks for some distance and then igniting the liquid. When volatile liquid

Hand-Placed Charges

Result

Figure 5.6. Securing Hand Charges to Rail Web and Result Obtained.

is not available, satisfactory results can be obtained by raising the track and ties several inches off the roadbed and starting fires underneath. Fires may also be used to destroy bridges, roundhouses, and structures, especially when they are of wood or of wood and steel construction.

b. Water. Roadbeds may be severely damaged by flooding with a sudden rush of water from opened dams, diverted streams, or water supply stations. Holes in the roadbed, slope failures, slides, shifted superstructures, washouts, and undermined bridge foundations may result just as they do from a natural breakthrough of a dam or a flood. Water impact is often strong enough to result in damage that may delay repair much longer than a destroyed strip of rails and the ties or several turnouts demolished by explosives.

c. Mechanical. Destruction by mechanical means consists of using cranes to over-turn tracks, earthmoving machinery to block the right of way, locomotives to wreck and derail equipment, and a tie ripper to destroy both track and ties. The tie ripper, an ingenious device perfected by the Germans, is shown in figure 5.7. It was attached to a car and towed by three locomotives at an approximate speed of 10 mph. It broke each tie in the middle of the track and dug into the ballast. The hook was equipped with a chute from which a 2.2-pound charge of explosive was dropped on every rail length, At a speed of 9.4 mph, and with a 20-second fuse, the charge detonated against the rail 55 yards behind the ripper. As evidence of its destructiveness, in one 28-mile stretch over which it traveled, 6,000 rail breaks and 2,500 broken ties were found.

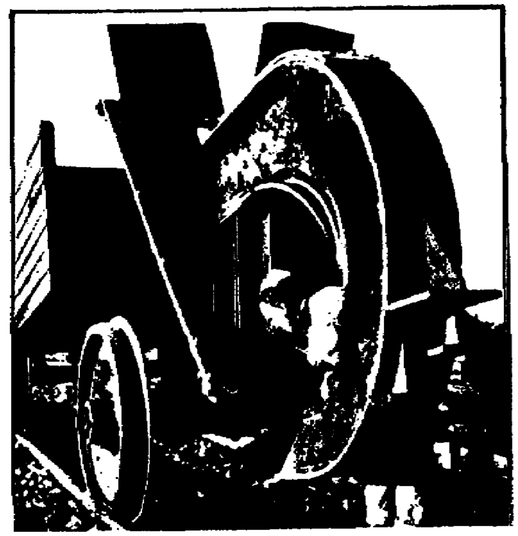
5.13. THEATER PRACTICES

Railroads and their effectiveness may be destroyed in many other ways and by other methods. The element of time and the possibility of future use will always control the extent of destruction. The track maintenance man's job in a theater will consist primarily of repair and rehabilitation to damaged right of way. Often, the principles outlined and stressed in this teaching of roadbed, track, curves, superelevation, line, surface, and gage will be followed almost to the letter. But in many other instances, the policy of refinements of track and roadbed followed on most commercial railroads will have to be dispensed with because of the urgency of the military situation.

5.14. SUMMARY

If you want to deny an enemy the immediate use of a railroad and increase the amount of effort required to rehabilitate it, you need specially trained crews, explosives, and wrecking equipment. The crews should know railroad construction, maintenance, and operating procedures and should be able to pick out the most vulnerable spots where destruction will cause the greatest amount of rehabilitation effort. However, if you have people trained only in using explosives but unfamiliar with rail-roads, the crews should be supplemented with train operating and maintenance-of-way people who know the vulnerable spots.

If you must rehabilitate a railroad that has been damaged deliberately, you need special construction equipment and a large work force.
Railroads in a theater of operations are rehabilitated by the



The Tie Ripper

Result

Figure 5.7. Tie Ripper in Operation and Resultant Destruction.

Corps of Engineers. The work force should be supplemented by local labor whenever it is available.

Section II. Management

5.15. INTRODUCTION

Any work force requires management even if it consists only of a single individual who plans, coordinates, and does his own work. Track maintenance is a complex business, and this section explains its management in terms of how it is organized, how the work forces are distributed, how the work is programmed, and how track charts are used are used.

5.16. ORGANIZATION

Railway systems, military or civilian, are divided geographically into divisions. The organization of a typical civilian maintenance-of-way division is described in subparagraph a; that of a military division in subparagraph b.

a. Typical civilian railway division. On a civilian line, the overall authority and responsibility for all phases of maintenance of a rail division rest in the hands of the division engineer. On some lines, he may have the title of maintenance-of -way superintendent. He is thus one of several members of the division superintendent's staff.

The division engineer further delegates his work to several supervisors. There will usually be two or more track supervisors, sometimes called roadmasters, per division, along with a bridges and buildings supervisor and a signal supervisor. The work is divided geographically among the track supervisors; that is, each supervisor is charged with track maintenance on a portion of the division known as a subdivision. Each subdivision has definite physical boundaries, usually designated by mileposts. Each superior then divides his territory into sections and places them under section foremen. There may be as many as eight main-line section foremen, each in charge of a section gang. In addition, the supervisor has at his disposal several branch-line section foremen and an extra gang and foreman which he uses anywhere on the subdivision.

b. Military rail division. The area covered by a military rail division ranges from 144 to 240 kilometers. In charge of the division's maintenance of way is the maintenance-of-way superintendent. He is also the company commander of the transportation railway engineering company assigned to the railway battalion. His job is the same as that of a division engineer or maintenance-of-way superintendent on a civilian line. He is responsible for and is in charge of all engineering pertaining to maintenance of way. His assistant is a lieutenant who acts in his absence and is responsible for emergency stocks of material for the area of the battalion's maintenance responsibility.

The railway engineering company is divided into a company headquarters, a service support platoon, two track maintenance platoons, a bridges and structures maintenance platoon, and a communications and railway signal maintenance platoon. Its organization is shown in the chart in figure 5.8. The discussion in the remainder of the paragraph covers all of these except the company headquarters and the service support platoon.

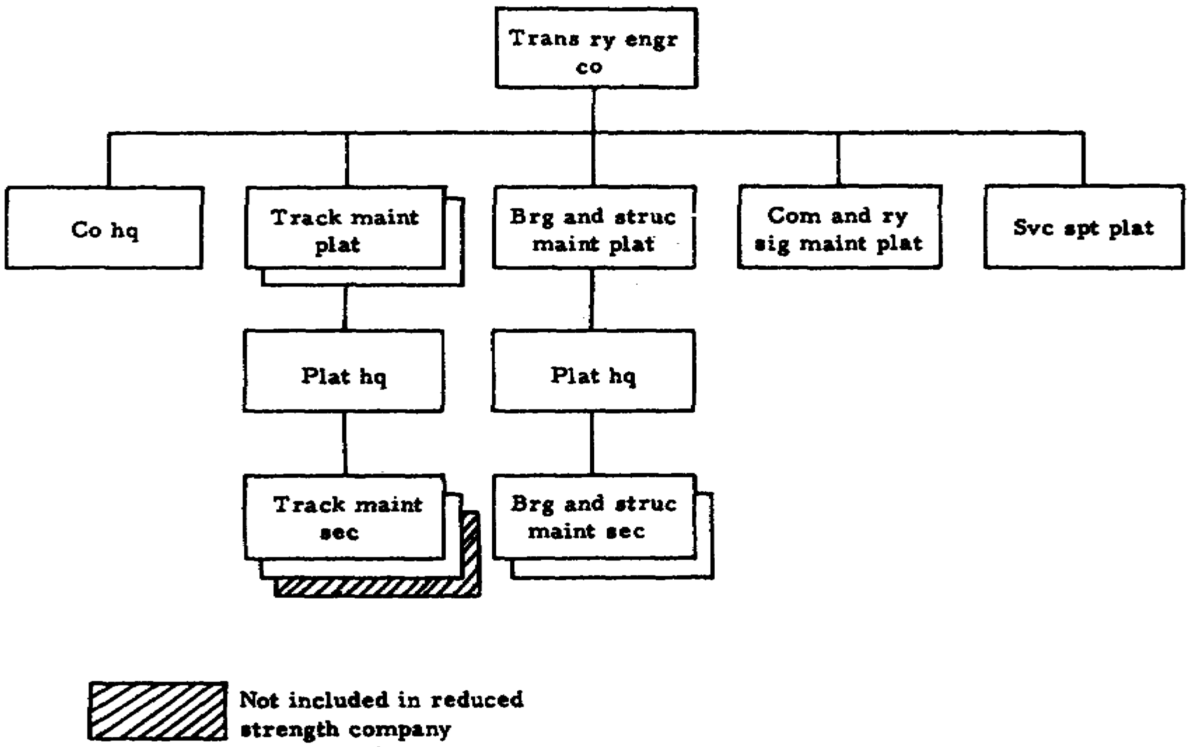


Figure 5.8. Organization Chart, Railway Engineering Company.

The two track maintenance platoons each have a headquarters section and three maintenance sections. The platoon leader, a lieutenant, is the track supervisor for an assigned territory in the railway division where he is responsible for the maintenance of the roadway and tracks. He assigns the working limits of each section, prescribes the duties, and supervises the work. Each section has a gang foreman, an enlisted man, who directs 18 other enlisted men in jacking up and lining track; in replacing ballast, rails, and ties; and in carrying out general track maintenance duties.

In addition to the track maintenance platoons, two other platoons are responsible for certain phases of track maintenance. They are the bridges and structures maintenance platoon and the communications and railway signal maintenance platoon; they are organized similar to the track maintenance platoons.

(1) Under the supervision of a lieutenant, the bridges and structures maintenance platoon is responsible for maintaining buildings, bridges, culverts, fueling and watering facilities, and tunnels. Each of the two maintenance sections in the platoon is supervised by its own construction foreman who directs the assigned carpenters, structural steelworkers, construction workers, riggers, welders, and compressor operators.

(2) The communications and railway signal maintenance platoon is responsible for installing, operating, and maintaining radio, telephone, and teletype equipment. It also repairs and maintains the signal devices, lines, and interlocking plants within the railway division.

5.17. TRACK CHARTS

Track charts are condensed graphic presentations of information that maintenance-of-way men need. The charts provide ready information on track layout, types of rail, ballast, grades, and structures. They should be distributed to all maintenance-of-way officers down to the level of section foremen. Different railroads may use slightly different forms of track charts, but essentially all provide the same information. The charts shown in annexes B and C are typical. Annex B is the cover sheet of the track chart which gives the limits of the chart, the scale of the diagram, the date issued, and the name of the office preparing the chart. The map, not always included, shows the entire division, station names, and other railroads that connect with or cross the division.

Annex C, a representative portion of a track chart, pictures a 10-kilometer segment of section 2. The main body is divided by vertical lines; the space between each two lines represents 1 kilometer on the ground. The number appearing at the top of each line is the same as that on the kilometer post at the corresponding physical location. The section number is shown at both of its boundaries; the name of the section foreman is given between the section boundaries.

Below the kilometer-post numbers appears the track diagram. On it, all the tracks appear as if they were tangent; curves are not shown. Also on it are the location of tracks, turnouts, major terrain features, and structures. In addition, the weight and section of main-line and passing-siding rail are shown. Horizontal parallel lines represent the track, and short vertical lines mark the location of compromise joints. On either side of the track lines, the weight and section of the rail of that track are given. On some charts, these parallel lines do not appear; instead the rail description is given by a color or a broken-line code on the track diagram. The description of ballast material is given in the same way as for the rail.

Since curves are not shown on the track diagram, there is a separate drawing for curvature. This is given in the next to the last line on annex C. The location, direction, length, and degree of curvature of each curve are given.

At the bottom of the track chart, a profile or gradient of the track is shown. It gives the exact location, direction, and percent of all grades. The signs of grades are arbitrarily assigned by the following convention: plus grades, uphill to westbound trains; minus grades, downhill to westbound trains.

To illustrate how the chart can be used, refer to annex C and note that the highest point between kilometer posts 70 and 80 occurs at kilometer post 73, on a curve of 0 degrees 26 minutes, where the main line is ballasted with crushed slag. Note also that near this point the eastbound main is laid with 115-pound RE-section rail while the westbound is laid with 133-pound.

5.18. DISTRIBUTION OF FORCES

Successfully accomplishing any task and maintaining good morale among the men doing the job depend on distributing the workload fairly. A simple but by no means always satisfactory distribution of the workload is to divide a railroad into equal portions and to assign an equal number of men to maintain each portion. Such an arrangement does not take into account the varying degrees of effort and skill required in maintaining turnouts, crossings, sidings, and curves. A kilometer of main-line track with frequent turnouts, highway grade crossings, and several curves presents a far greater maintenance problem than an uninterrupted kilometer of branch-line track. Therefore, tables of equivalents have been made to simplify the problem of equitably dividing work forces for railroad maintenance of way. Table VII gives examples of equivalents that may be used as a guide in dividing the workload.

Table VII. Comparative Maintenance Equivalents

Facility	Track Equivalent in Kilometer of Main Track
First main track, per kilometer	1.00
Additional main tracks, per kilometer	0.80
Branch-line track, per kilometer	0.49
Passing and running tracks, per kilometer	0.43
Yard and side tracks, per kilometer	0.32
Main line switch, each	0.07
Side track switch, each	0.05
Railroad crossing, each	0.10
Paved highway or street crossing, each	0.07
Unpaved road crossing, each	0.03

The track chart is a fine example of how track forces are distributed. The track diagram shows the extent of the track facilities between kilometer posts. If you add the amount of the various facilities and multiply by the factors given in table VII, you obtain the equivalent trackage in each case. The calculations given below illustrate the process for two hypothetical sections. The first is 20 kilometers long, has few switches, and has only a small amount of yard and side trackage. The second section, on the other hand, is only 12 kilometers long and contains a long passing siding as well as a large yard with a number of switches.

For section 1 between kilometer posts 1 and 20--

lst main track - 20 km @ 1.00	=	20.00
2d main track - 20 km @ 0.80	=	16.00
Passing track - 1 km @ 0.43	=	0.43
Yard and side track - 1 km @ 0.32	=	0.32
Main track switches - 3 @ 0.07	=	0.21

Side track switches - 4 @ 0.05	=	0.20
Paved grade crossing - 2 @ 0.07	=	0.14
Equivalent kilometers	=	37.30

For section 2 between kilometer posts 21 and 33--

1st main track - 12 km @ 1.00	=	12.00
2d Main track - 12 km @ 0.80	=	9.60
Branch line track - 2 km @ 0.49	=	0.98
Passing and running tracks - 1.5 km @ 0.43	=	0.65
Yard and side tracks - 4 km @ 0.32	=	1.28
Main track switches - 9 @ 0.07	=	0.63
Side track switches - 15 @ 0.05	=	0.75
Equivalent kilometers	=	25.89

5.19. PROGRAMMING MAINTENANCE

A track supervisor with a wealth of technical information, given the advantages of enough well-trained crews and adequate equipment and supplies, should be able to maintain his track in excellent condition. However, he will fail if he does not plan his work in advance. A program based on remedying weaknesses when and where they appear is haphazard and bound to result in track of variable condition and poor quality. Some of the steps of programming maintenance work are outlined in the next four paragraphs.

5.20. OBJECTIVES

One of the most desirable features of a railroad subdivision is good uniform quality. A subdivision made up of alternate stretches of carefully and poorly maintained track is worthless because its capability is limited to that of the poorest track within its boundaries. There will rarely be enough men and material to maintain a railroad perfectly. Therefore, any effort used to build up to perfection the quality of one particular section must usually take away from another. Careful long-range planning and preparation can eliminate the danger of duplicating work and make it possible to achieve uniform-quality track with a minimum amount of men and equipment.

5.21. PROGRAMMING FOR THE SEASONS

Experience and common sense have led most railroads to follow similar programs of determining what is to be done and at what time of the year. The details of these programs depend on the particular problems encountered; however, the subparagraphs that follow outline some of the usual items included in such programs.

a. In severe winters, snow, ice, and frost prevent large-scale track work. During this time, the men are fighting off snow and ice and shimming heaved track. Where snow is not a serious problem, small jobs, such as replacing joint bars, may be tried. In mild winters, rails can also be replaced. This is an ideal time to report on previous progress, make plans for the coming year, and requisition supplies and equipment. During the winter, many of the heavy repairs on maintenance-of-way tools and machines are made.

b. In the spring, winter damage is repaired, and the heavy maintenance program is started. Shims are removed from heaved track (par. 4.21b), culverts and ditches are cleaned and repaired, and rail and tie renewals begin as soon as the ballast thaws and can be worked to surface the track.

c. During the summer, all kinds of maintenance work are done; it is the period of the greatest track maintenance effort. Ballast is cleaned or replaced; tie and rail renewals continue; and weeds and grass are cut, burned, or sprayed.

d. Fall is the time to finish the projects previously begun and to prepare the line for winter. A final surfacing is usually made while the ballast is still unfrozen, and snow-fighting equipment is readied and distributed. All scrap is collected from the roadbed.

5.22. SEQUENCE OF WORK

Within the broad scheme of the work plan, there should be a definite sequence to the detailed operations performed. A proper sequence eliminates duplicating tasks, undoing what has been done previously, and unnecessary abuse and destruction of track materials. Keeping records up to date at all times often eliminates work duplication. For a smooth working operation, follow the steps outlined in subparagraphs a through d.

a. Step one. Track should be in fairly good line and surface before new rail is laid to prevent permanent bending and excessive wear. On the other hand, track must be brought to perfect line and surface after it has been disturbed by the laying of new rail.

b. Step two. Tie renewals are usually scheduled to begin in early spring, but if rail renewal is expected, it is better to delay replacing ties until after the new rail is installed. This eliminates redriving spikes in the new ties, thereby giving them longer life.

c. Step three. If a subdivision has been maintained in good condition, rail renewals may be possible during the winter if it is not too severe in the particular area. Then new ties can be placed in the early spring without requiring a second spiking within a few weeks of the first.

d. Step four. Whenever track is disturbed by rail re-lay, grouting, or replacing joint bars, it should be surfaced and lined immediately afterward. But rail-end welding and grinding should never be done until after the track is surfaced and lined, or the good effects of the work are lost.

5.23. PROGRESS

A good program of track maintenance is worthless unless followed steadily. Of course, interruptions and emergencies make it difficult to follow the program, but these should not be allowed to upset the broad aims of the plan. As an aid in recording progress, many supervisors keep track charts and color-code them to show what work is planned, when it is scheduled for completion, and the status of weekly or monthly progress. Another scheme for planning and keeping a check on progress is shown in figure 5.9. This chart, however, has the weakness of not showing the locations where work is to be done or is in progress. It is shown to give an example of the sequence of work as well as a means of checking progress. This chart is not intended as a final guide for planning work. Every railroad and every subdivision have different characteristics of weather and traffic which affect such planning.

5.24. SUMMARY

Both military and civilian railway systems are divided geographically into divisions. Each division of a civilian railroad has a superintendent who has the authority and responsibility for the operation and maintenance of his division. One of the members of the superintendent's staff is the division engineer, who is responsible for all maintenance of way on his particular division. He delegates some of his duties to subdivision supervisors. The subdivisions are usually divided into sections with a section foreman responsible for the work done on each.

On a military rail division, the maintenance-of-way superintendent is the company commander of the transportation railway

Month	Precentage of tie replacement program complete	Progress	Percentage of ballast replacement program complete	Progress	Percentage of rail renewal program complete	Progress	Work to be done during month
Jan		This column to be filled in at end of each month		This column to be filled in at end of each month	10	This column to be filled in at end of each month	Laying new rail, ditching, shimming, surfacing after rail renewals; snow and ice removal; and gaging.
Feb			20		20		January project continued.
Mar					40		Rail renewals; starting tie replacement; cleaning right-of-way.
April	30		20		50		Rail renewals, tie replacement, surfacing and raising track.
May	50		30		65		April track work continued.
June	60		50		75		May projects continued; weed control.
July	70		70		90		Rail, tie, and ballast program.
Aug	90		80		100		Lining, surfacing, gaging, and ballast program.
Sep	95		95				Weed control, tie and ballast program continued.
Oct	100		100				Completing tie and ballast program, repair of highway grade crossings.
Nov							Final lining, surfacing, and gaging. Begin preparing switches for winter.
Dec							Erecting snow fences and other protection against snow and ice. Repair track tools.

Figure 5.9. Track Maintenance Progress Chart.

engineering company of the railway battalion. His company has two track maintenance platoons, each of which consists of a headquarters section and three maintenance sections. In charge of each section is a track supervisor who directs the work of his gang foreman and 18 other enlisted men. Two other platoons in the company carry out maintenance duties in connection with bridges and structures and with communications and railway signals.

The maintenance work is distributed as evenly as possible, but this does not mean that a railroad is divided into equal sections with an equal number of men assigned to each section. The varying degrees of effort and skill required in maintaining curves, turnouts, crossings, and sidings must be taken into account, because a kilometer of main-line track containing many of these characteristics presents a much greater maintenance problem than does a kilometer without them. Maintenance work should be well planned; a program of continued maintenance is more desirable than one based on remedying weaknesses where and when they appear.

CORRESPONDENCE COURSE OF THE
U. S. ARMY
TRANSPORTATION SCHOOL

RAILWAY TRACK MAINTENANCE II

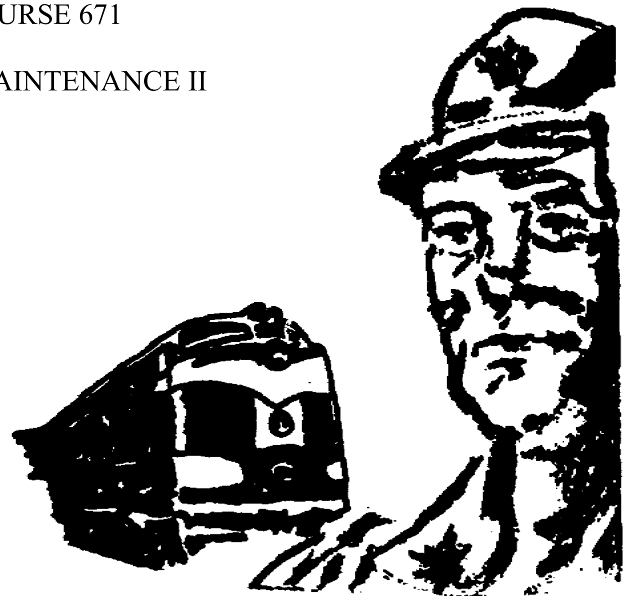
LESSON EXERCISES
TRANS SUBCOURSE 671

February 1971

Supersedes Trans 671, Railway Track Maintenance II, February 1968.

TRANS SUBCOURSE 671

RAILWAY TRACK MAINTENANCE II



INTRODUCTION

In mid-nineteenth century, Major General George H. Thomas said, "The fate of an army may depend on a buckle." If the general had been a railroad man, he might have said something like this--battles cannot be won while soldiers wait for railroaders to deliver a train of ammunition, nor can a rail operating crew deliver such a train while waiting for maintenance-of-way forces to repair the track.

Expediency is the order of the day in a theater of operations; the prompt arrival of trains at their destinations is far more important in wartime than that of any train operated in peacetime. As a student of maintenance of way, you must realize that the shine on the "buckle"--the refinements of track and roadbed described in this subcourse and its predecessor, Trans Subcourse 670--will have to be bypassed in oversea theaters. There, no profit angle exists and no long-range maintenance programs to protect capital investment are involved. Nevertheless, each track maintenance man must recognize the advantage of knowing the maintenance procedures presented in this subcourse. Such knowledge adds to the efficiency needed in performing, planning, and directing the maintenance activities that enable the trains in a theater to keep rolling to fulfill their essential logistic mission.

After studying the reference text to this subcourse, you should be able to explain the types, methods, and principles of routine track maintenance; to describe the function, components, design, location, construction, and maintenance of various types of turnouts; to identify the design, function, and characteristics of the various types of railroad curves; to explain the method of stringlining curves when they get out of line; to explain the function, design and maintenance of highway grade crossings and guard rails; to identify the more important problems of seasonal maintenance; to identify special maintenance problems; and to describe certain principles of maintenance -of-way management.

The subcourse consists of five lessons and an examination divided as follows:

		Credit Hours
Lesson 1,	Track Rehabilitation	3
2,	Turnouts and Special Switches	3
3,	Curves	3
4,	Highway Grade Crossings, Guard Rails, and Seasonal Maintenance	2
5,	Special Problems and Maintenance-of-Way Management	2
Examination		2
	Total	15

Upon completion of this subcourse, you retain the reference text and lesson exercises.

LESSON 1.. Track Rehabilitation.

CREDIT HOURS .... 3.

TEXT ASSIGNMENT.. Reference Text 671, pars. 1.1 - 1.28.

MATERIALS REQUIRED... None.

LESSON OBJECTIVE.. To enable you to explain the types, methods, and principles of routine track maintenance.

SUGGESTIONS... None.

EXERCISES

Weight	True-False

Put a "T" for true and an "F" for false.

2 1. Out-of-face surfacing precedes reballasting.

2 2. Surfacing involves both surface and cross level.

2 3. When a stretch of track is given an out-of-face raise, poor surface is corrected.

2 4. Rail-mounted machinery is routinely used in spot replacement of rail.

Cluster True-False

(Each question of this kind consists of a series of statements related to the stem that precedes them. Indicate which are true and which false with respect to the stem.)

5. In out-of-face track surfacing, it is correct procedure to:

2 a. Ordinarily proceed with the work in the direction of traffic.

2 b. On steep grades, generally proceed with the work uphill regardless of the direction of traffic.

2 c. Place jacks away from joints, to lessen the strain on joint bars.

2 d. Make the final elevation of the rails the same as the height of the grade stakes.

2 e. Place track jacks under the rail at the point where one end of the spot board rests.

6. In performing track maintenance:

2 a. All old rail removed is saved, for it can be used in yards and on branches.

2 b. Out-of-face surfacing is an operation in which the entire track is raised to a new uniform height.

Weight

2 c. Removal of ties necessitates halting train traffic.

2 d. Both rails are usually replaced simultaneously in an out-of-face rail re-lay.

2 e. Spot rail replacement is more common than out-of-face.

7. Traffic would have to be restricted during tie replacement when:

2 a. One tie on tangent track has been removed but all others are fully spiked, tamped, and in good condition.

2 b. Three adjoining ties have been removed on a tangent.

2 c. One tie on a tangent has been removed with only two fully spiked ties on either side.

2 d. One tie has been removed with two fully spiked ties flanking it on either side on a curve of 3 degrees.

2 e. Two adjoining ties have been removed on a tangent, with four ties fully spiked, tamped, and in poor condition on either side of the removed ties.

8. When distributing ballast for an out-of-face track raise, you:

2 a. Can cut notches in the car trucks to spread the ballast.

2 b. Can dump ballast from moving cars in piles about one rail length apart and then spread as needed.

2 c. Will seldom need to dump ballast where there is a raise of more than 4 inches.

2 d. Should never have more ballast on the track than can be tamped in 1 working day.

2 e. Can successfully dump ballast from an ordinary hopper car if a ballast car is unavailable.

Weight

9. During an out-of-face track raise:

2 a. The rail is at the correct height when it is level with the top of the grade stake.

2 b. Grade stakes painted with sighting bands of contrasting color are placed outside the grade rail.

2 c. A track level may be used to bring the second rail to proper surface after the first has been raised.

2 d. Ballast under the ties holds the track at the corrected height until the tamping gang arrives.

2 e. The spot board is held level by wooden blocks or shims placed on top of the rails.

10. Under the provisions of rule 101 of the Railway Operating Rules, the:

2 a. Trains must be protected against track conditions that may prevent their proceeding safely at normal speed.

2 b. Track supervisor would be responsible for providing train protection if he found a broken rail.

2 c. Foreman is to provide train protection if the track repairs are such that trains could pass them safely but only at reduced speed.

2 d. Foreman need not send flagmen out if the dispatcher has agreed to route trains around his work.

2 e. Foreman in charge of track repair is responsible for placing flagmen to protect trains approaching the scene of his work.

Completion

8* 11. Several kilometers of track are to be replaced in your subdivision. Listed among the choices below are the steps to be

---

*1 point for each correct entry.

Weight

carried out in the proper work sequence indicated by the numbered blanks in the narrative describing the replacement. Indicate the steps to be followed by writing the proper letter in the numbered blank.

A. Removing old rails from ties.
B. Placing shims between rail ends.
C. Installing the catenary system.
D. Plating the joint bars.
E. Adzing crossties.
F. Removing old rail anchors, bolts, and joint bars.
G. Setting new tie plates.
H. Tightening spot board in place.
I. Driving wooden plugs in old spike holes.
J. Cleaning up fastenings and removing old rail.
K. Driving down stubs of broken spikes.
L. Tightening joint bars.

The first step in a mechanical out-of-face rail replacement is ____(1)____, followed by the burning off of bolts when necessary. The third step involves ___(2)____, after which the old tie plates are removed. When you finish the fifth step--leveling ballast and sweeping ties, you go on with ___(3)___. Having done that, the next step is to complete the ___(4)_____, followed by ___(5)____. After the bare wood has been creosoted, ___(6) is the next step. Then the new rail is set in place, after which ____(7)____is done. Gaging and lightly spiking the new rail is then accomplished, after which the final steps are completed, which are, in order, tightening the joint bars, fastening the rail anchors, applying the signal bond wires, and ___(8)_____.

Multiple Choice

(Each question in this group contains one and only one correct answer.)

3 12. One way to dispose of discarded ties is to use them for shoring a track while building, a ______________________ drain.

A. German.
B. French.

Weight

C. Spanish.
D. Korean.

3 13. Old crossties are removed from the track by using tie:

A. Jacks.
B. Gages.
C. Tongs.
D. Adzes.

3 14. In carrying out an out-of-face raise, the track foreman's duties include all of the following <u>except</u>:

A. Safeguarding the men and trains.
B. Making the final check of the completed work.
C. Assigning the men's duties.
D. Determining what tools are available.

3 15. The lining of high-speed tangent track is best established by:

A. Spot board.
B. Sighting block.
C. Eye.
D. Transit.

3 16. Gage is checked with a:

A. Track gage.
B. Scratch board.
C. Lifting bar.
D. Gage rod.

3 17. An inspection of crossties by the track foreman indicates that several need to be replaced. If you ware the track supervisor, your next move would be to:

A. Inspect the ties after they have been removed from the roadbed.
B. Daub red lead paint on the end of each one to be replaced.
C. Spot check the ties before they are removed from the roadbed.
D. Give the ties a final inspection before they are removed from the roadbed.

Weight

3 18. Tangent track requires four spikes per tie while curved track requires:

A. 6.
B. 8.
C. 10.
D. 12.

3 19. On a single track running north and south, the line rail would be on the ______________ side.

A. East.
B. West.
C. Southeast.
D. Southwest.

LESSON ASSIGNMENT SHEET

TRANS SUBCOURSE 671..	Railway Track Maintenance .
LESSON 2	Turnouts and Special Switches.
CREDIT HOURS..	3.
TEXT ASSIGNMENT..	Reference Text 671, pars. 2.1 - 2.37.
MATERIALS REQUIRED...	None.
LESSON OBJECTIVE...	To enable you to describe the function, components, design, location, construction, and maintenance of various types of turnouts.
SUGGESTIONS...	None.

EXERCISES

Weight		**True-False**
		Put a "T" for true and an "F" for false.
2	1.	In a track crossing, the wider the crossing angle the wider the flangeway openings.
2	2.	A derail frog may be substituted for a manganese steel frog.
2	3.	To construct a gantlet track, you need two sets of derail frogs.
2	4.	To divert traffic easily, turnouts are located on curves when possible.

Weight **Cluster True-False**

(Each question of-this kind consists of a series of statements related to a stem that precedes them. Indicate which are true and which false with respect to the stem,)

5. A frog is installed in a turnout so that a train's wheels and wheel flanges can cross the rails. It is true of a frog that:

1 a. While the wing rail of a spring frog is being held open by spring tension, the train can follow the alternate path through the frog.

1 b. The bolted-rigid type may be made from standard rail.

I c. When a train passes over its actual point, the wheel is unsupported.

1 d. Its theoretical and actual points are between its heel and throat.

1 e. A train never reaches it when a trailing-point move is made.

6. Concerning switch-throwing arrangements, it is true that:

1 a. Yard turnouts are controlled by electric switches located in the yardmaster's office.

1 b. A manually operated switch stand may be kept locked to keep anyone from throwing it accidentally.

1 c. An electrical switch-control system is operated by remote control.

1 d. A manually operated switch stand includes a target to show which way the switch is lined.

1 e. Split switches are unequipped with throwing mechanisms.

7. In choosing where to locate a turnout, you would determine the:

1 a. Speed at which trains should be able to pass through it.

Weight		
1		b. Type of electrical track circuits used.
1		c. Type of rolling stock that would use it.
1		d. Space available for its installation.
1		e. Condition and type of ballast at the proposed location.
	8.	If you found a badly chipped frog point while inspecting track, you might:
1		a. Have to replace some spike-killed ties.
1		b. Relocate and regage the running rails, the guard rails, or both.
1		c. Suspect that the switch points are lower than the stock rails.
1		d. Have a welder build up the damaged point to its normal size.
1		e. Adjust the rods on the switch-throwing mechanism.
	9.	A stub switch differs from a split switch in that:
		a. It needs no moving parts.
1		b. Its switch rails are unspiked.
1		c. It needs no frog.
1		d. Maintaining its alinement is difficult.
1		e. Both main-line rails move.
	10.	Main lines in the United States seldom use stub switches because:
1		a. Split switches are preferred.
1		b. They are expensive to install.
1		c. The alinement of the rails is difficult to maintain.

Weight

d. They frequently cause derailments.

1 e. They may jam in one position.

Completion

1* 11. Given below is a list of terms from which selections are to be made to complete the description of the installation of a turnout which follows. Write the proper letter in the numbered blank.

A. Guard rails.
B. Toe and heel.
C. Frog and straight running rail.
D. Frog, straight closure rail, and switch rail.
E. Switch ties and ballast.
F. Movable points.
G. Theoretical PF.
H. Bent stock rail.

NOTE: The point of frog (PF) and the point of switch (PS) have been located on the ground.

Take out the old rails, ballast, and ties from between the PF and PS, after which you are to install the ___(1)___. Next, you place and spike the straight stock rail and position and loosely spike the ___(2)___. Then comes the assembly of the ___(3)___ after which that assembly is gaged and spiked. The PS is then lightly spiked in place and the curved closure rail and turnout point of switch permanently spiked. Gaging and spiking the bent stock rail and assembling and spiking the ___(4)___ follow. When the switch points have been connected with the switch rods and the switch stand installed, the turnout is complete.

12. Listed below are words to be used in completing the statements on turnouts that follow. Choose the word or group of words that best completes each statement.

---

* 1 point for each choice.

Weight

A. Slip switch.	G. Toe.
B. Crossover.	H. Switch plate.
C. Spring switch.	I. Gantlet track.
D. Switch rail.	J. Movable-point frog.
E. Heel block.	K. Switch point.
F. Straight closure rail.	L. Through rail.

2 (1) Two turnouts connecting parallel tracks are known as a ________________.

2 (2) The type of switch that is specially designed for a particular location is a ______________.

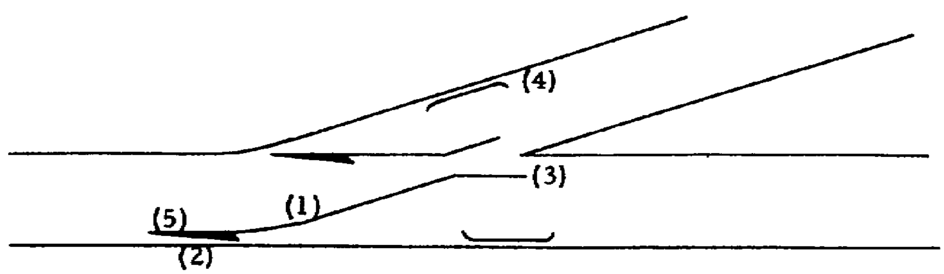
2 (3) The straight stock rail is also called the _____________.

2 (4) Stock rails are supported by rail braces attached to the _________________.

Matching

5* 13. The diagram in column I shows a split switch turnout with certain parts numbered. Their functions are listed in column II. Match the part with the function. Choices in column II may be used once, more than once, or not at all.

Column I



Column II

A. Provides bearing surface for switch ties.

*1 point for each choice

Weight

Column II (contd.)

B. Diverts flanges of facing movement trains to turnout.

C. Separates switch rail from stock rail.

D. Connects switch rail and frog.

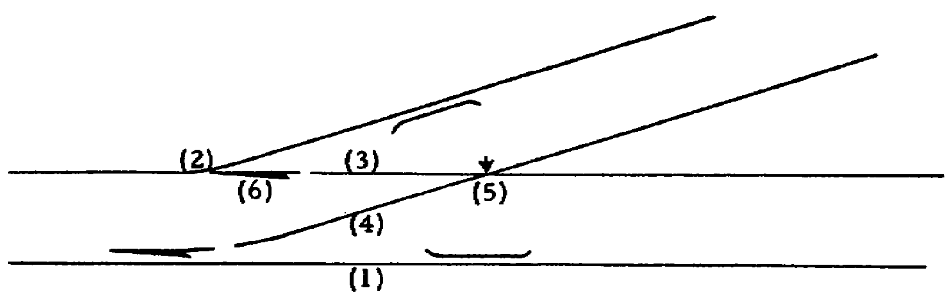
E. Protects frog point from being struck by flanges.

F. Provides opening opposing rails for flanges to pass through.

G. Provides bearing surface for switch point.

6* 14. The names of the parts of a turnout are given in column II. Match those lettered terms to the numbered parts of the turnout shown in the diagram in column I. (Choices in column II may be used once, more than once, or not at all.)

Column I



Column II

A. Straight stock rail.

B. Frog.

C. Guard rail.

D. Curved closure rail.

E. Bent stock rail.

F. Straight closure rail.

G. Switch point.

*1 point for each choice.

Weight	**Multiple Choice**
	(Each question in this group contains one and only one correct answer.)

3 15. To prevent a cut of cars descending on a spur toward a main line from colliding with a through train, a _______________ is installed.

A. Derail.
B. Track crossing.
C. Slip switch.
D. Spring switch.

3 16. "Puzzle switch" is a popular name for a _____________________ switch.

A. Split-point.
B. Slip.
C. Spring.
D. Stub.

3 17. When other types of track bumpers are unobtainable, you may use __________________ as an expedient.

A. Magnetic switches.
B. Manganese frogs.
C. Timbers.
D. Sawhorses.

3 18. Switch plates are used under switch rails instead of ________________________ plates.

A. Magnetic.
B. Spring.
C. Tie.
D. Planed.

3 19. A No. 20 frog is used in a certain turnout. The distance between the theoretical and actual points of the frog is _____________________ inches.

A. 20.
B. 15.
C. 10.
D. 5.

Weight

3 20. The rails connected by switch rods so that they may be moved simultaneously are called____________________ rails.

A Closure.
B. Switch-throwing.
C. Stock.
D. Switch.

3 21. When preparing to install a turnout, the foreman must:

A. Arrange to have the engineers set the grade stakes.
B. Have all rails cut to the correct lengths.
C. Prepare the track chart.
D. Restrict traffic with sawhorses.

3 22. In the turnout pictured in figure 2.14 of your text, there are _________________ switch ties.

A. 18.
B. 24.
C. 26.
D. 28.

3 23. In a turnout, rail braces support the:

A. Stock rails.
B. Switch rails.
C. Curved closure rail.
D. Straight closure rail.

3 24. For a train to make a trailing movement through a turnout regardless of the direction for which it is lined, there must be a ____________________ switch installed in it.

A. Derail.
B. Stub.
C. Interlocking.
D. Spring.

3 25. For one single track crossing another, you need __________________ frogs.

A. 4.
B. 5.

C. 6.
D. 7.

3 26. Yard turnouts are usually sharp because of the:

A. Interlocking system.
B. Space restrictions.
C. Puzzle switches needed.
D. Height limitations.

3 27. What is the minimum frog number and minimum length switch rails which could be used in a turnout designed for speeds of 35 miles an hour?

A. Frog No. 20, switch rail length 30 feet.
B. Frog No. 10, switch rail length 20 feet.
C. Frog No. 8, switch rail length 18 feet.
D. Frog No. 8, switch rail length 20 feet.

LESSON ASSIGNMENT SHEET

TRANS SUBCOURSE 671...	Railway Track Maintenance II.
LESSON 3...	Curves.
CREDIT HOURS..	3.
TEXT ASSIGNMENT..	Reference Text 671, pars. 3.1 - 3.32, annex A, sheets 1 and 2.
MATERIALS REQUIRED...	None.
LESSON OBJECTIVE	To enable you to identify the design, function, and characteristics of the various types of railroad curves; and to explain the method employed in stringlining them when they get out of line.
SUGGESTIONS..	None.

EXERCISES

Weight		**True-False**
		Put a "T" for true and an "F" for false.
2	1.	The sharpness of a curve depends upon the length of its radius.
2	2.	A locomotive with a long, rigid wheelbase may have difficulty going around sharp curves.
2	3.	A reverse curve may consist of two simple curves.
2	4.	Elevation may be gained by using a curve.
2	5.	Trains approaching spiral curves at low speeds require longer spirals than at high speeds.

Weight	Cluster True-False

(Each question of this kind consists of a series of statements related to the stem that precedes them. Indicate which are true and which false with respect to the stem.)

Put a "T" for true and an "F" for false.

6. A spiraled curve is so designed that:

2 a. Its length depends on the superelevation of the circular curve.

2 b. In a theater, a newly constructed railway curve of 2 degrees or less should not include spirals.

2 c. A short one can be approached safely by a high-speed train.

2 d. The increased superelevation to which the train is subjected per second is considered.

2 e. A curve with the greatest superelevation will need the shortest spiral.

7. Highway engineers bank a curve to compensate for inertia; railway engineers use superelevation. Of the following, which is true and which is false of superelevation?

3 a. It is more of a problem on single track than on double track.

3 b. Four inches should be the maximum ever used on a military railroad.

3 c. If the maximum is used and is insufficient for expected speeds, speed limits have to be increased.

3 d. When a train rounds a curve at the correct speed for the equilibrium superelevation, the wheels should bear evenly on the high and low rails.

3 e. When the correct speed for the equilibrium superelevation is exceeded, a greater force bears on the high rail.

Weight

8. Railway curves are needed to change the direction of rail lines. It is true of such curvature that:

2 a. A throw on a curve at a restricted clearance must be limited to +3.

2 b. If a curve is installed on a grade, it increases the capabilities of locomotives.

2 c. Grade reduction on curves should be planned by engineers.

2 d. The sharper a curve is, the more resistance to movement a locomotive will have.

2 e. When a curve is out of line, its superelevation is unaffected.

9. A spiraled curve is built between a tangent and a circular curve. Of spiraled curves, it is true that they:

3 a. Are called easements because of their function.

3 b. Provide correct superelevation needed without suddenly altering the track's banking.

3 c. Differ from circular curves in that their curvature is constant throughout their length.

3 d. Become sharper where they join tangents.

3 e. Can be designed by most section foremen.

Matching

10. Several abbreviations are helpful to the stringlining crew when recording data and marking points in the field. Match the meanings of the abbreviations listed in column II with the abbreviations given in column I.

Choices in column II may be used once, more than once, or not at all.

Weight

	Column I	**Column II**
1	(1) CT.	A. Tangent to curve.
1	(2) SC.	B. Curve to center.
1	(3) CS.	C. Spiral to curve.
1	(4) TC	D. Curve ends-tangent begins.
1	(5) TS.	E. Point of curvature.
1	(6) ST.	F. Tangent ends-spiral begins.
		G. Curve to spiral.
		H. Spiral ends-tangent begins.
		I. Center to tangent.

Multiple - Choice

(Each of the following questions has one and only one correct answer.)

2 11. A curve has been stringlined and staked using an imaginary line 12 inches from the base of the high rail. If the stakes ranged from 12 1/2 to 14 1/2 inches from the outside rail before throwing; it would show that:

A. The finished curve would fail to provide smooth riding.
B. All the throws were minus.
C. All the ordinates were plus.
D. A mistake had obviously been made in the calculations.

2 12. An ordinate may also be called an:

A. Offset.
B. Error at a station.
C. Error at a marked point.
D. Easement.

Weight

2 13. A dogleg may be described as one or more of the following: (1) a reverse bend, (2) a full throw at a station, (3) a negative ordinate, (4) a half throw at a station.

A. Only (1) and (2).
B. All but (4).
C. Only (1) and (3).
D. All but (3).

2 14. When adjusting the proposed ordinates for the actual curve described in the text to make the final throw a zero, those at stations 4 and 18 were adjusted. Another pair of stations that could have been used is stations:

A. 3 and 24.
B. 5 and 13.
C. 6 and 20.
D. 10 and 26.

2 15. On sheet 1 of annex A, Sta. 2 reads "+5," which means the measured ordinate is:

A. 5/8 of an inch.
B. 5 inches.
C. 5/8 of a foot.
D. 5 feet.

2 16. You have measured the ordinates and calculated the throws for a 72-station curve, and you find that the last half throw is +4. The best way to correct this is to:

A. Add 1 to the ordinate at station 44 and subtract 1 at station 48.
B. Add 1 to the ordinate at station 27 and subtract 1 at station 29.
C. Add 2 to the ordinate at station 65 and subtract 2 at station 67.
D. Subtract 1 from the ordinate at station 36 and add 1 at station 40.

Weight

2 17. Among the preferred equipment when laying out stations in the field is a ruler that measures in ______________________ of an inch.

A. Fourths.
B. Eighths.
C. Twelfths.
D. Sixteenths.

2 18. When marking or staking track in lining a curve, it is true that:

A. A scratch board is useful for marking a single track.
B. Once the stakes are set, the track gang can wait as long as 6 months before throwing the track.
C. Line stakes should be driven soon after the curve is measured.
D. Line stakes are driven on the right of way but outside the ballast section to avoid disturbing it.

2 19. When laying off stations in the field, you divide a curve into _______________ foot lengths.

A. 21.
B. 31.
C. 46.
D. 62.

2 20. Generally speaking, full track throws should not exceed _______________ inches.

A. 6.
B. 8.
C. 10.
D. 12.

2 21. Which of the following statements is true regarding the lining of railway curves?

A. Curves are almost always lined by using surveying equipment.
B. A simple curve may be lined properly by eye.

C. Proper lining is determined by a method called stringlining.
D. Train traffic is unaffected by curved track alinement.

2 22. The sum of the proposed ordinates must equal:

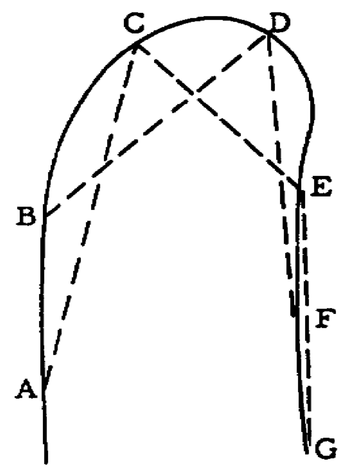
A. The number of stations measured.
B. The sum of the measured ordinates.
C. The number of doglegs.
D. The number of easement curves.

2 23. Actual track throws should be kept as small as possible because:

A. Large ones allow more room for error.
B. They result in less rail wear.
C. They increase riding comfort.
D. Short throws are physically easier to make.

SITUATION

A portion of a spiraled curve is shown in the diagram at the right. Note that the stations are indicated by letters rather than by consecutive numbers.



REQUIREMENT

Answer the next four multiple-choice questions on the basis of the diagram.

2 24. If the ordinate at point C measures 1 1/2 inches, you would record it in your logbook as:

A. -12.
B. 12/24.
C. 12/3.
D. +12.

Weight

2 25. To measure the ordinate at B, two men would stretch the string between points:

A. C and A.
B. D and C.
C. B and A.
D. B and G.

2 26. If the throw at point D were a positive number, it would mean that the track must be moved:

A. Downward.
B. Outward.
C. Forward.
D. Inward.

2 27. The dotted line between points E and G indicates a ___________________ ordinate.

A. Positive.
B. Negative.
C. Zero.
D. Ten percent.

LESSON ASSIGNMENT SHEET

TRANS SUBCOURSE 671..	Railway Track Maintenance II.
LESSON 4...	Highway Grade Crossings, Guard Rails, and Seasonal Maintenance.
CREDIT HOURS..	2.
TEXT ASSIGNMENT...	Reference Text 671, pars. 4.1 - 4.23.
MATERIALS REQUIRED..	None.
LESSON OBJECTIVE..	To enable you to explain the function, design, and maintenance of highway grade crossings and guard rails; and to identify the more important problems of seasonal maintenance.
SUGGESTIONS...	None.

EXERCISES

Weight **True-False**

Put a "T" for true and an "F" for false.

Weight		
3	1.	Wedge-shaped pusher-type snowplows are designed for removing medium-sized drifts from double-track lines.
3	2.	Braces are spiked to the head of the rail when shims are installed.
3	3.	Eighty-five pound guard rails are suitable for use where 100-pound traffic rail is used.
3	4.	When highway crossings are renewed, the crossties under the highway material should also be replaced.

Weight	Cluster True-False

(Each question of this kind consists of a series of statements related to the stem that precedes them. Indicate which are true and which false with respect to the stem

5. Grade crossings are often the site of numerous motor vehicle accidents. It is also true of such crossings that they:

3 a. Necessitate the use of immovable paving material.

3 b. Require deeper flangeways when constructed on 8-degree curves.

3 c. Are more popular now than 50 years ago.

3 d. Are built with sand between the tracks.

3 e. Can be the cause of derailments.

3 f. Are the source of numerous maintenance difficulties.

6. To help keep heaved track usable in winter, some of the remedies are:

2 a. Installing electric or gas heaters.

2 b. Installing track shims.

2 c. Removing the tie plates.

2 d. Removing ballast at high spots.

2 e. Treating ballast with salt water.

7. The Corps of Engineers is to construct a highway grade crossing in your territory. Which of the following specifications would you attempt to have included in the construction? That:

2 a. The crossing be constructed of durable material that cannot easily be torn up.

2 b. No rail joints occur within the limits of the crossing.

Weight

2 c. The flangeways be at least 2 1/2 inches deep.

2 d. Flangeways be no wider than 2 inches.

2 e. The highway cross the tracks on a tangent.

8. It is up to you to decide where guard rails should be located. You recommend that they be installed:

2 a. On a main-line track passing a station platform on an extremely sharp curve.

2 b. On an open-floor deck bridge 30 feet long carrying two yard tracks around a 5-degree curve.

2 c. On a siding which narrowly clears a warehouse wall.

2 d. At the entrance to a 3,500-foot tunnel approached on a 1-degree curve.

2 e. In a through cut on a high-speed main line which makes a 2-degree curve.

9. Excessive weed growth may result in:

2 a. Loss of surface.

2 b. Rotted ties.

2 c. Decreased drainage.

2 d. Slope erosion.

2 e. Ballast contamination.

10. Proper precautions or maintenance techniques to be followed in winter are to:

2 a. Remove ballast from cribs under switch points.

2 b. Remove ice from flangeways in turnout frogs with a salt-water solution.

2 c. Tamp heaved track to correct its poor surface.

Weight

2 d. Prepare and install snow-melting pots.

2 e. Use flangers to clear the drainage ditches.

11. Snow fences are used to protect certain sections of the railroad from hazardous snow conditions. It is true of snow fences that they:

2 a. Provide protection from snow slides.

2 b. Reduce wind velocity causing the snow to be dropped before it reaches the track.

2 c. Keep snowdrifts off the track.

2 d. Are set up at the ends of the crossties.

2 e. Are located on the side of the track from which the prevailing wind blows.

Multiple- Choice

(Each question in this group contains one and only one correct answer.)

2 12. The term frozen joint indicates that:

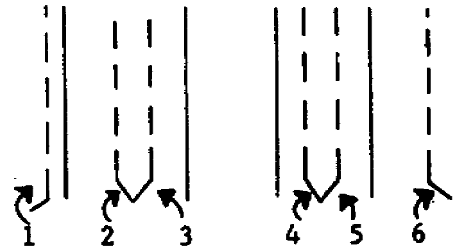
A. Rail expansion there is impossible.
B. Joint lubrication is lacking.
C. The joint is improperly insulated.
D. Buckling of the rail is unlikely.

2 13. When preparing to remove a snowslide, you recall that:

A. Snowplows cannot be used.
B. The spreader plow is the most suitable one to use.
C. Flangers are used first, followed by spreader plows.
D. The rotary plow is the most suitable one to use.

Weight

2 14. The broken lines on the accompanying diagram indicate the guard rails on a two-track main line (solid lines) as it enters an open-floor deck bridge. Which of the guard rails are necessary?



A. 1 and 3.
B. 1 and 6.
C. 3 and 4.
D. 2 and 5.

2 15. Ice in poorly drained tunnels creates a problem because it causes:

A. Derailments.
B. Rails to buckle.
C. Corroded flangeways.
D. Excessive weed growth the next summer.

2 16. The season during which limited visibility is a serious safety hazard for the track maintenance crew is:

A. Summer.
B. Winter.
C. Fall.
D. Spring.

LESSON ASSIGNMENT SHEET

TRANS SUBCOURSE 671...	Railway Track Maintenance II.
LESSON 5..	Special Problems and Maintenance-of-Way Management.
CREDIT HOURS..	2.
TEXT ASSIGNMENT..	Reference Text 671, pars. 5.1 - 5.24; annexes B and C.
MATERIALS REQUIRED..	None.
LESSON OBJECTIVE..	To enable you to identify special maintenance problems and to describe certain principles of maintenance-of-way management.
SUGGESTIONS..	None.

EXERCISES

Weight		**True-False**
		Put a "T" for true and an "F" for false.
2	1.	Third rails often carry alternating current at voltages as high as 11,000 volts.
2	2.	An interlocking plant is so designed that its control mechanism can be operated to set up opposing movements.
2	3.	It is twice as difficult to maintain a two-track main line as it is a single-track one.
2	4.	Before work can begin near high-voltage overhead wires, they must be disconnected from the power source and grounded.

Weight	Cluster True-False

(Each question of this kind consists of a series of statements related to the stem that precedes them. Indicate which are true and which false with respect to the stem.)

5. From your study of the destruction of rail facilities in a theater, you learned that:

3 a. The roadbed can seldom be hurt by sudden flooding.

3 b. Destruction by fire is limited to the use of volatile liquids.

3 c. A 20-second fuse was attached to a tie-ripper charge.

3 d. The tie ripper dropped a heavier charge than that which is recommended for spot destruction of rail.

3 e. Water-impact damage may take longer to repair than that created by the demolition of several turnouts.

6. The track supervisor should call for assistance from personnel of other platoons when:

3 a. Spot surfacing under overhead electrification.

3 b. Lining track in third-rail electrified territory.

3 c. Cleaning ballast in an interlocking plant.

3 d. Surfacing track over a ballasted-deck bridge.

3 e. Surfacing track over an open-floor bridge.

7. The trackage in section 2 on the track chart in annex C has:

3 a. 115-pound RE rail throughout the length of the westbound main.

3 b. T. H. Wells as the section foreman.

3 c. Crushed slag and crushed stone ballast on eastbound main.

Weight

3 d. A curve of 1 degree 5 minutes.

3 e. 115-pound RE rail on the siding between KMP's 73-75.

8. When destroying track by explosives, it is true that:

3 a. Switches are best destroyed by placing explosives at the points.

3 b. The charges should always be tamped.

3 c. One-pound charges will usually break the web of rails.

3 d. The track crew may advise the demolition crew where to place charges.

3 e. A frog should be destroyed by placing a charge in the heel.

Multiple Choice

(Each of the following questions has one and only one correct answer.)

2. 9. Three persons are primarily responsible for maintaining the track of a military rail division. What is the correct order of the levels of responsibility from highest to lowest?

A. Maintenance-of-way superintendent, track supervisor, section foreman.
B. Track supervisor, section foreman, maintenance-of-way superintendent.
C. Track supervisor, maintenance-of-way superintendent, section foreman.
D. Section foreman, maintenance-of-way superintendent, track supervisor.

2 10. A shoo-fly may also be called a _________________ track.

A. Catenary.
B. Puzzle.
C. Compromise.
D. Bypass.

Weight

2 11. The Corps of Engineers is responsible for:

A. Minor track maintenance.
B. New railway construction.
C. All track maintenance.
D. Demolition of the enemy's rail facilities.

2 12. Track can be surfaced on open-floor bridges by:

A. Jacking.
B. Tamping.
C. Changing individual tie sizes.
D. Grading.

2 13. When compared with the track maintenance on ballasted-deck bridges, that done on open-floor ones is:

A. Less complex.
B. Less expensive.
C. More often necessary.
D. More difficult.

2 14. Track should not be raised in tunnels or under bridges without proper authority from higher headquarters because:

A. Clearance might be reduced to below an established minimum and result in endangering train movement.
B. Proper lining might be destroyed.
C. Track maintenance personnel might be placed in danger.
D. The supervisor must have the division engineer's permission before any maintenance work begins.

2 15. Among the characteristics that make a ballasted-deck bridge superior to an open-deck one are its:

A. Low cost of construction.
B. Ease of conversion to a highway bridge.
C. Ease of track surfacing.
D. Greater capacity.

Weight

2 16. On a track chart, you can usually find the:

A. Arrangement of tracks.
B. Width of right of way.
C. Type of guard rails used.
D. Name of division trainmaster.

2 17. Based on the information in table VII of the text, the effort and skill required to maintain a kilometer of branch-line track when compared with that needed to maintain a railroad crossing is approximately ______________________ times more.

A. 6.
B. 5.
C. 4.
D. 3.

2 18. The extent to which rail facilities should be destroyed is governed by:

A. The train density of the rail division.
B. Whether single or double track.
C. Whether a specially trained demolition crew is available.
D. The time element and the future need for them.

2 19. If you are told that a certain oversea rail yard is used by equipment requiring 56 1/2-inch gage track and by some requiring 66-inch, you know that you will find _____________ there.

A. Metered rail.
B. Three-rail track.
C. Catenary rail.
D. Compromise rail.

2 20. The progress made in completing a subdivision's work program may be entered on a/an:

A. Gradient record.
B. Rail re-lay graph.
C. Track chart.
D. Alinement diagram.

Weight		**Analytical**

Using the following key, mark your reaction to each of the statements.

A. The underscored statement is true, and the reason for it or the result of it is true.

B. The underscored statement is true, but the reason or result is false.

C. The underscored statement is false.

2	21.	<u>If both tie renewal and rail re-lay are programmed, the tie renewal should follow the rail re-lay</u>, because this sequence gives the ties a longer life span.
2	22.	<u>Final track surfacing should be completed in the summer months</u> because heavy autumn rains usually prevent such track work.
2	23.	<u>Spring is the best season in which to remove shims from heaved track</u> because it is the period in which the greatest track-work activity is scheduled.
2	24.	<u>The quality of a railway subdivision's maintenance can be likened to the old saying, "A chain is only as strong as its weakest link,</u>" because the degree of quality attained can only be as good as the poorest stretch of track in the subdivision.

CORRESPONDENCE COURSE OF THE
U. S. ARMY TRANSPORTATION SCHOOL
SOLUTIONS

TRANS SUBCOURSE 671..Railway Track Maintenance II.

(All references are to Reference Text 671.)

LESSON 1

Weight	Exercise				Weight				
2	1.	F.	(par. 1.4)		2		b.	T.	(par. 1.22)
2	2.	T.	(par. 1.2)		2		c.	F.	(par. 1.22)
2	3.	T.	(par. 1.4)		2		d.	T.	(par. 1.22)
2	4.	F.	(pars. 1.12, 1.13)		2		e.	F.	(par. 1.22)
2	5.	a.	F.	(par. 1.9)	2	8.	a.	F.	(par. 1.8)
2		b.	T.	(par. 1.9)	2		b.	F.	(par. 1.8)
2		c.	T.	(par. 1.9)	2		c.	F.	(par. 1.8)
2		d.	T.	(par. 1.5)	2		d.	T.	(par. 1.8)
2		e.	F.	(par. 1.5)	2		e.	T.	(par. 1.8)
2	6.	a.	F.	(par. 1.16)	2	9.	a.	T.	(par. 1.5)
2		b.	T.	(par. 1.4)	2		b.	F.	(par. 1.5)
2		c.	F.	(par. 1.22)	2		c.	T.	(par. 1.5)
2		d.	F.	(par. 1.15)	2		d.	T.	(par. 1.5)
2		e.	F.	(par. 1.14)	2		e.	T.	(par. 1.5)
2	7.	a.	F.	(par. 1.22)	2	10.	a.	T.	(par. 1.10)

All concerned will be careful that neither this solution nor information concerning the same comes into the possession of students or prospective students who have not completed the work to which it pertains.

FEBRUARY 1971

Weight	Exercise				Weight	Exercise			
2		b.	T.	(par. 1.10)	1		(7)	B.	(par. 1.15c)
2		c.	T.	(par. 1.10)	1		(8)	J.	(par. 1.15d)
2		d.	F.	(par. 1.10)	3	12.	B.	(par. 1.24)	
2		e.	T.	(par. 1.10)	3	13.	C.	(par. 1.21)	
1	11.	(1)	F.	(par. 1.15a)	3	14.	B.	(par. 1.9)	
1		(2)	A.	(par. 1.15a)	3	15.	D.	(par. 1.26a)	
1		(3)	I.	(par. 1.15b)	3	16.	A.	(par. 1.27)	
1		(4)	K.	(par. 1.15b)	3	17.	C.	(par. 1.20)	
1		(5)	E.	(par. 1.15b)	3	18.	A.	(par. 1.25)	
1		(6)	G.	(par. 1.15b)	3	19.	A.	(par. 1.23)	

LESSON 2

Weight	Exercise				Weight	Exercise			
2	1.	T.	(par. 2.33)		1	6.	a.	F.	(par. 2.14)
2	2.	F.	(pars. 2.5b, 2.32)		1		b.	T.	(par. 2.11a)
2	3.	F.	(pars. 2.32, 2.35)		1		c.	T.	(par. 2.11a)
2	4.	F.	(par. 2.19)		1		d.	T.	(par. 2.11a)
1	5.	a.	T.	(par. 2.5a)	1		e.	F.	(par. 2.4b)
1		b.	T.	(par. 2.5b)	1	7.	a.	T.	(par. 2.13)
1		c.	F.	(par. 2.6)	1		b.	F.	(par. 2.13)
1		d.	T.	(par. 2.5; fig. 2.6)	1		c.	T.	(par. 2.13)
1		e.	F.	(par. 2.7)	1		d.	T.	(par. 2.13)
					1		e.	F.	(par. 2.13)

Weight	Exercise			
1	8.	a.	T.	(par. 2.25)
1		b.	T.	(par. 2.25)
1		c.	F.	(par. 2.25)
1		d.	T.	(par. 2.25)
		e.	F.	(par. 2.25)
1	9.	a.	F.	(par. 2.4a)
1		b.	T.	(par. 2.4a)
1		c.	F.	(par. 2.3a; fig. 2.2)
1		d.	T.	(par. 2.4a)
1		e.	T.	(par. 2.4a)
1	10.	a.	T.	(par. 2.4b)
1		b.	F.	(par. 2.4a)
1		c.	T.	(par. 2.4a)
1		d.	T.	(par. 2.30)
1		e.	T.	(par. 2.30)
1	11.	(1)	E.	(par. 2.22, fig. 2.18)
1		(2)	H.	(par. 2.22, fig. 2.18)
1		(3)	D.	(par. 2.22, fig. 2.18)
1		(4)	A.	(par. 2.22; fig. 2.18)

Weight	Exercise			
2	12.	(1)	B.	(par. 2.15a)
2		(2)	A.	(par. 2.34)
2		(3)	L.	(par. 2.8c)
2		(4)	H.	(par. 2.9)
1	13.	(1)	D.	(pars. 2.3, 2.8b) (closure or lead rail)
1		(2)	G.	(pars. 2.3, 2.8c) (stock rail)
1		(3)	F.	(pars. 2.3, 2.5) (Frog)
1		(4)	E.	(pars. 2.3, 2.8a) (Guard Rail)
1		(5)	B.	(par. 2.3, 2.7) (Switch Point)
1	14.	(1)	A.	(pars. 2.3, 2.8c)
1		(2)	E.	(pars. 2.3, 2.8c)
1		(3)	F.	(pars. 2.3, 2.8b)
1		(4)	D.	(pars. 2.3, 2.8b)
1		(5)	B.	(pars. 2.3, 2.5)
1		(6)	G.	(par. 2.3)
3	15.	A.		(par. 2.32)
3	16.	B.		(par. 2.34)
3	17.	C.		(par. 2.36)

Weight	Exercise	Weight	Exercise
3	18. C. (par. 2.9)	3	23. A. (par. 2.9)
3	19. C. (par. 2.5)	3	24. D. (par. 2.31)
3	20. D. (par. 2.8b)	3	25. A. (par. 2.33)
3	21. B. (par. 2.20)	3	26. B. (par. 2.14)
3	22. C. (par. 2.10; fig. 2.14) There are 26 switch ties. They extend from point B to point C.	3	27. A. (par. 2.16; table I)

LESSON 3

Weight	Exercise	Weight	Exercise
2	1. T. (par. 3.5)	3	c. F. (par. 3.10)
2	2. T. (par. 3.4)	3	d. T. (par. 3.8)
2	3. T. (par. 3.3)	3	e. T. (par. 3.8)
2	4. T. (par. 3.2)	2	8. a. F. (par. 3.25)
2	5. F. (par. 3.14)	2	b. F. (par. 3.4)
2	6. a. T. (par. 3.14)	2	c. T. (par. 3.4)
2	b. T. (par. 3.14)	2	d. T. (par. 3.4)
2	c. F. (par. 3.14)	2	e. F. (par. 3.31)
2	d. T. (par. 3.14)	3	9. a. T. (par. 3.13)
2	e. F. (par. 3.14)	3	b. T. (par. 3.13)
3	7 a. T. (par. 3.9)	3	c. F. (par. 3.13)
3	b. T. (par. 3.10)	3	d. F. (par. 3.12)

Weight	Exercise
3	e. F. (par. 3.14)
1	10. (1) D. (par. 3.23)
1	(2) C. (par. 3.23)
1	(3) G. (par. 3.23)
1	(4) A. (par. 3.23)
1	(5) F. (par. 3.23)
1	(6) H. (par. 3.23)
2	11. B. (par. 3.30a(2))
	When the throw is minus, it is added to 12, the number of inches the stake was driven from the base of the high rail. When the throw is plus, it is subtracted from 12.
2	12. A. (par. 3.17)
2	13. C. (par. 3.21b)
2	14. C. (par. 3.24; fig. 3.6)
2	15. A. (par. 3.20; annex A, sheet 1)

Weight	Exercise
2	16. A. (par. 3.24)
	Choice A is correct because the stations given are four numbers apart. In applying rule (2) in par. 3.24, you add 1 to the ordinate of the earlier station (44) and subtract 1 from the ordinate of the later station (48).
2	17. B. (par. 3.18)
2	18. C. (par. 3.30)
2	19. B. (par. 3.19)
2	20. A. (par. 3.28b)
2	21. C. (par. 3.16)
2	22. B. (par. 3.21c)
2	23. D. (par. 3.28b)
2	24. D. (par. 3.20)
	$1\ 1/2 = \frac{3}{2} = \frac{12}{8}$ which would be recorded in your logbook as +12.
2	25. A. (par. 3.20)
2	26. B. (par. 3.22)
2	27. B. (par. 3.21)

LESSON 4

Weight	Exercise			
3	1.	F.	(par. 4.15c)	
3	2.	F.	(par. 4.21b)	
3	3.	T.	(par. 4.9)	
3	4.	T.	(par. 4.4)	
3	5.	a.	F.	(par. 4.5)
3		b.	F.	(par. 4.3)
3		c.	F.	(par. 4.2)
3		d.	F.	(par. 4.3)
3		e.	T.	(par. 4.5)
3		f.	T.	(par. 4.2)
2	6	a.	F.	(par. 4.18b)
2		b.	T.	(par. 4.21b)
2		c.	T.	(par. 4.21a)
2		d.	T.	(par. 4.21a)
3		e.	T.	(par. 4.21a)
2	7.	a.	F.	(par. 4.5)
2		b.	T.	(par. 4.5)
2		c.	T.	(par. 4.3)
2		d.	F.	(par. 4.3)
2		e.	T.	(par. 4.5)
2	8.	a.	T.	(par. 4.8)

Weight	Exercise			
2		b.	T.	(par. 4.8)
2		c.	F.	(par. 4.8)
2		d.	T.	(par. 4.8)
2		e.	F.	(par. 4.8)
2	9.	a.	T.	(par. 4.12)
2		b.	T.	(par. 4.12)
2		c.	T.	(par. 4.12)
2		d.	F.	(par. 4.12)
2		e.	T.	(par. 4.12)
2	10.	a.	T.	(par. 4.18a)
2		b.	F.	(par. 4.19)
2		c.	F.	(par. 4.21)
2		d.	T.	(par. 4.18b)
2		e.	F.	(par. 4.15a)
2	11.	a.	F.	(par. 4.17b)
2		b.	T.	(par. 4.17a)
2		c.	T.	(par. 4.17a)
2		d.	F.	(par. 4.17a)
2		e.	T.	(par. 4.17a)
2	12	A.	(par. 4.13)	
2	13.	D.	(par. 4.16)	

Weight	Exercise		
2	14.	B.	(par. 4.8)
2	15.	A.	(par. 4.20)
2	16.	B.	(par. 4.22)

LESSON 5

Weight	Exercise			
2	1.	F.	(par. 5.7a)	
2	2.	F.	(par. 5.5)	
2	3.	F.	(par. 5.18)	
2	4.	T.	(par. 5.7b)	
3	5.	a.	F.	(par. 5.12b)
3		b.	F.	(par. 5.12a)
3		c.	T.	(par. 5.12c)
3		d.	T.	(pars. 5.11, 5.12c)
3		e.	T.	(par. 5.12b)
3	6.	a.	T.	(par. 5.7)
3		b.	T.	(par. 5.7)
3		c.	T.	(par. 5.5)
3		d.	F.	(par. 5.4)
3		e.	T.	(par. 5.4)
3	7.	a.	F.	(par. 5.17; annex C)
3		b.	F.	(par. 5.17; annex C)
3		c.	T.	(par. 5.17; annex C)
3		d.	T.	(par. 5.17; annex C)
3		e.	F.	(par. 5.17; annex C)
3	8.	a.	T.	(par. 5.11)
3		b.	F.	(par. 5.11)
3		c.	T.	(par. 5.11)
3		d.	T.	(par. 5.11)
3		e.	F.	(par. 5.11)
2	9.	A.	(par. 5.16b)	
2	10.	D.	(par. 5.10b)	
2	11.	B.	(par. 5.10)	
2	12.	C.	(par. 5.4)	
2	13.	D.	(par. 5.4)	
2	14.	A.	(par. 5.3)	
2	15.	C.	(par. 5.4)	
2	16.	A.	(par. 5.17)	

Weight	Exercise		
2	17.	B.	(par. 5.18; table VII)
2	18.	D.	(par. 5.13)
2	19.	B.	(par. 5.6)
2	20.	C.	(par. 5.23)
2	21.	A.	(par. 5.22b)
2	22.	C.	(par. 5.21d)
		Final surfacing should be completed in the fall before freezing weather.	
2	23.	B.	(par. 5.21b)
		Since shims are usually added during the winter months because of the crew's inability to correct low spots in the roadbed during freezing weather, spring would be the time to remove them. The greatest track-work activity is during the summer months.	
2	24.	A.	(par. 5.20)

Appendix I

REFERENCES

Army Regulations

AR 310-25	Dictionary of United States Army Terms
AR 310-50	Authorized Abbreviations and Brevity Codes

Field Manuals

FM 5-25	Explosives and Demolitions
FM 21-30	Military Symbols

Technical Manuals

TM 5-370	Railroad Construction
TM 5-627	Railway Track Maintenance; Repairs and Utilities
TM 55-204	Maintenance of Railroad Way and Structures.

Commercial Publications

Henry, Robert S., <u>This Fascinating Railroad Business</u>, Indianapolis, The Bobbs-Merrill Co., 1946.

Raymond, William G., Riggs, Henry E., and Sadler, Walter C., <u>Elements of Railroad Engineering</u>, New York, John Wiley & Sons, Inc., 1947.

Rench, Walter F., <u>Roadway and Track</u>, New York, Simmons-Boardman Publishing Corp., 1946.

Tratman, E. E. R., <u>Trackwork, and the Section Foreman</u>, Scranton, International Textbook Co., 1935.

Webb, Walter L., <u>Railroad Construction, Theory and Practice</u>, New York, John Wiley & Sons, Inc., 1944.

Appendix II

GLOSSARY

[Selected items from the glossary of Reference Text 670 are included in this one. The reader may find it helpful to consult that glossary for other terms pertinent to track maintenance not given here]

Adzing--cutting or planing a crosstie enough to provide a smooth, satisfactory seat for rail or tie plate.

Adzing machine--portable power-operated machine designed to refinish (adz) crossties to provide proper bearing for rails or tie plates.

Alinement--railroad's horizontal location or ground plan as distinguished from its profile; also the path the railroad follows.

Ballast--selected material placed on the roadbed to hold track in line and surface. Consists of hard particles easily handled in tamping, which distribute the load, drain well, and resist plant growth. Materials used include broken or crushed stone, gravel, slag, sand.

Ballast section--cross section of a track between and above the toes (lowest points) of the ballast slopes, whether or not this section includes subballast.

Ballast shoulder--that portion of ballast between the end of the tie and the toe (lowest point) of the ballast slope. It distributes the traffic load over a greater width of roadway and helps hold the track in alinement.

Ballast tamper--portable power-operated machine for compacting ballast under crossties.

Ballast tamping--compacting ballast under crossties to maintain the line and surface of track.

Batter--mashing of the surface of the rail's head close to the end of the rail.

Board, spot--See Spot board.

Bridge, ballasted-deck--bridge with a solid floor on which ballast and track structure are placed, to reproduce as nearly as possible an earthen roadbed.

Bridge, open-floor--bridge on which bridge ties, which see, form the principal part of the flooring. During an emergency, plank flooring can be installed, if 14-foot alternate ties are in place, for easy conversion to a highway bridge.

Bridge tie--sawed tie of the correct size and length for track on a bridge. Normally, 6 inches by 8 inches by 9 feet except alternate ties 14 feet long are used if emergency conversion to highway bridge is anticipated. *See* Bridge, open-floor.

Car, ballast--specially designed car for hauling and distributing ballast.

Car, motor--motor-driven railroad work or inspection car.

Catenary--curve formed by a cord or cable hanging freely from two fixed points or supports.

Catenary system--method of supporting a trolley wire horizontally by suspending it by messenger wires from a catenary.

Closure rail--lead rail connecting the heel of a switch with the toe of the frog.

Compensated curve--curve on an incline on which the percent of grade has been reduced to meet a train's resistance.

Crane, locomotive--self-propelled crane equipped with revolving boom and mounted on steel wheels to move over railroad track.

Crib--the ballast or open space between two adjacent crossties; also, a crisscross structure of logs, timber, concrete, or other members used to retain a fill or as a bridge support.

Crossing, grade--crossing or intersection of a railroad and a highway at the same level or grade.

Crossing, track--track structure installed where two tracks intersect at grade, consisting of four connected frogs, one for each rail intersection.

Crossing protection--arrangement of signaling devices designed to prevent accidents at grade crossings.

Crossover--two turnouts with the track connecting their frogs, arranged to form a passage between two nearby and, usually, parallel tracks.

Crosstie--*See* Tie.

Curvature, degree of--measure of the sharpness of a curve.

Curve, compound--alinement curve consisting of two or more simple curves (arcs of circles) with different radii. The curves join on common tangent points or common easement curves and lead in the same general direction, that is, to left or right.

Curve, easement--alinement curve that provides a gradual transition between a tangent and a simple curve or between two simple curves. Also called spiral.

Curve, reverse--alinement curve consisting of two simple curves (arcs of circles) which may or may not have the same radii. The curves join at a common tangent point or by a short tangent track or a reverse easement curve, and bear in opposite directions, that is, to left or right, or vice versa.

Curve, simple--alinement curve with uniform radii; an arc of a circle, usually described in terms of its degree of curvature.

Curved closure rail--length of outer curved rail in a turnout, from heel of switch to toe of frog.

Degree of curvature--*See* Curvature, degree of.

Derail--track safety device to guide locomotives and rolling stock off the rails at a selected spot, to protect against collisions or other accidents.

Drill, track--machine tool designed to operate horizontally to drill holes through webs of track rails, especially for track bolts.

Easement curve--*See* Curve, easement.

Electrified railway--railway on which the locomotives are powered by electricity supplied by a third rail or overhead trolley wire.

Expansion shim--spacer inserted between ends of abutting rails while track is being laid, to provide allowance for expansion of steel when temperature changes.

Facing-point--switch in which points face the normal direction of traffic.

Flange--projecting edge, rib, or rim on any object. Examples: on a rail, the base; on a car wheel, the inside rim which projects below the tread.

Flanger--snowplow designed to clear ice and snow from the inside of rails, to provide a clear passage for wheel flanges.

Flangeway--space between running rail and guard rail to provide clearance for passage of wheel flanges.

French drain--rock drain located higher than a drainage ditch to help in correcting water pockets.

Frog--device used where two running rails intersect, providing flangeways to permit wheels and wheel flanges on either rail to cross the other.

Frog, bolted-rigid--frog built entirely of rolled rails, with fillers between rails, and rigidly held together with bolts.

Frog, point of--(1) actual point of frog, or one-half inch point of frog, is the point at which the spread between gage lines is one-half inch. This is the standard width of any manufactured frog point except that of a solid manganese steel frog point except that of a solid manganese steel frog whichis five-eighths inch wide but can be converted to one-half inch. All measurements in laying out a turnout are made from the one-half inch point of frog. (2) Theoretical point of frog, the point of intersection of the gage lines, is at a distance from the one-half inch point equal, in inches, to one-half the frog number.

Frog, throat of--point at which the converging wings of a frog are closest together.

Frog angle--angle formed by intersecting gage lines of a frog.

Frog number--number to show the size of a frog. Common sizes are Nos. 8, 10, 15, and 20.

Frog point--that part of a frog lying between the gage lines, extending from their intersection to the heel end.

Gage of track--distance between gage lines of rails laid in track.

Gage rail--the line rail.

Gage rod--device for holding track to correct gage. Also called tie rod.

Gaging (of track)--bringing two rails into their correct relative positions as regards gage.

Gantlet track--convergence of double-track lines by using two frogs but no switch rails.

Grade--rate of rise or fall of the grade line, expressed as a percentage of length; feet of rise or fall per 100 feet of length. Also referred to as gradient.

Grade crossing--See Crossing, grade.

Grade line or grade--line on a profile representing top-of-rail elevations of track; also a series of staked elevations transferring this line to the ground or roadbed.

Grade rail--rail first surfaced to track elevation: the line rail on tangents, the inner rail on curves.

Guard rail--(1) rail laid parallel to and inside a running rail to prevent wheels from being derailed or to hold wheels in proper alinement and keep wheels on the other rail from striking the points of switches or frogs in turnouts or crossings. (2) An additional pair of rails laid parallel to and between the running rails of bridges and bridge approaches and at other critical locations, to keep derailed wheels on the ties and near the running rails.

Guard timbers--timbers, usually 6 by 8 inches, laid on bridge ties 8 to 10 inches outside each running rail on bridges and bolted to the ties, to maintain tie spacing and, in the event of derailment, to prevent ties from spreading and to hold wheels near the running rails.

Head block--pair of ties used to support the switch-point operating mechanism and the switch stand.

Head rod--switch rod nearest the point of a switch, usually placed between the two head-block ties.

Heaved track--term applied to track when proper surface is disturbed by frost or by expansion of water freezing in the roadbed.

Heel block (switch)--block which spans joints and fills the space between adjacent rails at the heel of a switch.

Heel length--distance between the heel end and half-inch point of a frog, measured along gage lines.

Heel of frog--end of the frog farthest from the switch.

Heel of switch--end of the switch rail farthest from the point of switch.

Heel spread (frog)--distance between gage lines at the heel end of a frog.

Heel spread (switch)--distance between gage lines at the heel of the switch rails.

Highway-crossing protection--See Crossing protection.

Interlocking--arrangement of signals, switch lock, and signal appliances so interconnected that their movements succeed each other in a predetermined order. It may be operated manually or automatically.

Jack, track--compound ratchet-lever jack which trips its load by a single operation, as distinguished from an automatic lowering jack which lets the load drop by successive stages.

Latch, switch stand--device for catching and holding the lever of a switch stand in position; also called a switch keeper. Two latches are used at each stand.

Lead, actual--length between the actual point of switch and the half-inch point of frog, measured on the line of the parent track.

Lead track--extended track connecting either end of a yard with the main track.

Level, cross--condition of a track in which the elevation of the rails is transversely equal.

Line--condition of track in regard to uniformity in direction over short distances on tangents, or uniformity in variation in direction over short distances on curves.

Line rail--rail on which alinement is based: the east rail of tangent track running north and south; the north rail of tangent track running east and west; the outer rail on curves.

Lining track--shifting the track laterally to conform to established alinement.

Main track--track extending through yards and between stations upon which trains are operated by timetable or train order or both, or the use of which is governed by block signals. Also called main line.

Number, turnout--number corresponding to the number of the frog used in a turnout.

Ordinate--distance measured from gage line or rail on a curve to the middle of a string drawn tautly and held in contact with gage line of rail at its ends. Forms a convenient way to measure detailed curvature and is used in adjusting curves, investigating accidents, and bending rails to a desired curvature. Also called middle ordinate or offset.

Parent track--track from which a turnout is constructed. A main track is the parent track to a passing track or spur; a ladder track is the parent track to yard tracks.

Passing track--track auxiliary to the main or parent track for meeting or passing trains.

Point of switch--point where the spread between the gage lines of the stock rail and the switch rail is sufficient to allow for the standard one-fourth inch width of switch point.

Profile--longitudinal section through a track that shows elevation and depression. Also, a drawing showing grade line of a railroad, usually obtained from levels taken on top of the rail.

Push snowplow--snowplow designed to shove snow to one or both sides of a track. Blade may be wedge shaped or sloped.

Rail, high--outer or elevated rail of curved track.

Rail, lead--See Closure rail.

Rail, low--inner rail of a curve which is maintained at grade while the opposite or outer rail is elevated.

Rail section--pattern or dimensional details of rail, such as width of base, height of rail, thickness of web, width and thickness of head, angle of head, and angle of base. Each particular pattern is identified by a brand name or symbol, such as ASCE, AREA, and ARA.

Right of way--land or water rights necessary for the roadbed and its accessories.

Rigid frog--bolted-rigid or stiff frog.

Roadbed--finished surface of roadway upon which track and ballast rest.

Roadbed shoulder--portion of subgrade lying between the ballast-covered portion and the ditch in cuts, and the top of slope on embankments. A roadbed shoulder not less than 18 inches wide should be maintained outside the toe, or lowest point, of the ballast slope.

Rod, operating--rod attached to a switch, derail, or other deivce, for moving it from one position to another.

Rotary snowplow--car with a bladed wheel on the front end set at right angles to track and driven by an engine on the car. It cuts the snow and discharges it to one side of track.

Running rail--rail or surface on which the wheel bears, as distinguished from a wing rail or guard rail.

Runoff (curve)--profile through which the superelevation of a curve is brought to the level of the tangent, or through which different elevations on a compound curve are connected.

Runoff (surface)--grade through which the raised portion of a track is connected with the old grade. Generally includes the two rails and is made at a long, easy slope for comfort and safety.

Scratch board--device with numbered notches on one end and a point on the other, used to mark the length of throw a track needs at a particular spot to correctly line track.

Section (of a railway)--portion of a rail division assigned to one of the six track maintenance sections in the two track maintenance platoons of a railway engineering company. The two platoons are responsible for maintaining 90 to 150 miles (144 to 240 kilometers) of railway.

Shim, track--See Track shim.

Shoo-fly track--bypass track.

Snow fence--structure erected to form artificial eddies on the windward side of a cut far enough to cause snow to be deposited between fence and cut. Examples: portable or permanent wood fence, a hedge, or a stone fence.

Snow melter--contrivance designed to prevent accumulation of snow and ice in tracks; sometimes a blowtorch held close to the snow, or a steam, electric, oil, or gas heater attached to the rails through the switch leads at interlockers or railroad crossings; sometimes chemicals poured or strewn along the tracks.

Snow shed--roofed structure built over tracks to protect traffic against snow blockades. Restricted to locations where snow encroaches seriously and cannot be handled with plows, usually in side hill cuts on mountain slopes where snowslides amounting to avalanches frequently bury the tracks.

Spike puller--steel bar about 5 feet long with a claw end shaped for pulling spikes by leverage. Also called claw bar.

Spiral--See Easement curve.

Split switch--See Switch, split.

Spot board--sighting board placed above and across a track at an established height above top of rail elevation, to indicate a new surface and insure uniformity of surface.

Spreader snowplow--spreader ditcher or specially designed equipment, equipped with "wings," to shove snow away from the track.

Spur track--dead end branch track diverging from a main or other track.

Stiff frog--bolted-rigid frog.

Stringlining--method for determining corrections to be made in the alinement of a curve, by measuring ordinates to the outer rail and without the use of surveying instruments.

Stringlining station--marked point on a stringlined curve.

Stub switch--See Switch, stub.

Subballast--gravel, crushed rock, or the like, usually inferior to the ballast used in the track, spread on the surface of the cut or fill before distributing ties.

Subgrade--elevation of a roadbed; finished surface of a roadbed before ballast added.

Superelevation--height the outer rail is raised above the inner, or grade, rail on curves, to resist the centrifugal force of moving trains.

Surface (of track)--vertical evenness or smoothness of a track over short distances.

Surface, running (tread)--top part of track structures on which treads of wheels bear.

Surfacing, out-of-face--raising the entire track to a new grade.

Surfacing, spot--raising isolated low spots in track to correct grade.

Switch--pair of movable track rails, with their fastenings and operating rods, providing a connection over which to move rolling stock from one track to another.

Switch, double slip--movable-point frog crossing with switch rails added. Also called puzzle switch.

Switch, split--two tapered movable rails with necessary connections, designed to divert rolling stock from one track to another.

Switch, spring--split switch with a throwing mechanism that enables a train to make a trailing-point movement through a turnout regardless of direction for which switch is lined.

Switch, stub--type of switch in which both of the main-line rails move for turnout operation. Now seldom found in the United States but may be in oversea areas.

Switch lock--fastener, usually a spring padlock, used to secure the switch or derail stand in place and thus maintain correct position of these members.

Switch plate--special metal tie plate for use on switch ties, each plate being long enough to extend not only under the stock rail and its supporting braces but also under the switch rail in open position.

Switch points--tapered ends of the switch rails of a split switch.

Switch rail--tapered rail of a split switch.

Switch rod--connecting rod that runs from the switch stand to the movable rails of a split-point switch, thereby enabling an operator to move the rails.

Switch stand--device by which a switch is thrown and locked, and its position indicated. Consists essentially of a base, spindle, lever, and connecting rod, with a target equipped with a lamp for main-line tracks.

Switch target--visual day signal fixed on the spindle of a switch stand, or the circular flaring collar fitted around the switch-lamp lens, and painted a distinctive color to indicate the position of the switch.

Switch, throw of--distance, measured along the centerline of the rod nearest the point connecting the two switch rails, through which switch points are moved sideways to bring either point against the stock rail; standardized at 4 3/4 inches.

Tamper--air-, electric-, or power-driven tool used for compacting ballast under ties.

Tangent--straight section of track.

Team track--track on which freight is transferred directly between a rail car and a highway vehicle.

Throat of frog--point at which the converging wings of a frog are closest together.

Throw--(noun) distance to move a track laterally with lining bars or track liner; (verb) to move by shifting laterally.

Throw rod--rod attached to the head rod of a switch, connecting the switch to a switch stand or other operating device.

Tie ripper--device designed by the Germans to destroy track by breaking ties and detonating explosives on the rail itself.

Tie rod--See Gage rod.

Tie tongs--implement designed to engage a tie with a pliers-like action and equipped with handles by which ties can be carried or drawn into or out of the track in renewals.

Toe end of frog--end of a frog nearest the switch.

Toe spread--distance between gage lines at the toe end of the frog.

Track, ladder--track connecting successively the body tracks of a yard.

Track, spur--track connected with the parent track at one end only.

Track bumper--device at the end of a spur track to prevent rolling stock from going off the ends of rails. Also called bumping post.

Track chart--graphic representation of a segment of a rail line which shows type of rail, ballast, grade, and structure.

Track crossing--See Crossing, track.

Track-laying machine--machine designed to decrease the manual labor of placing rails, fastenings, ties, and other materials.

Track level--board containing a spirit level used to check the evenness of rails; usually equipped with a series of notched steps to set superelevation on the outside rail of curves.

Track liner--device designed to decrease manual labor in lining track. Generally consists of a base resting securely on the roadbed to act as a fulcrum for some form of lever arm.

Track shim--hardwood or fiber plate, generally as wide as the bearing of a standard tie plate but of varying thickness; used to restore the running surface of track heaved by frost or otherwise distorted.

Trailing point--switch in which points face away from the normal direction of traffic.

Transition spiral--easement curve.

Turnout--arrangement of a switch and a frog with closure rails, by which rolling stock can be diverted from one track to another. In railroader's parlance, a "switch."

Water pocket--cavity formed in the roadbed because of improper surface drainage in which water collects; an uneven, spongy track results.

Yard--system of tracks within defined limits provided for receiving and making up trains, classifying and storing cars, and other purposes, over which movements not authorized by timetable or by train order may be made through prescribed signals and rules or special instructions.

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