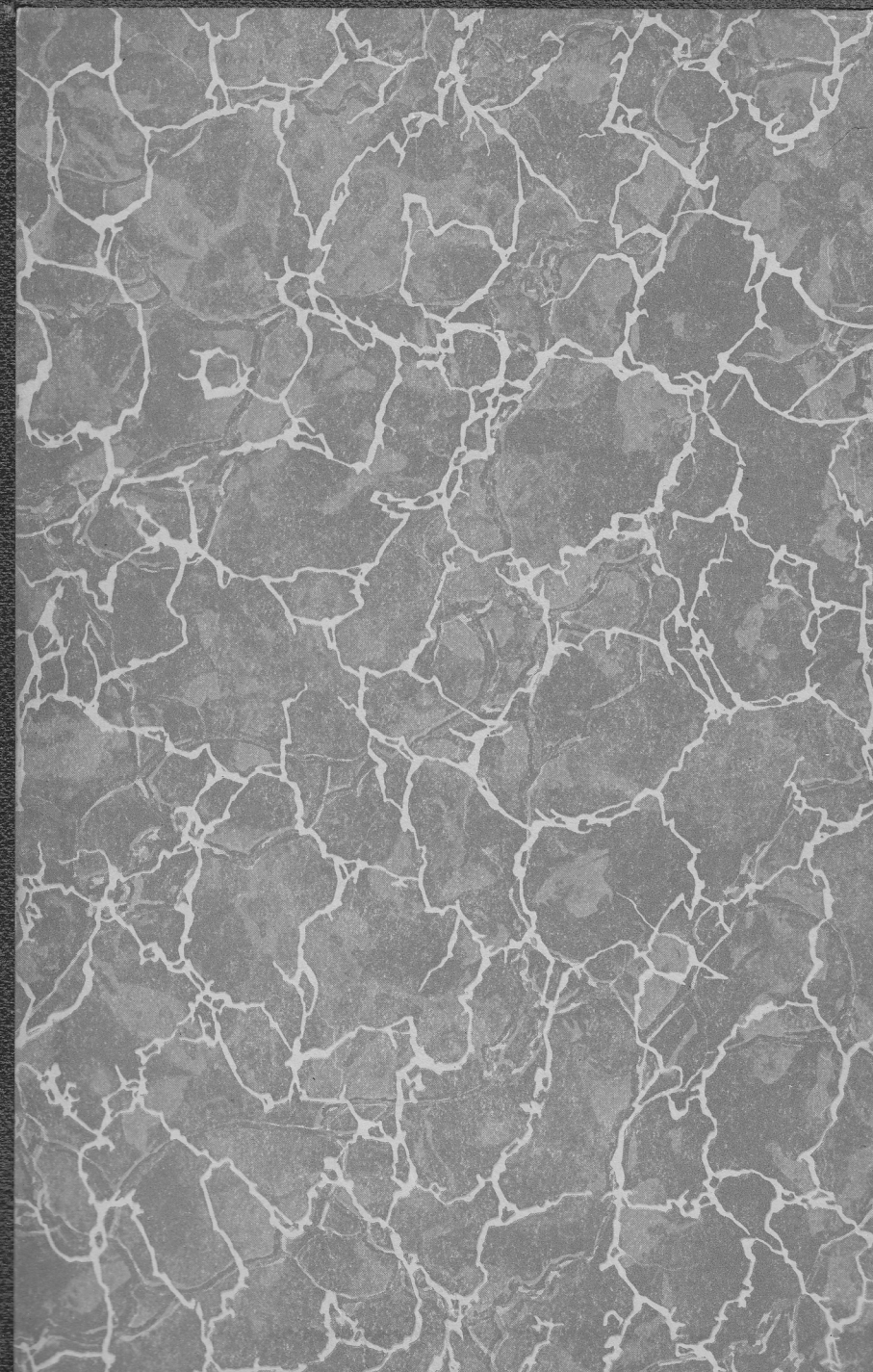
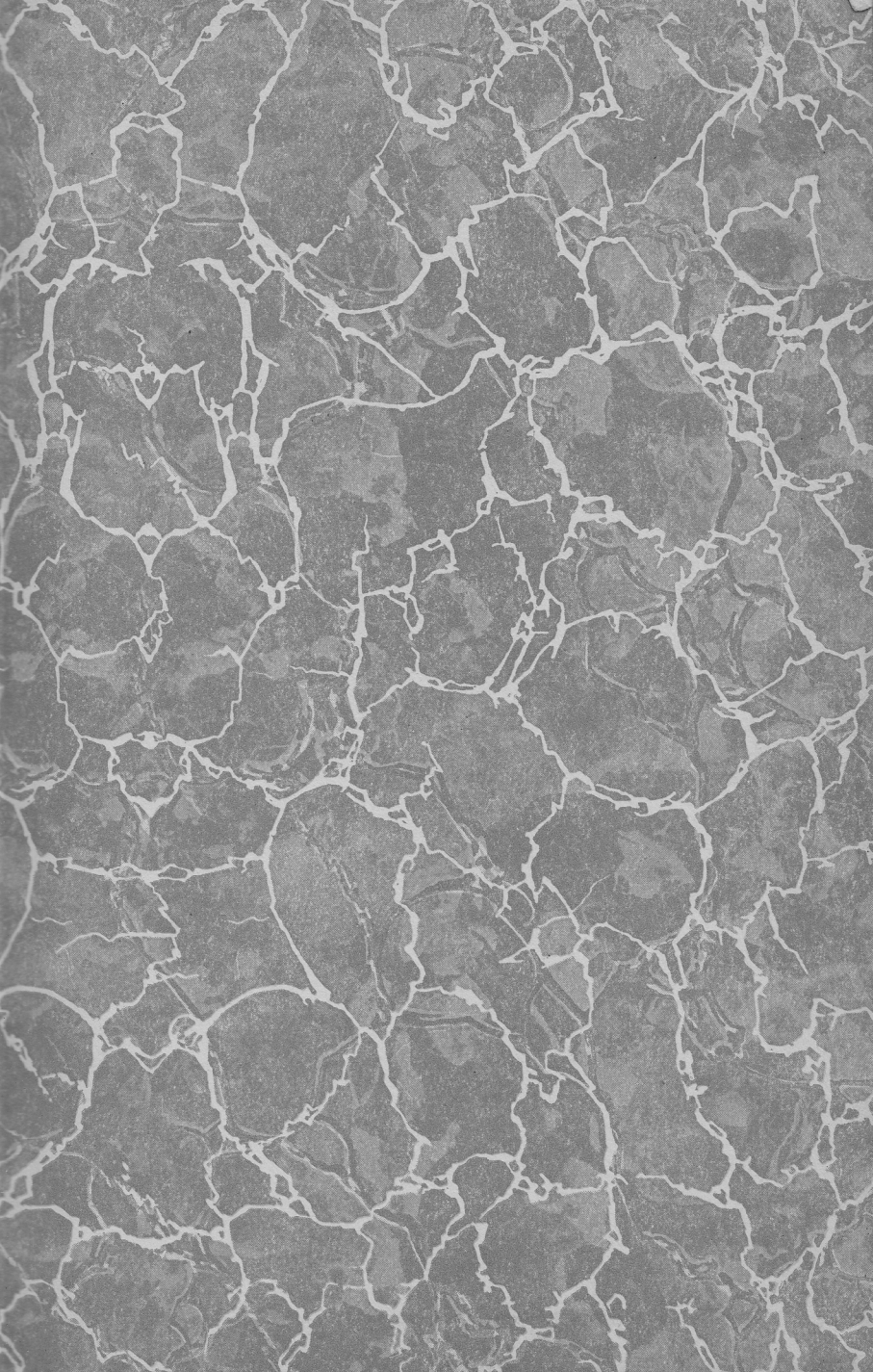


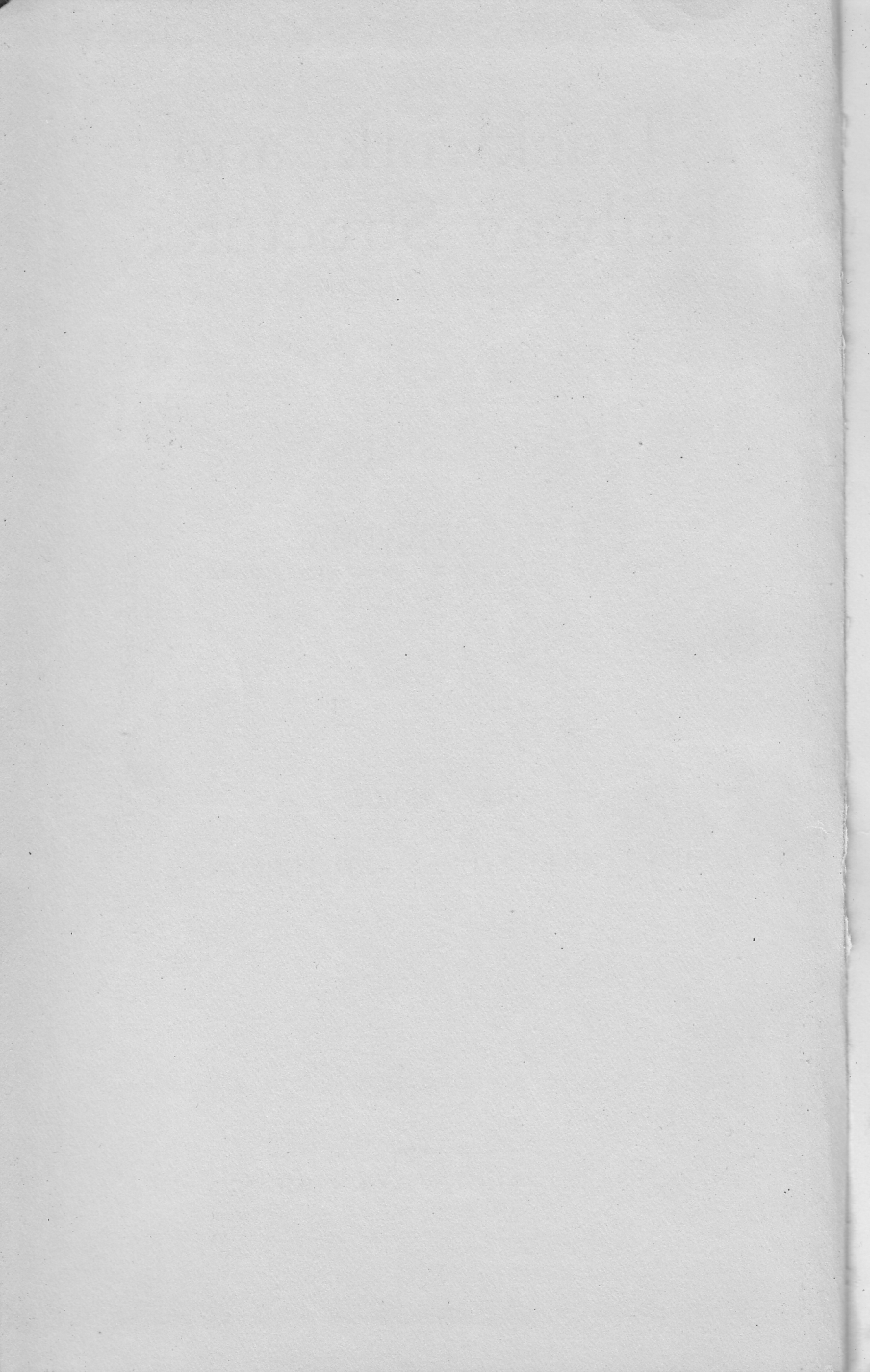
TRACKWORK
AND RAILWAY
STRUCTURES



INTERNATIONAL
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SCRANTON, PA.







Trackwork, and Railway Structures

By

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and

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TRACKWORK

Parts 1-2

RAILWAY STRUCTURES AND TERMINALS

332

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TRACK WORK

(PART 1)

Serial 3061A

Edition 1

TRACK MATERIALS AND CONSTRUCTION

TRACK MATERIALS

BALLAST

1. Introduction.—The continuous finished surface of the cuts and embankments, or fills, on a line of railway is known as the *subgrade*, or *roadbed*. In cuts a ditch is formed on each side to drain the subgrade and carry off rainwater. For single-track lines the width ranges from 16 to 22 feet over the edges of fills and between the ditches in cuts. For double track with tracks 13 feet between centers, the width is 30 to 35 feet. In some cases the roadbed is flat, but in general the center is made 3 to 8 inches higher than the edges in order to give a slope for drainage. On the subgrade is laid the track, which consists of a bed of ballast supporting cross-ties to which are spiked the rails to carry the wheels of trains.

2. Purpose of Ballast.—The soil or earth of the subgrade is not firm enough to support the ties directly; and as it does not drain readily, it is likely to be softened by rain and heaved by frost. For these reasons the subgrade is covered with a layer of suitable loose material called *ballast* to provide for drainage of the track, to distribute the load of trains over the surface of the roadbed, and to enable track to be leveled or surfaced. On this layer of ballast the ties are placed. For

ordinary main track a 12-inch depth of ballast under the ties is usually employed. The principal materials, mentioned in the order of their value, are crushed stone, washed gravel, slag, plain gravel, burned clay, and cinders.

3. Crushed Stone.—For first-class track carrying heavy and high-speed passenger traffic, crushed-stone ballast is generally used; for, although it is the most expensive, it is practically dustless and it holds the track in place better than do most other materials. A hard grade of stone is needed, preferably trap or limestone, in pieces ranging in size from $\frac{3}{4}$ inch to $2\frac{1}{2}$ inches. Since dirt and engine cinders gradually collect in the ballast and prevent proper drainage, the ballast is usually taken up every few years, screened, and replaced. From 15 to 25 per cent. of new material is required when the ballast is put back.

4. Gravel.—Washed gravel is about as good for ballast as crushed stone, and screened gravel comes next. But gravel as it comes from the pit usually has so much sand and dirt in proportion to the pebbles that it will shift and settle, will not drain well, and is likely to be heaved by frost. For these reasons track with pit-gravel ballast requires more maintenance work.

5. Slag.—In iron- and steel-mill districts the slag or waste from the furnaces is largely used for ballast, but it needs to be selected carefully. Good crushed slag is hard, holds the track, and drains well, but inferior qualities will disintegrate under traffic.

6. Burned Clay.—The quality of burned clay depends on the quality of the clay and on thorough burning. In its preparation, alternate layers of coal and clay are piled up in a long heap to a height of about 10 feet and the whole mass is then allowed to burn. This material is extensively used for ballast in the Southwest.

7. Cinders.—Engine cinders from roundhouses and ashes from power houses are much used for ballast on branches and

less important lines, as well as in yards, but they are too soft and dusty for main tracks. They are of special advantage for sub-ballast under more expensive material where low and wet spots are to be filled and where the track is likely to be heaved by frost.

8. Miscellaneous.—Several inferior materials are used for ballast in localities where they are plentiful and cheap. These include sand, shells, chats (lead- and zinc-mill refuse), chert (a species of gravel), and culm. Earth, or so-called *mud ballast*, composed of local soil, is used only on unimportant lines. The use of such materials results in increased maintenance expenses except under light traffic.

TIES

9. Kinds of Wood.—A great number of woods are used for ties, differing widely in value and cost. Few railways can now obtain a complete supply from forests along their own lines, so that there is a wider distribution and increasing cost for transportation. In Table I are listed some of the principal woods used for ties with the average periods in years that they will resist decay.

10. Life of Ties.—The life of ties in railway track depends on various factors besides the kind of wood. These factors include the locality where the ties were cut, method of seasoning, climate and rainfall, drainage of ballast and road-bed, maintenance of track, weight of engines, and amount of traffic. Therefore, the life of untreated ties as given in the table is only a general average.

Resistance to decay and resistance to wear by the rail are equally important in determining the life of ties. Thus, some soft woods having a great resistance to decay may be cut and worn out by the rail long before reaching their normal life, as given in Table I, unless they are protected by steel tie-plates. Redwood ties, which will last for 12 years if thus protected, may be damaged and rendered useless in about 5 years if used without tie-plates. In track carrying heavy and frequent loads

even hardwood ties may be damaged if not protected. On the other hand, white oak and black locust have high resistance to decay and wear.

The spikes that secure the rails to the ties are gradually loosened by the vibration of the rail and must be driven down from time to time. This continual movement eventually

TABLE I
LIFE OF TIES

Hardwood		Softwood	
Variety	Years	Variety	Years
Ash	4	Cedar	6 to 8
Beech	4 to 5	Cypress	6 to 10
Birch	4 to 5	Fir, Douglas	6 to 8
Catalpa	10	Hemlock	5 to 8
Cherry	6 to 8	Larch, or Tamarack..	7 to 8
Chestnut	8 to 10	Pine, Long-leaf	6 to 8
Elm	4 to 6	Pine, Western	3 to 4
Gum	3 to 4	Redwood	12
Hickory	3 to 4	Spruce	6 to 8
Locust, Black	10 to 16		
Locust, Honey	7 to 9		
Maple	4 to 5		
Oak, White	7 to 9		
Oak, Chestnut	7 to 8		
Oak, Red	3 to 4		
Poplar	5		
Sycamore	3 to 4		
Walnut, Black	8 to 10		

destroys the grip of the wood fibers, admits water, and causes rot; the tie is then said to be *spike-killed*. When a spike is to be replaced, the old hole should be filled with a tight-fitting plug of wood and the spike driven into the plug. Long life of ties is economical not only in cost of ties but also in reducing expense and track disturbance due to tie renewals.

11. Seasoning.—It is important that new ties be thoroughly seasoned or dried before they are put in the track, as they will last longer and hold the spikes more securely. For this purpose they are stacked in piles of about fifty, each pile having alternate rows of two ties and seven ties, arranged as shown in Fig. 1. The seven ties are placed far enough apart to allow a free circulation of air, and the top layer is inclined so as to shed water. Ties are usually cut during the fall and winter, so that they can season while the temperature is too low to cause the sap fermentation that results in rot.

12. Kinds of Ties.—A *pole tie* is made from a tree only large enough to produce one tie; two sides are hewn or sawed and the other sides are the natural rounded surfaces. Larger

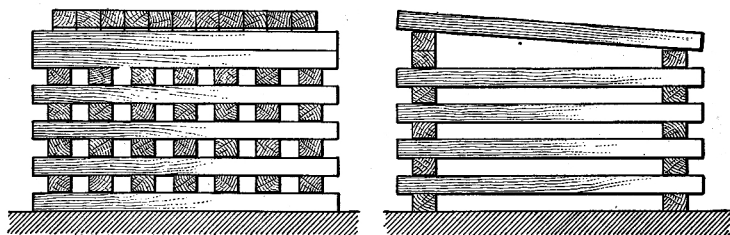


FIG. 1

trees are sawed into two ties called *split ties*, or into four ties called *quartered ties*. It has been generally accepted that hewn ties are superior to those that are sawed; but it is doubtful if there is much difference, particularly if the ties are to be treated chemically. The hewing takes much more time, is more wasteful, and does not give an even seat for the rail. Sawed ties are necessary on bridges and trestles where an even bearing and uniform thickness are required.

Heartwood is the harder central portion of the trunk of a tree, and sapwood is the softer outer portion next to the bark. In a heart tie the width of sapwood must be not more than one-fourth of the width of the top of the tie for a distance of from 20 to 24 inches from the middle. Where there is a greater width of sapwood, the tie is called a *sap tie*. Ties should be laid with the heart down.

13. Size of Ties.—The length of ties is usually $8\frac{1}{2}$ feet, sometimes 8 feet, and more rarely 9 feet, the long ties being used more especially on soft or swampy ground. The thickness is generally 6 or 7 inches and the width 8, 9, or 10 inches.

14. Chemical Treatment of Ties.—With increasing shortage and price of first-class long-life wood ties, there is increasing use of preservative treatment with chemicals in order that softer and inferior kinds of wood may be used. This is often economical, since a cheaper tie treated at small expense and protected by tie-plates may last even longer than a first-class untreated tie. Thus, a good white-oak tie costing \$1.30 may have a life of 8 or 10 years, while a cheaper red-oak tie which ordinarily has a life of 3 or 4 years may last from 12 to 16 years after a treatment that brings its total cost up to \$1.40. There is a tendency also to treat even the better woods, such as white oak, with chemical preservatives.

For the treatment of railway ties, creosote and zinc chloride are used principally. In both cases the seasoned ties are placed on small cars that are run into a long cylindrical chamber. Heated creosote or zinc-chloride solution is admitted to the cylinder and a pressure of from 100 to 200 pounds per square inch is applied. In one method, known as the *full-cell process*, all the liquid that can be forced in under pressure is left in the tie, but in the *empty-cell process* part of the liquid is drawn out by a vacuum, thus reducing the amount of preservative used but leaving the cell walls sufficiently well coated to prevent fermentation or fungus growth. Ties treated with zinc chloride are used mainly in dry regions, as the chemical gradually leaks out of ties in a moist climate and damp ballast. To prevent this, however, the zinc-creosote process includes a second light treatment with creosote to seal or plug the pores of the wood.

15. Substitute Ties.—The term substitute tie is applied to ties of all materials except wood. Numerous experiments with substitute ties have been made in the United States, usually on a small scale. Steel ties of I-beam section with bolt fastenings are used on some eastern lines. Concrete ties in

main tracks usually have failed by cracking or crushing, but they are thought to have advantages for yards and sidings by reducing the amount of tie renewals.

RAILS

16. History of Present Design.—The **T** rail or flange rail now used exclusively in the United States, and to a large extent in other countries, is developed from the design made in 1830 by Robert L. Stevens, an American engineer. As railways increased and extended, innumerable modifications were adopted by engineers of various lines, nearly every important railway having its own particular sections, many of which differed only in minor details but sufficiently to require special sets of rolls in their manufacture, thus causing trouble and expense in rail production. To check this uneconomical practice, the American Society of Civil Engineers several years ago appointed a committee to study the question of rail design, and, after long investigation, a series of standards was adopted which became widely used. As the heavier sections did not prove so good as was expected, the American Railway Association later adopted a modified section. Finally, the American Railway Engineering Association carried on further study and developed a set of standard sections for heavy rails, of which a typical section is shown in Fig. 2. These several investigations have resulted in improved rails, with economy in manufacture and increased service.

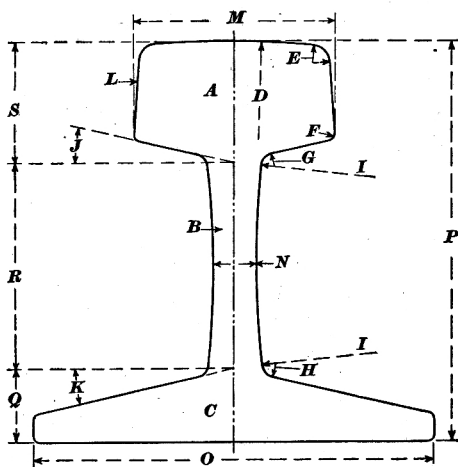


FIG. 2

17. Elements of Rail Sections.—Good proportions in a rail are as essential as good metal. The three parts are the head *A*, Fig. 2, the web *B*, and the base, or flange, *C*. The side of the head toward the center of the track is called the *gauge side* of the rail. The head must be broad enough and deep enough to withstand the effects of wheels carrying heavy loads, but if it is too large in proportion to the section, the metal will not be sufficiently worked in the rolls to get the desired density and strength, while the lighter parts will also suffer. In the sections of the American Society of Civil Engineers (A. S. C. E. sections) the proportions were uniformly 42, 21, and 37 per cent. for the head, web, and base, respectively; but for the larger rails this head proportion was excessive. In the American Railway Engineering Association (A. R. E. A.) sections these proportions range from 38.2, 22.6, and 39.2 per cent. in the 90-pound rail, to 37.1, 22.7, and 40.2 per cent. in the 120-pound rail.

18. Strength of Rails.—The rail must have sufficient strength to act as a beam between the ties and to give a minimum deflection under load. It must also have a base width sufficient for stability. In the A. S. C. E. sections the width of the base was made equal to the height to give sufficient bearing on the ties to prevent cutting the wood. Rails with very wide flanges, however, are likely to be weak in the thin edges. In the A. R. E. A. sections the width is ample for stability, but is less than the height, reliance being placed on steel tie-plates for the protection of the tie.

Selection of the weight of rails to be used must be based upon judgment and experience, as it is impossible to determine exactly the stresses to which the rails will be subjected. This difficulty is due to the fact that the rails have not a rigid foundation, since there is an irregular settlement of the ballast and roadbed. Vertical loads due to weight are increased enormously by irregularities of track, low joints, and loose ties. In addition there are severe lateral pressures, especially on curves. The weight of rail, however, should have some relation to the wheel loads carried. A rule of the Baldwin Locomotive

Works is that rails of less than 60 pounds per yard may carry 250 pounds for each pound per yard; the figure is 300 for rails of 60 to 90 pounds, and 350 for rails of more than 90 pounds per yard. Thus a 100-pound rail may carry wheel loads up to 35,000 pounds. The rule applies to good track with not less than 14 ties to each 30-foot rail length. To get the weight of rail desirable for a given maximum wheel load, divide this wheel load by 250 for loads up to 15,000 pounds; use a 60-pound rail for wheel loads between 15,000 and 18,000 pounds; divide the wheel load by 300 for values between 18,000 and 27,000 pounds; use a 90-pound rail for wheel loads from 27,000 to 31,500; and for wheel loads greater than 31,500 pounds, divide by 350.

EXAMPLE.—An engine has a load of 280,000 pounds on its eight driving wheels. What weight of rail should be used?

SOLUTION.—The load on each wheel is $280,000 \div 8 = 35,000$ lb. Since this is greater than 31,500, the proper weight of rail is found by dividing by 350; thus $35,000 \div 350 = 100$ lb. Ans.

19. Weight and Length of Rails.—Rails are classified according to their weight per yard. Rails weighing less than

TABLE II
CONSTANT DIMENSIONS OF RAIL SECTIONS

Dimension	A. S. C. E.	A. R. E. A.
Top radius of head, <i>D</i>	12 in	14 in.
Top corner radius, <i>E</i>	$\frac{5}{16}$ in.	$\frac{3}{8}$ in.
Bottom corner radius, <i>F</i>	$\frac{1}{16}$ in.	$\frac{1}{16}$ in.
Top fillets, <i>G</i>	$\frac{1}{4}$ in.	$\frac{3}{8}$ in.
Bottom fillets, <i>H</i>	$\frac{1}{4}$ in.	$\frac{5}{8}$ in.
Radius of web, <i>I</i>	12 in.	14 in.
Fishing angles, <i>J</i> and <i>K</i>	13°	1 in 4
Side of head, <i>L</i>	vertical	slope 1 in 16

75 pounds per yard are now rarely used in important main tracks. The 100-pound rail is very generally adopted for lines of heavy traffic, but rails of 120 to 135 pounds per yard are in use.

TABLE III
WEIGHTS AND VARYING DIMENSIONS OF RAILS

Dimension	Weight of Rail, in Pounds per Yard									
	50	60	75	80	100	90	100	110	120	A. R. E. A. Sections
	A. S. C. E. Sections									
Width of head, <i>M</i>	2½	2¾	2½	2½	2¾	2½	2½	2¾	2¾	2¾
Web thickness, <i>N</i>	⅞	¾	¾	¾	¾	¾	¾	¾	¾	¾
Width of base, <i>O</i>	3½	4¼	4½	5	5¾	5½	5¾	6¼	5¾	5¾
Height, <i>P</i>	3½	4¼	4½	5	5¾	5¾	6	6¼	6½	6½
Height of base, <i>Q</i>	1½	1¾	1¾	1¾	1¾	1	1½	1½	1¾	1¾
Height of web, <i>R</i>	2½	2¾	2¾	2¾	3¼	3½	3¾	3¾	3¾	3¾
Height of head, <i>S</i>	1½	1¾	1¾	1½	1¾	1½	1½	1½	1½	1½

The length of rails is usually 30 feet, but some railroads use 33 feet in order to reduce the number of joints. Rails 60 feet long have been used largely in tunnels to reduce maintenance work on the joints, and at road crossings to avoid having rail joints covered by the paving. On curves a certain number of rails 28 or 29 $\frac{1}{2}$ feet long are used on the inside line so as to keep the joints approximately midway between those in the longer outside line of rails. Rails worn at the ends, but otherwise good, are frequently sawed or cropped to a length of 27 feet, and then drilled for bolts like new rails.

20. Dimensions of Rails.—Although some dimensions of the different rail sections vary with the weight, others are constant. The constants for the two principal types of sections are given in Table II, in which

the letters refer to Fig. 2; dimensions that vary with the weight are given in Table III.

21. Chemical Composition and Tests.—Rails are made of steel produced either by the Bessemer or by the open-hearth process, the latter being now more generally used. Quality in a rail in regard to strength, soundness, and resistance to wear depends largely on the chemical composition of the steel, as well as upon proper rolling. In open-hearth rails of over 85 pounds per yard, the carbon may be from .62 to .75 per cent., manganese, .60 to .90 per cent, and phosphorous not more than .04 per cent. In Bessemer rails the proportions would be .45 to .55 per cent. of carbon, .80 to 1.10 of manganese, and not more than .10 per cent. of phosphorus. In both kinds of steel there would be not less than .10 per cent. of silicon. Alloy steels with relatively high proportions of nickel, silicon, and manganese are used to some extent.

In addition to chemical analyses of the steel, a certain number of rails from each *blow* of steel are subjected to a drop test to determine their strength. A piece of rail is placed base upwards on supports 3 feet apart (or 4 feet for rails of more than 110 pounds per yard). The supports are part of an anvil block weighing 10 tons and resting on springs. A hammer weighing 2,000 pounds is allowed to fall on the rail from a height varying from 16 to 20 feet, according to the weight of rail. When the test piece is struck, the elongation should be within certain prescribed limits. If the test piece does not break under the blow and shows the required elongation, it is nicked and broken to determine whether there are any interior defects, such as seams, cavities, or impurities. If, when struck, any rail fails to show the required elongation, or if, when broken, it shows interior defects, other tests are made on rails from the same blow of steel. If these fail, all the rails from that blow are rejected.

EXAMPLES FOR PRACTICE

1. The total load on the eight driving wheels of a locomotive is 230,000 pounds. What weight of rails should be used? Ans. 90 lb.
 2. A locomotive carries a load of 300,000 pounds on its eight driving wheels. Find the required weight of rails. Ans. 110 lb.
-

RAIL JOINTS AND FASTENINGS

22. Rail Joints.—The ends of rails must be spliced to hold them in line both vertically and laterally, in order that the wheels will roll smoothly across the joint. Further, in the suspended type of joint, which is described later, the splice has to support the overhanging ends of the rails, and it should make the joint practically as strong as the body of the rail. This latter aim is rarely realized and rail joints are nearly always an important feature in track maintenance work. As a rule, rails are laid with staggered or broken joints; that is, each joint in one line of rails is opposite the middle of a rail in the other line.

In nearly all joints the main element consists of a pair of splice bars bolted to both rails. The old-fashioned flat bars, called *fish plates*, have been abandoned for important work in favor of angle splice bars which can be made more rigid vertically and thus better resist bending. Moreover, their flanges give additional lateral stiffness to hold the rails in line. Various attempts have been made to reduce the shock of wheels crossing the small open gap between the rails. In some designs the rail ends have been cut diagonally or halved so as to lap side by side, and in others a high splice bar has been used on the outside of the rail to give a bearing to the wheel. None of these plans has given results that would warrant the expense involved.

Elimination of rail joints by welding the rails to form a continuous bar is impracticable (except with street-railway rails which are protected by being embedded in the pavement) owing to the necessity of providing for the changes in length with changes in temperature. However, the number of joints has

been reduced to a large extent by the use of longer rails. Thus, with 33-foot rails the number of joints per mile is 320, instead of 352 with 30-foot rails.

23. Angle-Bar Rail Joint.—A typical rail joint with angle splice bars is shown in Fig. 3. The shape of the bars varies greatly, and for heavy rails the stiffness of the bar is often increased by ribs or flanges along the top and bottom of the vertical web. In the upper part of the drawing is shown

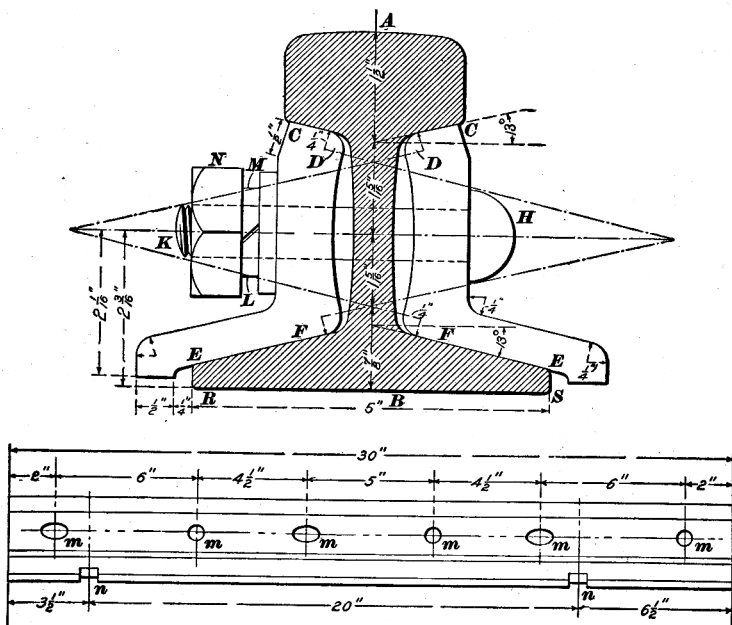


FIG. 3

the rail *AB* with two angle bars *CDFE* secured to it by bolts *HK*. The bars are drawn together and held firmly in place by screwing up the nut *N*, which is prevented from working loose by the nut-lock *LM*. A side view of a splice bar is shown in the lower part of Fig. 3. Some of the bolt holes *m* are oval because one bar of each pair should have holes to fit oval necks on the bolts, which are thus prevented from turning when the nuts are screwed on. In modern practice, alternate

bolts have the nuts on opposite sides of the rail, and therefore the bolt holes in the splice bars are alternately oval and round. These holes are also slightly larger than the bolts, to allow movement of the bolts when the rails expand or contract in length because of changes in temperature.

An important requirement of splice bars is that they must make an exact fit against the bottom of the head and the top of the base of the rail. These contact surfaces are inclined, so that as the splice bars are drawn together they are wedged tightly between the head and base of the rail; the angle of inclination, *J* and *K*, Fig. 2, is called the *fishing angle* and

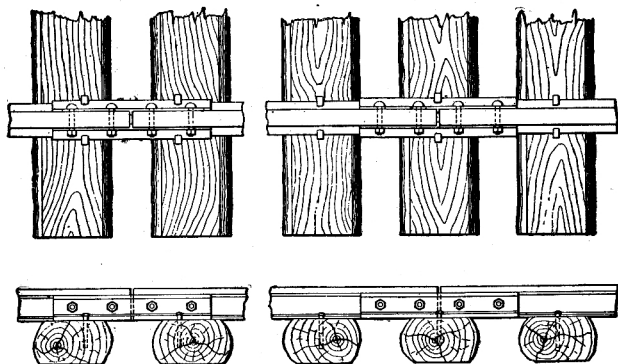


FIG. 4

is about 13° . In this way the splice bars add to the stiffness of the joint, as long as they are kept tight, and prevent independent vertical motion of the rail ends. Splice bars from 22 to 28 inches long, with four bolts, are generally used, but six-bolt joints with bars from 30 to 36 inches long are also in use. In general, the flanges of the bars have notches or slots *n*, Fig. 3, to receive the track spikes, as this arrangement allows slight movement but checks excessive creeping or longitudinal movement of the rails on the ties. However, there is a growing opinion in favor of omitting the slots and using rail anchors in order to relieve the spikes of the longitudinal thrust.

24. Suspended and Supported Joints.—As a rule, the joint comes between two ties called *joint-ties* that are spaced closer together than the intermediate ties. Such an arrange-

ment is termed a *suspended joint*. An alternative plan that is used to a limited extent is to place the two rail ends on a tie, making a *supported joint*. A supported joint is likely to make

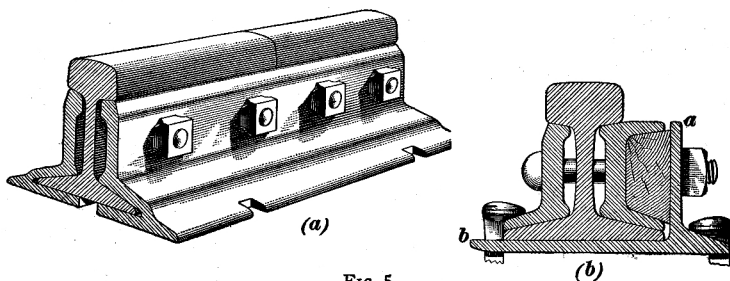


FIG. 5

a hard spot in the track, causing more jar to trains than a suspended joint that allows for deflection between the ties. Both plans are shown in Fig. 4.

25. Other Forms of Joints.—Numerous special designs of rail joints are in use, some of which give a bottom support to the rails in a suspended joint, as in Figs. 5 and 6. In the continuous joint, shown in Fig. 5 (a), each splice bar has its flange grooved to receive the rail flange. In the Weber joint, view (b), a separate L-shaped plate *a* *b* is used, which rests on the ties and carries the rails. The bolts are long enough to pass through the web of this plate, as well as through the splice bars, and a wood filler is placed between the plate and

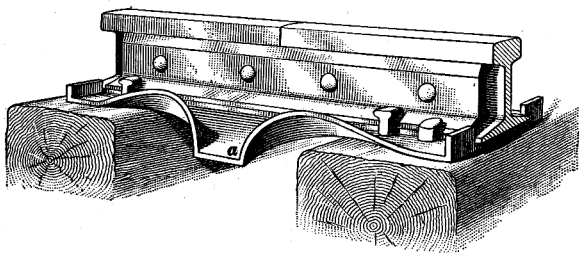


FIG. 6

the outer splice bar; this bar is of channel section, as shown. Another method is illustrated in the Abbott joint, Fig. 6, in which a separate bridge plate *a* is used under the rails. The ends of the plate rest on the joint-ties and its sides are bent

downwards to form stiffening ribs. In several special designs of splice-bar joints the flanges of the bars are bent down vertically so as to project below the rail, thus increasing the stiffness of the bar and joint. When rails of different heights or sections are connected, a *step joint*, or *compromise joint*, is used, with forged or malleable cast-iron bars so made that half the length fits one rail and the other half fits the other rail.

26. Bonded and Insulated Joints.—Where electric track circuits are used in connection with signaling, the electric current travels through the rails. Passage of the current across

TABLE IV
EXPANSION SPACES AT RAIL JOINTS

Temperature of Air When Rails Are Laid Degrees F.	Length of Rail, in Feet	
	30 and 33	60
	Expansion Space, in Inches	
0 to 12	$\frac{1}{4}$	$\frac{1}{2}$
12 to 25	$\frac{1}{4}$	$\frac{7}{16}$
25 to 37	$\frac{3}{16}$	$\frac{3}{8}$
37 to 50	$\frac{3}{16}$	$\frac{5}{16}$
50 to 62	$\frac{1}{8}$	$\frac{1}{4}$
62 to 75	$\frac{1}{8}$	$\frac{3}{16}$
75 to 87	$\frac{1}{16}$	$\frac{1}{8}$
87 to 100	$\frac{1}{16}$	$\frac{1}{16}$
Over 100	Close	

the joint is assisted by copper bars or bonds welded to the ends of the two rails or by copper bond wires having their ends fitted to small studs in holes drilled in the rails. At the end of each track circuit the current must be prevented from passing through the joint. For this purpose, strips of insulating material are placed between the bearing surfaces of the bars and rails and between the ends of the rails, while sleeves of the same material are fitted over the bolts in the bolt holes.

27. Expansion Spacing at Joints.—A 30-foot rail increases or decreases in length about .00234 inch for each

degree Fahrenheit of variation in temperature, and this change in length must be provided for at the joints. Therefore, the rails are not laid in contact, end to end, but are separated by a short space, varying according to the atmospheric temperature when the rails are laid. In Table IV the width of opening is given for ordinary and long rails. With 30-foot and 33-foot rails, no opening should exceed $\frac{3}{8}$ inch. The spaces for 60-foot rails are double the corresponding values for 30-foot rails, since the rails are twice as long; the spaces for other lengths of rails can be found by interpolation.

28. Bolts and Nuts.—Proper service of the rail joint depends largely on the strength and tightness of the bolts; one

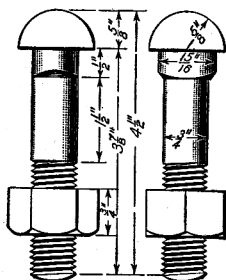


FIG. 7

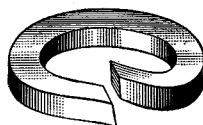


FIG. 8

form, with round heads, is shown in Fig. 7. The bolts are usually $\frac{7}{8}$ inch or 1 inch in diameter, but $1\frac{1}{4}$ -inch bolts are used for very heavy rails. They have round or square heads and square or hexagonal nuts. An oval neck is formed under the head to fit the oval holes in the splice bars.

The vibration and shocks to which the rails are subjected during the passage of trains tend to cause the nuts to work loose. To prevent this a nut-lock is used. Usually this device acts as a spring and is placed between the nut and splice bar, as at *L M*, Fig. 3. One of the most common forms of nut-locks is a steel ring cut at one side and twisted to a spiral, as shown in Fig. 8. As the nut is screwed up, it flattens the ring and causes the two points to press on the under part of the nut on the one side and on the face of the angle plate on the other. In turning up the bolt the nut slides easily past the

point. Whenever there is any tendency for the nut to turn backwards, the point of the lock bites into the nut and effectively prevents it from turning.

29. Spikes.—Rails are fastened to the ties by steel spikes of square section having hook heads that bear on the rail base. An ordinary size of spikes for heavy rails is $\frac{1}{2}$ inch or $\frac{9}{16}$ inch square and $5\frac{1}{2}$ inches long under the head. The lower end tapers on two sides to a chisel edge, as in Fig. 9 (a) and (b), or has a shorter taper on four sides to form a point as in (c). The best spike has a sharp edge or point to cut the wood fibers,

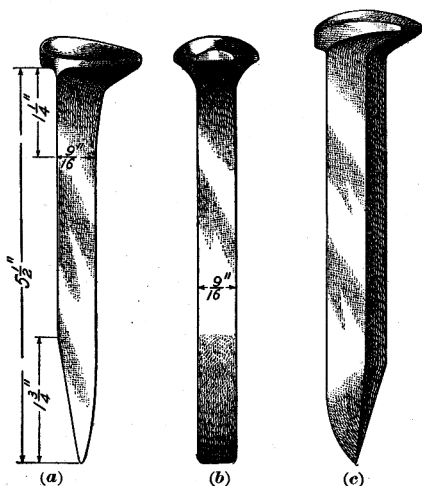


FIG. 9

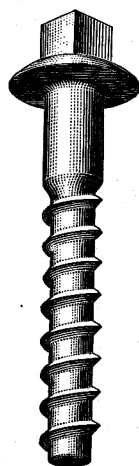


FIG. 10

and a smooth body to press back the fibers without tearing and crushing them. In this way the fibers pack tightly against the spike and hold it in place, and there is the least chance for water to enter and cause decay.

Extensive use is made also of screw spikes, Fig. 10, the threads of which cut into the sides of the spike hole and so obtain a firm grip in the wood. It is necessary to bore holes in the tie of slightly smaller diameter than the body of the spike. The head of the screw spike may bear directly on the rail flange or upon a clip shaped to rest on the rail flange and the tie or tie-plate.

30. Tie-Plates.—Rails on softwood ties will gradually cut into the wood; and on curves the outer edge of the rail base will cut even into hard wood, as the rail tends to overturn under the lateral pressure of the wheel flanges. In this way ties may be so damaged as to require removal long before they decay. To protect the tie against such destructive action, plates of steel, wrought iron, or malleable iron are placed under the rail to distribute the pressure over a large area of the wood and

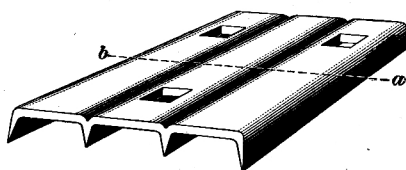


FIG. 11

to resist the tendency of the rail to overturn. Many of these plates have projecting lips or ribs on the under side, as in Fig. 11, to bite into the wood and give a secure hold.

The plates are placed lengthwise on the tie, so that the rail crosses them along the line *a b*. The square holes are for the spikes to pass through, two being driven on the outer side of the rail flange and one on the inner, in the form of the plate shown. Other forms of plates are made flat in order to avoid any cutting of the wood, and these should be fastened to the tie by spikes separate from those which hold the rails. On

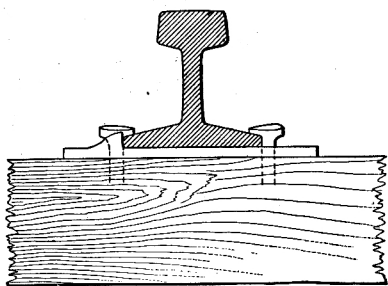


FIG. 12

the upper surface of the plate there is often a rib or shoulder that fits against the outer edge of the rail base, and thus relieves the spikes of some of the lateral pressure tending to displace them. Such a shoulder tie-plate, with a flat bottom is shown in Fig. 12.

It is important that the tie-plates be placed carefully in proper position by the aid of a gauge or measure, as the spike holes in the plates determine the positions of the rails, and therefore, the width of the track. Plates with bottom rib should be driven down flat on the tie, so that dirt and gravel may not get under them and cause them to be

bent or buckled, thus preventing a flat bearing for the rail. The ribs on the plates may be driven into the tie by machine, but if a hand sledge or maul is used, a wood striking-block should be placed on the plate so that it will not be bent by the blows.

31. Rail Braces.—On curves, the wheel flanges exert a strong lateral pressure against the rails, tending to force them outwards or to overturn them. As the resistance of the spikes is not sufficient to prevent this overturning, rail braces are spiked to the tie. Of the two rail braces shown in Fig. 13, the one at the left bears only against the rail web while the other bears against both the web and the head. These braces are usually required on the outside of both outer and inner rails, as the wheels of fast trains exert pressure mainly against the outer rail of the curve, while those of slow heavy trains

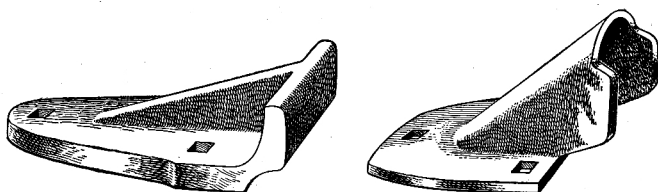


FIG. 13

bear heavily against the inner rail. Rail braces are often used also to support guard-rails at frogs, as these rails have to hold each wheel against the track rails in order that the opposite wheel on the same axle will be in line to pass through the frog properly. These braces are frequently made of cast iron, but the best forms are of malleable iron or else are stamped and punched from wrought-iron plates by special machines.

32. Rail Anchors.—Due to the rolling effect of wheels on grades and soft ground, the rails have a tendency to creep or move longitudinally along the ties. Such movements may cause considerable trouble at switches, frogs, and crossings. Creeping is resisted to best advantage by holding each rail, rather than by holding or anchoring the rails at long intervals. In one type of an anchor, shown in Fig. 14 (a), an angle-shaped piece of steel has one leg bolted to the rail web and the other leg spiked to the tie, or this lower leg may be long enough

to rest on two ties. Another type, in more general use, is a clamp fitted to the bottom of the rail and bearing against the side of the tie, as shown in (b). Any tendency of the rail to

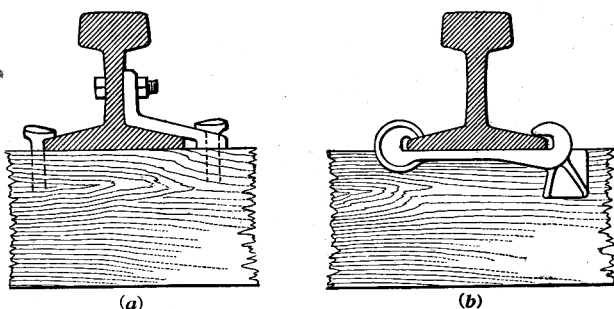


FIG. 14

move increases the grip of the clamp. On single track it may be necessary to anchor the rail against movement in both directions.

COST AND QUANTITIES OF TRACK MATERIALS

33. Cost Figures.—Prices of materials vary frequently and depend largely on the locality and on market conditions. With any material, also, the price or first cost is only a part of the expense represented by the material when finally put in service in the track. Inspection, transportation, and placing all add their share to the total cost.

34. Ballast.—The quality, quantity, and cost of ballast must be in proportion to the traffic. Cheap and inferior ballast on track carrying heavy traffic will not only require continual work and expense for track maintenance, but will have a direct, though indefinite, influence in increasing operating expenses by greater fuel consumption and repairs to rolling stock. In general, the total expense for ballast in track depends on: 1, the first cost of the material as received by the railway; 2, the distance the material must be hauled; 3, the method of handling the material. Thus, if ballast is shoveled from cars its cost will be much greater than if it is dumped or deposited in place by ballast cars.

The quantity of ballast varies with the cross-section. On single track it ranges from 1,000 cubic yards per mile for light ballasting on new lines of very small traffic to 2,630 and 3,800 cubic yards per mile for depths of 8 inches and 12 inches, respectively. On double track the quantity may be from 5,130 cubic yards for a depth of 8 inches to 7,300 cubic yards for a 12-inch depth.

35. Ties.—The total cost of a tie in the track includes initial cost, inspection, freight, placing, fastenings, and supervision; also, perhaps, preservative treatment and tie-plates.

TABLE V
NUMBER OF TIES PER MILE

Spacing of Ties Center to Center	Number of Ties per Rail	Number of Ties per Mile
30-Foot Rail		
1 ft. 6 in.	20	3,520
1 ft. 8 in.	18	3,168
1 ft. 10½ in.	16	2,816
2 ft.	15	2,640
2 ft. 1¾ in.	14	2,464
2 ft. 6 in.	12	2,112
33-Foot Rail		
1 ft. 10 in.	18	2,880
1 ft. 8 in.	20	3,200

Treatment may be estimated at 50 cents per tie for creosoting and 25 cents for the zinc-chloride process. On main track, there are usually from 16 to 18 ties to each 30-foot rail, while 14 ties per rail are used on branch lines. The number of ties per mile for different spacings is given in Table V.

36. Rails.—The market price of rails varies from as low as \$22 per gross ton of 2,240 pounds to as high as \$48. In 1922 it averaged \$43. For a given weight of rail, the number of gross tons per mile of single track can be obtained from Table VI, but these figures should be increased by 1 or 2

per cent. to allow for waste in cutting. The rule for obtaining the number of gross tons per mile of single track is to multiply the weight of rail in pounds per yard by 11 and

TABLE VI
WEIGHT OF RAILS PER MILE OF TRACK

Weight of Rail per Yard Pounds	Weight of Rails per Mile of Track	
	Tons	Pounds
40	62	1,920
50	78	1,280
60	94	640
65	102	320
70	110	
75	117	1,920
80	125	1,600
85	133	1,280
90	141	960
95	149	640
100	157	320
120	188	1,280

divide the product by 7. Thus, from Table VI, for 80-pound rails the weight per mile is 125 tons+1,600 pounds, or 125.7 tons; and by the rule, the weight is $80 \times \frac{11}{7} = 125.7$ tons.

EXAMPLE.—Track is laid with 80-pound rails. Find the cost of rails per mile of track if the price is \$40 per ton and 2 per cent. is allowed for waste.

SOLUTION.—From Table VI the weight of rails per mile is 125 T.+1,600 lb.=125.71 T. When 2 per cent. is allowed for waste, the total weight required is $125.71 \times 1.02 = 128.22$ T. Hence, the cost is $128.22 \times 40 = \$5,129$. Ans.

37. Splice Bars and Bolts.—Angle bars and track bolts are usually sold by the pound, but for some of the patented forms of rail joints the price per pair is quoted. The weight of bars varies widely with the size and the form of section.

Bolts are put up in kegs of about 200 pounds, the average

number of bolts of different sizes in each keg being given in Table VII. In Table VIII are given the number of pairs of

TABLE VII
NUMBER OF TRACK BOLTS IN A 200-POUND KEG

Size of Bolt Inches	Thickness of Nut Inch	Width of Nut over Faces Inches	Bolts per Keg	
			Square Nuts	Hexagonal Nuts
$\frac{3}{4} \times 4$	$\frac{3}{4}$	$1\frac{1}{4}$	245	256
$\frac{7}{8} \times 4\frac{1}{2}$	$\frac{7}{8}$	$1\frac{7}{16}$	159	166
$1 \times 4\frac{1}{2}$	1	$1\frac{5}{8}$	120	126
1×5	1	$1\frac{5}{8}$	112	117

angle bars and the number of bolts per mile of track for different rail lengths. The weights of splice bars per foot for

TABLE VIII
RAILS, SPLICE BARS, AND BOLTS PER MILE OF TRACK

Length of Rail Feet	Number of Rails per Mile	Number of Pairs of Angle Bars	Number of Bolts, Four to Each Joint	Number of Bolts, Six to Each Joint
18	587	587	2,348	3,522
20	528	528	2,112	3,168
21	503	503	2,012	3,018
22	480	480	1,920	2,880
24	440	440	1,760	2,640
25	422	422	1,688	2,532
26	406	406	1,624	2,436
27	391	391	1,564	2,346
28	377	377	1,508	2,262
30	352	352	1,408	2,112
33	320	320	1,280	1,920
60	176	176	704	1,056

different weights of rails are approximately as follows: $8\frac{1}{2}$ pounds for 60-pound rails; $10\frac{3}{4}$ for 75-pound rails; $11\frac{1}{2}$ to 13

for 80-pound rails; $13\frac{1}{2}$ to 17 for 90-pound rails; and 16 to 20 pounds for 100-pound rails. For a given pattern of splice bars and a given size of bolts, the number and total weight of the bars and bolts per mile of single track can be found by means of Tables VII and VIII.

EXAMPLE.—For 30-foot rails the angle bars weigh 70 pounds per pair and have six bolts $\frac{3}{4}$ in. $\times$ 4 in., with square nuts. The prices are 2.4 cents per pound for the bars and \$6 per keg for bolts. Find the cost of (a) angle bars, and (b) bolts per mile of track.

SOLUTION.—(a) Table VIII gives 352 pairs of angle bars for 30-foot rails, with 2,112 bolts. The weight of the bars is $352 \times 70 = 24,640$ lb., and the cost is $24,640 \times .024 = \$591.36$. Ans.

(b) Table VII gives 245 bolts per keg, and the number of kegs is $2,112 \div 245 = 8.6$. Hence the cost is $8.6 \times 6 = \$51.60$. Ans.

38. Spikes.—The approximate number of spikes per keg of 200 pounds is given in Table IX for different sizes. The

TABLE IX
SPIKES PER MILE OF TRACK

Size of Spike Under Head Inches	Average Number per 200-Pound Keg	Number of Spikes per Mile with 2,640 Ties and Four Spikes to Each Tie is 10,560	
		Average Weight Pounds	Average Number of Kegs
$\frac{1}{2} \times 4$	600	3,520	17.6
$\frac{1}{2} \times 4\frac{1}{2}$	536	3,940	19.7
$\frac{1}{2} \times 5$	490	4,320	21.6
$\frac{9}{16} \times 5\frac{1}{2}$	340	6,220	31.1
$\frac{5}{8} \times 6$	265	7,960	39.8

weight of the spikes and the number of kegs per mile are also given for ties spaced 2 feet between centers.

EXAMPLES FOR PRACTICE

1. Track is laid with 90-pound rails. If $1\frac{1}{2}$ per cent. is allowed for waste, and the price is \$36 per ton, what is the cost of the rails per mile of track?

Ans. \$5,168

2. The rails in a track are 33 feet long; the angle bars weigh 80 pounds per pair; and at each joint there are six bolts 1 in. $\times$ 4½ in. with square nuts. If the bars cost 2.4 cents per pound and the bolts \$6 per keg, what is the cost per mile of track of (a) the angle bars and (b) the bolts?

Ans. $\left\{ \begin{array}{l} (a) \$614.40 \\ (b) \$96 \end{array} \right.$

TRACK CONSTRUCTION

GENERAL METHODS OF LAYING TRACK

39. Handling Material.—For a new line, the track material is stored at the beginning of the line and forwarded to the front or *head of steel* on trains of flat cars. If a locomotive crane is at the front end of the train, the first cars are loaded with rails, the next car carries fastenings, and the other cars have ties. At the front the ties are loaded into wagons for distribution ahead. As the ties are placed on the roadbed the rails are taken from the car by the crane and placed on the ties, the train moving forwards as soon as each length of rails is fastened to the ties and spliced. For double tracking much of the material can be delivered from cars on the existing line, the handling of this work being arranged so as not to interfere with the regular traffic.

40. Preparing Subgrade.—Before laying the track the surface of the roadbed should be filled or leveled to grade and finished either flat or with a drainage slope of about 1 in 24 on each side from the center line.

41. Distributing and Placing Ties.—As the wagons hauling the ties move forwards, the ties are thrown off and carried to place. The larger ties are used at the joints, which are marked by small stakes. The ties must be laid far enough in advance to be clear of the rail-laying, but if they are laid for too great a distance ahead there is likely to be much shifting of the joint-ties to fit the rail joints. Stakes marking the center line of track are driven 100 feet apart on tangents and 50 feet apart on curves, when the degree of curve is less than 12°; for sharper curves, the stakes are 25 feet apart. A tack

in the head of the stake marks the center line. A tie line stretched between stakes driven at the proper distance from the center stakes marks the location of the ends of the ties. Care must be taken to place the ties at right angles to the center line, as, if laid askew, they will not hold the rails in the proper position.

The distance between the centers of ties varies from 18 inches to 2 feet in main track, and sometimes to 30 inches in sidings. Because of the difficulty of tamping under the ties, they should not be placed closer together than about 18 inches between centers; even then such a spacing can hardly be adopted unless the ties are small, since the clear space between the ties will be so narrow that good tamping will be impracticable. On the other hand, even with the largest ties that are ordinarily used, a spacing greater than 2 feet between centers will make too long a span for the rails in track carrying ordinary traffic. However, ties are not usually spaced with exact uniformity. Since it has been generally held that the joints should have a little better support, the ties are usually adjusted so that those under the joints are spaced a little closer than the others. But there is an increasing tendency to disregard the position of rail joints in spacing the ties.

42. Handling and Placing Rails.—Formerly rails were loaded and unloaded at the storage yard by hand; large gangs of men were required, and great care was necessary to prevent damage to the rails when they were dropped from cars. Now this work is generally done by some form of power hoist and crane, requiring only a few men and reducing the damage to the rails. In tracklaying, the rails are either slid into place by inclined chutes with rollers in the bottom or are placed by a crane at the head of the train. In case rails are bent in handling they should be carefully straightened before being placed in straight track. Straightening or bending rails by hammering with sledges should not be allowed, as it is likely to cause damage that will result in fracture of the rail in the track. The form of the rail bender commonly used will be described later.

43. Gauging Track.—The distance between the gauge sides of the heads of opposite rails is called the *gauge* of a track. On straight track, a uniform gauge must be maintained. Usually the right-hand rail is first lined and spiked and then

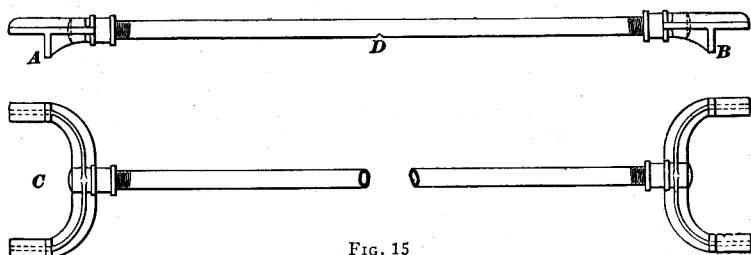


FIG. 15

the other rail is brought into position by a track gauge, one form of which is shown in Fig. 15. A bar or pipe has at each end a U-shaped casting with lugs *A* and *B*. The distance between these lugs on the castings *C* is the gauge of track, and a line between the two lugs on each side will be at right angles to the bar. The bar is placed on the line rail with both lugs tight against the inside of the rail head. The other rail is pushed against the two lugs on the other end of the bar and is then spiked in place. A notch *D* on the bar marks the center of the track.

44. Spiking Rails.—As the rails are laid they are spiked first to the joint-ties and two or three intermediate ties. Spikes should be driven vertically and with the body in contact with the rail base. It is poor work to drive a spike in a slanting position or to place it at a little distance from the rail and then bend the head so as to give the track the proper gauge. The proper position for the

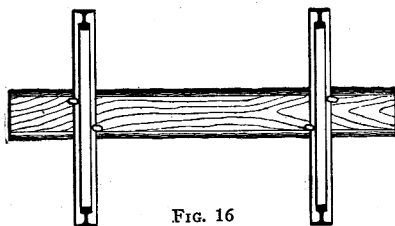


FIG. 16

spikes is from $2\frac{1}{2}$ to 3 inches from the sides of the tie, as shown in Fig. 16. If in the center of the tie and opposite each other, they are likely to split the wood.

45. Allowance for Rail Expansion.—In laying rails, provision must be made for expansion and contraction. As the temperature rises the rails lengthen, and unless sufficient space is left between their ends they may press together with such force as to bend the rails or buckle the track. If there is too great a space, so that the holes in the splice bars are tight against the bolts, these bolts may be sheared or broken by the shortening or contraction of the rails due to severe cold. Proper spacing to be used in laying rails at different temperatures has been given in Table IV. To provide this spacing, steel expansion shims of proper thickness are placed between the ends of the rails as they are laid. These are usually angular, as shown in Fig. 17, with two legs of different thicknesses for two different temperatures. The thickness should be stamped on each piece. As a rail is laid a shim is dropped into the joint and the rail pushed against it. The shim should remain in place until the joint is fully bolted.

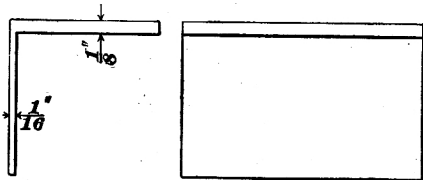


FIG. 17

46. Ballasting.

After the ties have been placed on a proper subgrade and the rails laid and fastened, the ballast is distributed from a train of flat cars or dump cars on the new track, but the train should move only at low speed. The track is then raised by jacks to bring the ties from 4 to 6 inches above the subgrade, and the ballast is shoveled and tamped under the ties. The process is repeated until the required depth of ballast is obtained. For this work grade stakes are set and marked to indicate the grade of the top of the rail in the finished track. Grade stakes should be placed at intervals of about 16 feet. A straightedge placed on these stakes marks the grade for the intervening points.

The placing of grade stakes so close together is contrary to common practice, but the increased labor by the engineer is more than compensated for by the saving of the time ordinarily consumed in sighting when grade stakes are set at inter-

vals of 50 or 100 feet. The surface will be better where a straightedge can be brought into use, and the danger of kinking rails or bending them out of surface is obviated.

47. Ballast Cross-Section.—Stone or washed-gravel ballast is usually filled in level with the tops of the ties and

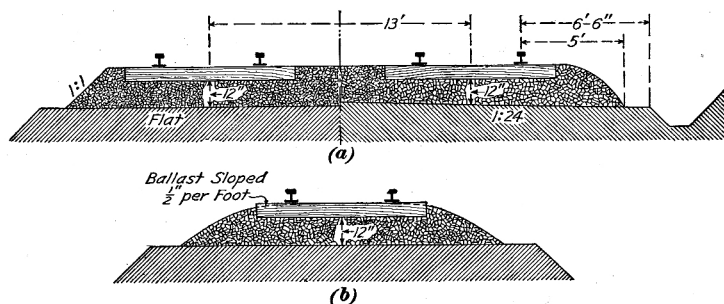


FIG. 18

extended as a shoulder about 1 foot beyond their ends and then sloped down to the subgrade, as shown on the left side in Fig. 18 (a), but sometimes it is rounded off from the ends of the ties, as shown on the right side. Ordinary gravel, however, is usually sloped from the middle of the track to about 2 or 3 inches below the tops of the ties at their ends, so as to be clear of the rail base as shown in (b). This allows water to

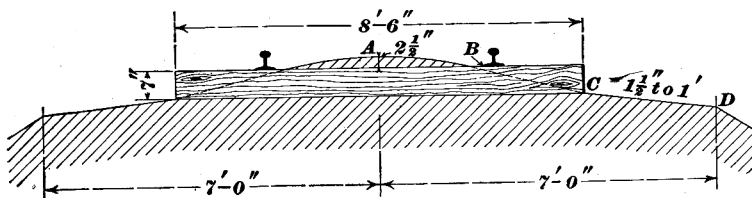


FIG. 19

drain away rapidly as it does not percolate through gravel so freely as through broken stone. Sand is sometimes finished level with the tops of the ties, as it drains readily. With earth ballast or cementing gravel which gives very poor drainage, the ballast is filled in about $2\frac{1}{2}$ inches above the ties at the center, as shown at A, Fig. 19, and is then sloped to pass

under the rails at *B* and reach the bottom of the ties at their ends, in order to give a steep slope to carry off the water. Beyond the ties there is a sloping shoulder *CD* to the edge of the embankment or ditch. With this arrangement the ballast has very little hold on the tie, and, consequently, the track is not suitable for high speeds.

LAYING CURVED TRACK

48. Curve Ordinates.—As previously explained, the center line of curved track is marked by stakes at intervals of

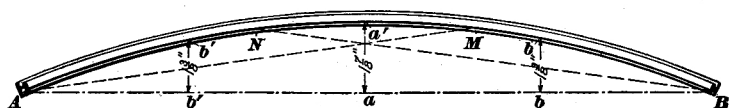


FIG. 20

25 or 50 feet and the positions of the rails at these points can be readily determined by means of a track gauge. The rails must be bent to form a smooth curve and their positions between stakes are best found by measuring ordinates from chords.

The *middle ordinate* of a curve for a given chord length is the perpendicular distance from the middle point of the chord to the curve. Thus, the middle ordinate of the curved rail *AB*, Fig. 20, is the distance *aa'* from the middle point of the line joining the gauge sides of the rail head at *A* and *B* to the gauge side at *a'*. The value of the middle ordinate of a circular curve can be calculated closely by means of the formula

$$m = \frac{c^2}{8R} \quad (1)$$

in which m = middle ordinate, in feet;

c = length of rail, in feet;

and R = radius of curve, in feet.

The middle ordinates in inches for various lengths of rail and degrees of curve are given in Table X.

The perpendicular distances from the chord to the curve at the quarter points are called *quarter ordinates*. Thus, in Fig. 20, *Ab'* and *Bb* are each equal to $\frac{1}{4}$ *AB* and the distances

$b'b'$ and bb are the quarter ordinates for the length of rail AB . The quarter ordinates are always equal to three-fourths of the length of the middle ordinate; if q is the quarter ordinate,

$$q = \frac{3}{4}m \quad (2)$$

EXAMPLE.—Find the middle and quarter ordinates of a 30-foot rail for an 8° curve.

SOLUTION.—The radius of an 8° curve is 716.78 ft. By formula 1,

$$m = \frac{30^2}{8 \times 716.78} = \frac{900}{5,734.24} = .157 \text{ ft.} = 1\frac{7}{8} \text{ in. Ans.}$$

By formula 2, $q = \frac{3}{4} \times 1\frac{7}{8} = 1\frac{1}{2}$ in., or, say $1\frac{3}{8}$ in. Ans.

TABLE X
MIDDLE ORDINATES FOR CURVING RAILS

Degree of Curve	Length of Rail, in Feet					
	30	28	26	24	22	20
	Middle Ordinate, in Inches					
1	$\frac{1}{4}$	$\frac{3}{16}$	$\frac{3}{16}$	$\frac{3}{16}$	$\frac{1}{8}$	$\frac{1}{8}$
2	$\frac{1}{2}$	$\frac{7}{16}$	$\frac{3}{8}$	$\frac{5}{16}$	$\frac{1}{4}$	$\frac{3}{16}$
3	$\frac{11}{16}$	$\frac{5}{8}$	$\frac{9}{16}$	$\frac{7}{16}$	$\frac{3}{8}$	$\frac{5}{16}$
4	$\frac{15}{16}$	$\frac{13}{16}$	$\frac{11}{8}$	$\frac{5}{8}$	$\frac{1}{2}$	$\frac{7}{16}$
5	$1\frac{3}{16}$	$1\frac{1}{16}$	$\frac{7}{8}$	$\frac{3}{4}$	$\frac{5}{8}$	$\frac{9}{16}$
6	$1\frac{7}{16}$	$1\frac{1}{4}$	$1\frac{1}{16}$	$\frac{7}{8}$	$\frac{3}{4}$	$\frac{5}{8}$
7	$1\frac{5}{8}$	$1\frac{7}{16}$	$1\frac{1}{4}$	$1\frac{1}{16}$	$\frac{7}{8}$	$\frac{3}{4}$
8	$1\frac{7}{8}$	$1\frac{5}{8}$	$1\frac{7}{16}$	$1\frac{3}{16}$	1	$\frac{7}{8}$
9	$2\frac{1}{8}$	$1\frac{7}{8}$	$1\frac{5}{8}$	$1\frac{3}{8}$	$1\frac{1}{8}$	$1\frac{15}{16}$
10	$2\frac{3}{8}$	$2\frac{1}{16}$	$1\frac{3}{4}$	$1\frac{1}{2}$	$1\frac{1}{4}$	$1\frac{1}{16}$
11	$2\frac{5}{8}$	$2\frac{1}{4}$	$1\frac{15}{16}$	$1\frac{11}{16}$	$1\frac{3}{8}$	$1\frac{1}{8}$
12	$2\frac{13}{16}$	$2\frac{1}{2}$	$2\frac{1}{8}$	$1\frac{13}{16}$	$1\frac{9}{16}$	$1\frac{1}{4}$
13	$3\frac{1}{16}$	$2\frac{11}{16}$	$2\frac{5}{16}$	$1\frac{15}{16}$	$1\frac{5}{8}$	$1\frac{3}{8}$
14	$3\frac{5}{16}$	$2\frac{7}{8}$	$2\frac{1}{2}$	$2\frac{1}{8}$	$1\frac{3}{4}$	$1\frac{1}{2}$
15	$3\frac{9}{16}$	$3\frac{1}{16}$	$2\frac{11}{16}$	$2\frac{1}{4}$	$1\frac{15}{16}$	$1\frac{9}{16}$
16	$3\frac{3}{4}$	$3\frac{1}{4}$	$2\frac{13}{16}$	$2\frac{3}{8}$	$2\frac{1}{16}$	$1\frac{11}{16}$
17	4	$3\frac{1}{2}$	3	$2\frac{9}{16}$	$2\frac{3}{16}$	$1\frac{3}{4}$
18	$4\frac{3}{16}$	$3\frac{11}{16}$	$3\frac{3}{16}$	$2\frac{11}{16}$	$2\frac{5}{16}$	$1\frac{7}{8}$
19	$4\frac{7}{16}$	$3\frac{7}{8}$	$3\frac{3}{8}$	$2\frac{7}{8}$	$2\frac{7}{16}$	2
20	$4\frac{11}{16}$	4 $\frac{1}{8}$	$3\frac{9}{16}$	3	$2\frac{9}{16}$	$2\frac{1}{8}$

49. Curving Rails.—For tracklaying, the rails are usually curved at the storage yard by means of a roller bender, the rails being pulled through by a cable or the rolls being driven by power. For bending rails on the work and also for straightening kinked rails, a screw bender, or *jim crow*, is generally used. This device, Fig. 21, consists of a heavy U-shaped frame with hooked ends *a* and *b* that fit over the head of the rail. Through the end of the frame, at *c*, passes the end of a screw *d*, the opposite end of which is supported by the guide *e*. By the long-handled wrench *f* the rail is forced outwards

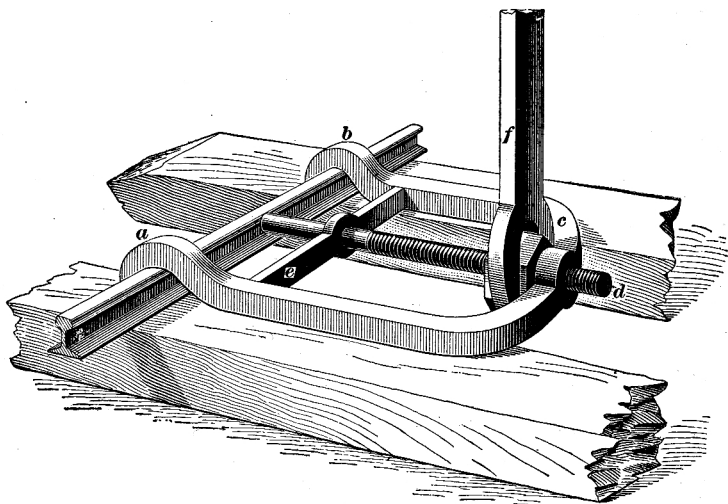


FIG. 21

between the hooks to the amount required. The bender is shifted along the rail to curve it from end to end.

If the end *A* is correctly located, the rail *AB*, Fig. 20, can be laid to the proper curvature by stretching a string from the gauge sides of the rail head at *A* and *B* and making the middle and quarter ordinates equal to the calculated values. For sharp curves or for long rails, it is usually better to curve part of the rail, about 20 feet long, by stretching the string between *A* and *M*, and then to shape the remainder by holding the string between *N* and *B*.

50. Widening Gauge on Curves.—In traveling on curved track the car wheels tend to ride hard against the outer rail because the line of wheelbase forms a chord with the rail instead of being parallel to it. As the axles remain parallel with each other and cannot be radial to the curve, there is a slipping and lateral sliding action of the wheels. The pressure against the rails may be resisted by rail braces, as described, but to make the cars ride easily, the gauge of track is widened on sharp curves. This widening may be $\frac{1}{8}$ inch for each 2 degrees, beginning with 9 degrees and reaching a maximum of $\frac{3}{4}$ inch for curves of 19 and 20 degrees. For example, on an 18° curve, the widening is $\frac{18-8}{2} \times \frac{1}{8} = \frac{5}{8}$ inch. When a guard-rail is placed on straight track, its head should be $1\frac{3}{4}$ inches from that of the track rail, but on curves where the gauge is widened, this space must be increased by the amount of gauge widening. On curves a special form of track gauge is used to show the proper widening due to curvature.

51. Length of Inner and Outer Rails.—Since the radius of the outer rail on a curve is greater than that of the inner rail, the length of the former must also be greater. For this reason, a number of rails 6 inches or 2 feet shorter than the standard length are supplied on the tracklaying train for use in the inner side of curves in order to maintain the joints in their proper positions relative to those in the outer rail. These short rails must be laid in proper order to insure correct positions of the joints. In general one $29\frac{1}{2}$ foot rail per 100 feet will be used for each 6 degrees of curvature. This difference in length between the inner and outer rails of a track may be determined by one of the two following rules, the first one being for light curves laid to standard gauge and the second for sharp curves with widened gauge.

Rule I.—*Multiply the degree of the curve by the length in stations of 100 feet, and this product by $1\frac{1}{32}$; the result will be the difference in length between the inner and the outer rail, in inches.*

Rule II.—Multiply the distance between the center lines of the rails by the length of the curve, in feet, and divide the product by the radius of the track curve; the quotient is the required difference in length, expressed in feet.

EXAMPLE 1.—The degree of a curve is 4° and the length is 520 feet. What is the difference in length between the inner and outer rails of the curve?

SOLUTION.—Since the curvature is less than 9° , the standard gauge is used and rule I applies. The length of the curve in stations of 100 ft. is 5.2. Then the difference in length between the rails is $4 \times 5.2 \times 1\frac{1}{2} = 21.45$ in. = 1.788 ft. Ans.

EXAMPLE 2.—A 15° curve is 387 feet in length. If 100-pound A. R. E. A. rails are used, find the difference in length between the inner and outer rails.

SOLUTION.—The curvature is greater than 9° and, therefore, the gauge must be widened. The difference between 15° and 8° is 7° ; since the widening is $\frac{1}{8}$ in. for each 2° , it is $\frac{1}{2}$ in. for 7° . The width of the head of a 100-lb. A. R. E. A. rail is found from Table III to be $2\frac{1}{2}$ in. Hence, the distance between the center lines of rails is 4 ft. $8\frac{1}{2}$ in. + $2\frac{1}{2}$ in. + $\frac{1}{2}$ in. = 4 ft. $11\frac{1}{8}$ in. = 4.974 ft. The radius of a 15° curve is 383.06 ft. Then, by rule II, the difference in length of rails is

$$\frac{4.974 \times 387}{383.06} = 5.025 \text{ ft. Ans.}$$

52. Superelevation on Curves.—On curved track the outer rail must be elevated above the inner rail, a track level being used to give the proper superelevation. As shown in Fig. 22,

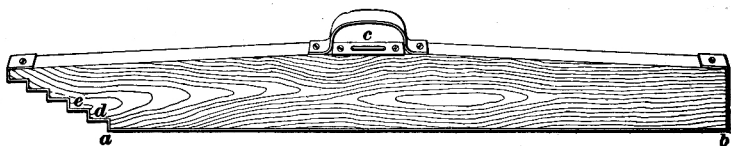


FIG. 22

this device consists of a straightedge ab with $\frac{1}{2}$ -inch steps d and e at one end, and a spirit level c to indicate when the edge ab is horizontal. On straight track the edge ab is placed on both rails and the bubble of the spirit level is brought to the center of the tube. For a curved track with a superelevation of 1 inch, the end b is laid on the inner rail, and the second step e is placed on the outer rail; then the bubble is centered by adjusting the height of the outer rail.

A cross-section on curved track is shown in Fig. 23. The subgrade is finished level, but the depth of ballast below the

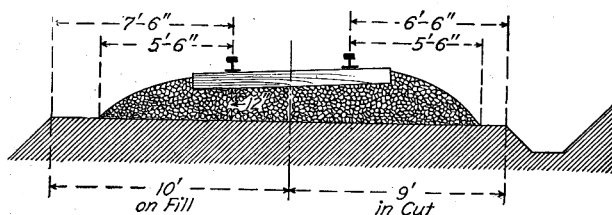


FIG. 23

ties is made 12 inches under the inner rail, and the ties are sloped so that the outer rail has the proper superelevation.

EXAMPLES FOR PRACTICE

1. Find the difference in length between the inner and outer rails of a 3° curve 1,480 feet long. Ans. 3.816 ft.

2. The rails on a 12° curve, 220 feet long, are 120-pound A. R. E. A. sections. Find: (a) the widening of the gauge; and (b) the difference in length of the inner and outer rails.

Ans. $\begin{cases} (a) \frac{1}{4} \text{ in.} \\ (b) 2.290 \text{ ft.} \end{cases}$

3. By formulas 1 and 2, Art. 48, and also by Table X, find the middle and quarter ordinates to the following rails. (a) Rail length is 20 feet; degree of curve is 10° . (b) Rail length is 30 feet; degree of curve is 6° .

Ans. $\begin{cases} (a) \text{ By formulas: } aa' \text{ is } 1.05 \text{ in.; } bb \text{ is } .79 \text{ in.} \\ \quad \text{By Table X: } aa' \text{ is } 1\frac{1}{8} \text{ in.; } bb \text{ is } \frac{13}{16} \text{ in.} \\ (b) \text{ By formulas: } aa' \text{ is } 1.41 \text{ in.; } bb \text{ is } 1.06 \text{ in.} \\ \quad \text{By Table X: } aa' \text{ is } 1\frac{1}{8} \text{ in.; } bb \text{ is } 1\frac{1}{8} \text{ in.} \end{cases}$

MAINTENANCE OF TRACK

53. Definition.—Maintenance work includes keeping the track in line and surface, with bolts and spikes tight, ballast properly tamped and shaped, and other parts in proper condition. It includes also the replacing of worn or defective material, and the general care or policing of track.

54. Shimming.—Track that is badly drained or has poor ballast will heave in winter owing to the action of frost in the roadbed or ballast. In order to make a regular surface, the

heights of the rails are adjusted by placing shims between the rails and the low ties. These shims are pieces of hardwood of uniform thickness, cut in different sizes from $\frac{1}{4}$ inch upwards. A spike hole is bored in each shim in order to prevent splitting. The shimming must be carried far enough on each side of the high spot to give an easy grade. If the track continues to heave, additional shims must be placed.

In case the required height of shims is over $\frac{1}{2}$ inch, the thin shims must be replaced with thicker ones; long spikes also should be used and rail braces placed outside the rails. Care must be taken to maintain shimmed track in gauge, surface, and line. During a thaw and when the frost is leaving the ground the shims should be removed gradually, the upper ones being taken out first. As soon as the frost is gone for the season and the water has drained from the roadbed, all the shims are removed.

55. Surfacing.—As traffic causes the track to settle at certain points, the low spots must be brought up to grade. For

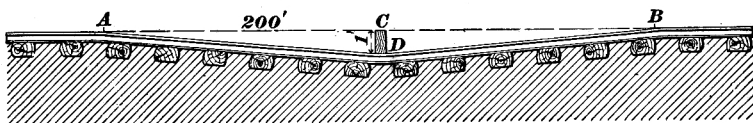


FIG. 24

this work the spikes and bolts must first be made tight. Then part of the ballast is removed from between the ties, the track is raised by jacks to the proper level and the ballast is tamped firmly under the ties. *Surfacing out of a face* means surfacing the track continuously over a certain length instead of at isolated spots. This should be done on about one-fourth of each track section annually, so that the entire section will be gone over once every 4 years.

When a large depression, or sag, occurs in the track, it may be necessary to place additional ballast. To find the amount required, a stake is driven at the lowest point C, Fig. 24, with its top in line with the normal track surface at A and B. The volume of ballast in cubic feet is equal to the product of one-half the distance AB, the top width of the embankment, and

the height CD of the stake above the rail. To find the volume in cubic yards, this product is divided by 27. For example, if the distance AB , Fig. 24, is 200 feet, the top width is 14 feet, and the height CD is 1 foot, the material required to fill the depression is $\frac{200}{2} \times 14 \times 1 \times \frac{1}{27} = 52$ cubic yards.

56. Raising Track.—When the new material has been placed between the rails, the track is raised to the proper grade by the use of a sighting board. Sighting by eye alone is not good practice on a main track. The sighting board is 1 in. $\times$ 4 in. and 5 feet long and has two notches 3 inches deep to fit over the rails. It is placed across the track to be raised at a point about eight or ten rail lengths ahead of the point where the raising is to begin and is shimmed up so that its top is level and at the elevation to which the rail is to be lifted. This position is determined by sighting from the top of the fixed rail at one end of the depression to the fixed rail at the other end and bringing the top of the sighting board to the grade between them. Then the foreman takes his position 50 to 75 feet behind the track which is being raised and sights from the fixed track to the sighting board. The intervening track is raised to the desired height by using two jacks under each rail, a heavy one at the joint and a light one at the center. A rail center should not be raised until the jack is in place at the next joint. The two jacks on each rail and the two opposite rails are then raised together, the two sides being kept at the same level by means of a track level. This prevents the bending of the rails and insures a smooth surface. When the sighting board is reached, it is removed and the track is brought to the proper height by sighting along the rails.

57. Surfacing on Curves.—Special care must be taken to maintain curved track in good condition, as low spots will cause the cars to lurch heavily to the low side. The superelevation of the outer rail must be kept accurate and uniform.

58. Lining Track.—After the track has been brought to grade, it should be lined up from the engineer's center stakes

by means of the track gauge. For ordinary maintenance work straight track may be lined by sighting, as follows: With both rails firmly spiked to gauge, one line of rails is taken as the line rail. The foreman sighting along this rail can readily detect swings or irregularities, which are corrected by the men shifting the rail and track by means of lining bars. With his back to the sun and with pebbles placed on the line rail at intervals, the foreman can straighten the track by sighting. After taking out the long swings by sighting from as great a distance as his eyesight permits, the foreman stands from 60 to 90 feet away to direct the men in removing the smaller irregularities.

59. Lining Curves.—Curves that are irregular or badly out of line should be reset by the engineer, but in ordinary

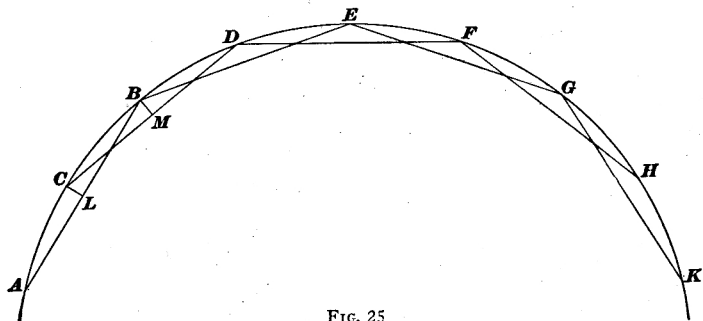


FIG. 25

work lining by means of a cord will give good results. This method is shown in Fig. 25. A stretch of 60 feet of curve that appears to be in good line is selected and center stakes are accurately placed at the ends *A* and *B* and midway between them at *C*. A cord is stretched between *A* and *B* and the distance from *C* to its middle point *L* is measured. The distance *CL* is the middle ordinate for a 60-foot chord. The middle point is marked on the cord and the end of the cord is moved from *A* to *C*. Then the cord is stretched from *C* in such a direction that the ordinate from the middle point *M* to *B* is equal to the middle ordinate *CL*. The other end of the cord locates the track center at *D*. If the center of the track

is not at *D*, the track is shifted. The end of the cord is then moved to *B*, the middle ordinate is measured from *D*, and the next point on the center of track is located at *E*. This method can be used only for circular curves; line for a transition curve must be given by the engineer.

60. Renewing Ties.—The life of ties is so variable, even for ties of the same species and the same lot, that renewals have to be made of occasional ties rather than of all the ties on a stretch of track. Tie renewals average 350 per mile per year for untreated ties and 200 for treated ties. Careful inspection of track is made in the fall, and ties bad enough to need renewal are marked. The foreman's marking and estimates may be checked by the roadmaster, to provide against excessive removal, which would result in high cost and additional work in restoring the track to its normal condition. New ties are distributed usually from trains and are piled beside the track to be carried to place by the section cars when required. With a mixed lot of ties the hardwood and larger ties may be unloaded at curves and the softwood ties on straight line. Before the work is undertaken the track should be put in good line and gauge.

To renew a tie, the spikes are removed and those on the next two or three are loosened, the rails being then raised slightly on these ties by means of a bar and held up by placing wedges or spikes under the rail base. The ballast on each side of the tie is loosened, and the tie is pulled out. After the old bed is leveled, the new tie is slipped into place, the rail is lowered upon it, and the tie is held up to the rail by bars while the spikes are being driven. Finally, the tamping is finished and the spikes of the adjacent ties are driven down. If ties are renewed during the surfacing of the track, the spikes may be drawn from all bad ties in a rail length and the track then jacked up while the poor ties are removed and new ones put in place.

61. Renewing Rails.—New rails being distributed along the track should not be thrown off the car, but slid down skids or lowered by a crane or hoisting device. The new rails may

be put in place one at a time, or they may be loosely bolted up in strings placed along the ends of the ties. The former method is used as a rule where traffic is heavy and where track cannot be closed to traffic. With the second method, during a long interval between trains or with the track temporarily closed to traffic, a corresponding stretch of old rail is unspiked and shifted toward the middle of the ties. After the rail seats have been dressed to an even surface, and the old spike holes plugged, the string of new rails is thrown into place with bars, the joints are adjusted, and the rails are lined and spiked in place. Expansion shims are placed between the rail ends in the string of new rails to insure the proper joint spacing.

62. Renewing Ballast.—When track is to be newly ballasted, the old material between and outside the ties should be removed and used to widen the shoulder of the roadbed. A layer of old stone ballast, however, may be cleaned by handling with forks and then put back again. A layer of ballast is plowed or dumped from cars and the track is raised by jacks to allow this material to be tamped under the ties.

63. General Care of Track.—Besides keeping the track and ditches in good condition, some attention must be given to the appearance of the track and the right of way. Weeds must be removed from the ballast since they interfere with its proper drainage; grass, weeds, and brush on the right of way should be cut; and the roadbed shoulder should be trimmed and kept clear. Old ties and scrap iron must be picked up and disposed of as required, the scrap being stored conveniently outside the section houses ready for delivery to a work train.

64. Track Inspection.—On main lines, one of the section men walks over the entire length of the section every day, to see that the track is in safe condition. The foreman is required to go over his section at least once a week, and the roadmaster or supervisor goes over his division at least once a month. The division engineer makes an inspection each spring and fall, examining the track, bridges, and culverts, the drainage of cuts and roadbed, and the general condition of the railway.



TRACKWORK

(PART 2)

Serial 3061B

Edition 1

TURNOUTS

SWITCHES AND FROGS

SWITCHES

1. Introduction.—Since the wheels of trains are flanged on the inner side in order to hold them on the rails, a special arrangement is necessary to divert and guide the wheels from one track to another. This diversion or transfer is effected by a *turnout* connecting the two tracks, as shown in Fig. 1, in which *MN* represents the main line and *WS* is a side track. A turnout is sometimes called a *switch*, but, properly speaking, the switch is only one part of the turnout. The principal parts of a turnout are: (a) a movable *switch* *ABCD* to guide the wheels to one track or the other; (b) a *frog* *ab* at the intersection of the rails of the two tracks to provide for the passage of the wheel flanges; and (c) the *lead rails* connecting the switch with the frog.

2. Types of Switches.—There are two general types of track switches, namely, the *split*, or *point*, *switch* and the *stub switch*. The point switch, *ABCD* in Fig. 1, is used almost exclusively; the stub switch, Fig. 2, has several important disadvantages and is, therefore, employed only to a limited extent for unimportant sidings and industrial tracks. The explanations in this Section refer chiefly to the point switch.

3. Parts of Switch.—The main parts of a switch are two switch rails *AB* and *DC*, Figs. 1 and 2; in a point switch, these

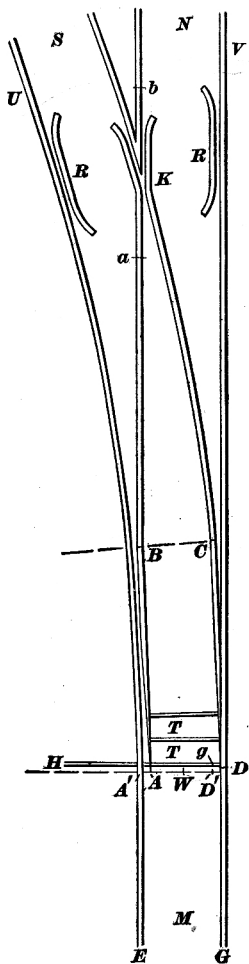


FIG. 1

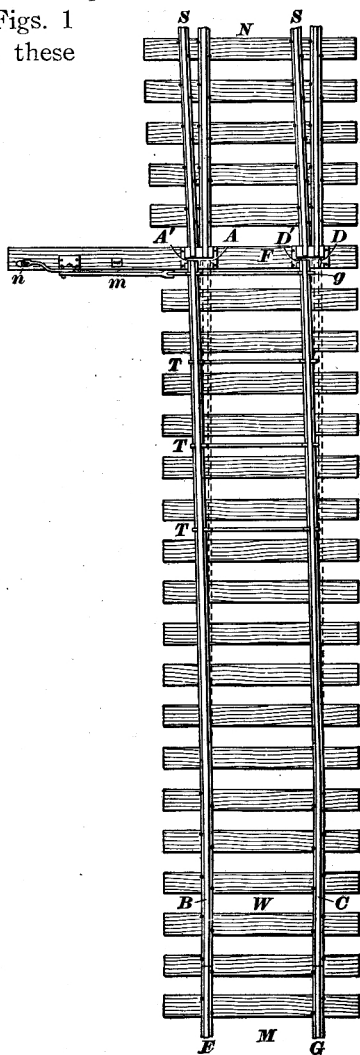


FIG. 2

rails are sometimes called *point rails*. The heel of switch is at the fixed ends of the switch rails, *B* and *C*. The toe of switch is at the movable ends of the switch rails, *A* and

D. The switch rails are connected at the toe by means of tie-rods T so as to move simultaneously in a lateral direction. The end tie-rod g is called the *head-rod* or *No. 1 rod*; it extends outside the rails and is connected to a device for moving the switch.

The point of switch is the point where the center line of the turnout meets the center line of the main track, as W in Figs. 1 and 2. Thus, the point of switch is at the heel in a stub switch and at the toe in a split switch.

The distance AA' or DD' through which the switch rails move at the head-rod is called the *throw of switch*; the American Railway Engineering Association recommends a throw of 5 inches. The distance from the main-track rail to the switch rail at the heel of switch is called the *heel distance*. It is measured between the gauge sides of the rails and is usually from $5\frac{1}{2}$ to $6\frac{1}{2}$ inches to allow room for spiking the rails.

The switch angle is the angle between the main-track rail and the switch rail, as VDC in Fig. 1 and DCD' in Fig. 2.

4. Facing and Trailing Switches.—When a train is running in such a direction that it passes the switch before reaching the frog, as in running from M to N , Fig. 1, it is said to *face* the switch, and the switch is called a *facing switch*. A train running in the opposite direction, from N to M , is said to *trail* the switch, and the switch is then a *trailing switch*. On double-track lines, practically all switches for sidings can be arranged as trailing switches; then trains to be sidetracked will run in the direction opposite that usually proper on the main track and thus back into the siding. This avoids the possible chance of diverting a train from its course by a facing switch in the wrong position.

5. Switch Construction.—The usual construction of a point switch, together with the operating mechanism, is shown in Fig. 3. The point rails CC' and DD' are usually straight and from 12 to 30 feet long, depending on the angle of turnout. The head of each is planed away at the toe to form a tapering end or tongue so as to fit closely against one of the fixed rails, or *stock rails*, AA' or BB' , for a length of 6 to 12

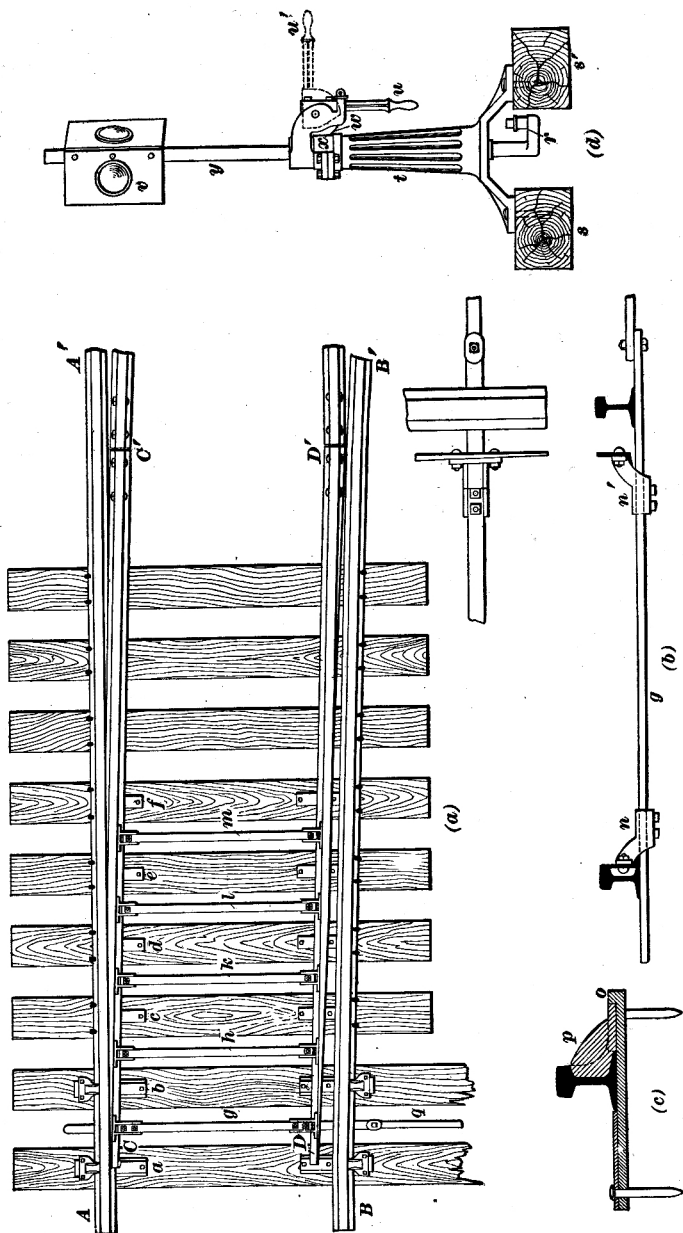


FIG. 3

feet. The switch rails are not planed to a very fine edge, but are usually $\frac{1}{4}$ inch thick at the movable ends. It is not necessary to consider the theoretical point where the direction of the switch rail intersects the stock rail, because the length of the switch rail is measured to the actual point, and the actual point is placed opposite the point of switch.

Near the ends of the switch rails their outer flanges are cut away so that the tongue will rest on the flange of the stock rail, as shown in Fig. 4. At the extreme points the tops of the heads of the switch rails are also planed away on an incline so that the wheel treads *AB* will not come in contact with the rails until the flanges reach a thicker and stronger part that is better able to stand the blows and pounding of the wheels. The thin point or tongue may be strengthened by a reinforcing bar or an angle riveted along the web.

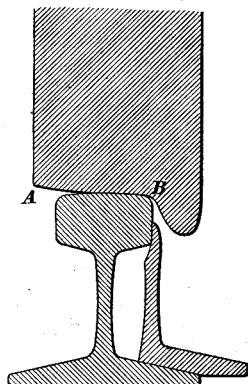


FIG. 4

As a protection to the point of the switch rail, the turnout stock rail *EU*, Fig. 1, is given a slight outward bend or knuckle just in advance of the point and then bent outwards to conform to the turnout curve. This knuckle is formed with a rail bender. Its distance ahead of the point is about as given in Table I.

TABLE I
LOCATION OF KNUCKLE

Length of switch rail, feet.....	11	15	16 $\frac{1}{2}$	24	30
Distance from point to knuckle, inches.....	7	8	9	13	16 $\frac{1}{4}$

6. Switch Operation.—In Fig. 1 the switch is shown in position for the turnout, so that a train moving from *M* will travel toward *S*. Thus, the flanges of wheels on the right-

hand rail will be guided away from the main line by the switch rail DC , while the flanges of the wheels on the left-hand rail will pass through the open space between the switch rail AB and the turnout rail EU .

When the switch is set so that a train moving from M will be guided along the main track to N , the switch rail BA will be in the position BA' with the tapered end against the stock rail EU , and the switch rail CD will be in the position CD' so as to leave an opening or flangeway for the wheel flanges.

The operation of moving the switch from one position to the other is called *throwing the switch*. Switches may be thrown mechanically by suitable connections from a switch tower or by hand by means of a device called a *switchstand* placed at the turnout. The splice joints at B and C , Fig. 1, are sufficiently flexible to allow the switch rails AB and DC to move with respect to the lead rails BK and CK .

A long tie called a *headblock* is placed at the point of switch and projects far enough to support the switchstand and thus maintain it in proper position relative to the switch. Sometimes the headblock consists of two long ties placed close together to give a more substantial support to the switch points and the switchstand, and also to protect the head-rod which is placed between the two ties as shown in Fig. 3 (a).

For easy and proper movement, the switch must be in good condition, but the passage of traffic tends to disturb the track and loosen the parts. It is important, therefore, to maintain the switch in good line and level and to keep all bolts tight and all movable parts properly adjusted.

7. Slide Plates.—To protect the ties from wear by the moving switch rails and to give these rails a firm bearing surface on which they will slide easily, steel slide plates, a to f in Fig. 3 (a), are placed under the stock rails and switch rails. These plates are spiked to the ties and are kept well greased. They may be shaped to form lugs fitting against the base of the stock rail; or they may be fitted with rail braces supporting the outer side of the stock rail, as at op in (c).

8. **Switchstands.**—A common form of a switchstand is shown in Fig. 3 (*d*). The stand *t* is mounted on the ends of two long ties *s* and *s'* forming the headblock, and carries a vertical shaft *y*, having at its upper end a target *v* and at its lower end a crank *r* to which the switch connecting-rod *q*, view (*a*), is attached. The target *v* consists of two rectangular pieces of sheet iron fastened to the shaft at right angles to each other. The two pieces are painted in different colors and the position of the target indicates whether the switch is set for the main track or for the turnout. Various forms and colors are used for targets. A handle *u* is pivoted to a casting *w* on the shaft. In its vertical position, this shaft is inoperative and may be locked to a lug on the stand. To

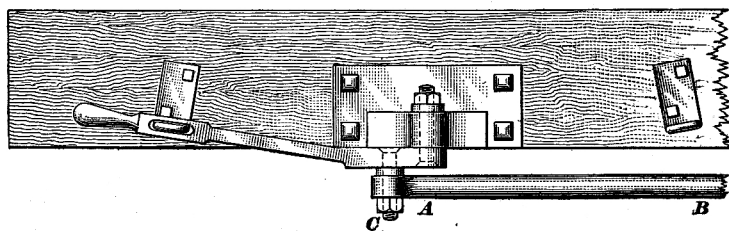


FIG. 5

throw the switch, the handle is first raised to the horizontal position *u'*; this brings its inner end into engagement with a lug *x*, so that when the handle is moved in a horizontal plane the shaft is turned and the positions of the target *v* and the crank *r* are changed. At night a lamp is placed on the top of the shaft.

Switchstands of this type are used both for main-track and yard switches, but sometimes with a taller shaft for the target. Short, or dwarf, switchstands are used at crossovers and yards. A simple form of a switchstand, known as the *ground lever*, or *drop lever, switchstand*, for use on unimportant tracks, is shown in Fig. 5. The switch connecting-rod *AB* is attached to a pin *C* on a hand lever pivoted in a casting on the headblock. When the lever is turned vertically through a half circle so that its slotted handle fits over the staple on the plate at the

right, the rod AB is forced to the right, moving the switch rails correspondingly. Such a switchstand is shown in position in Fig. 2 where n

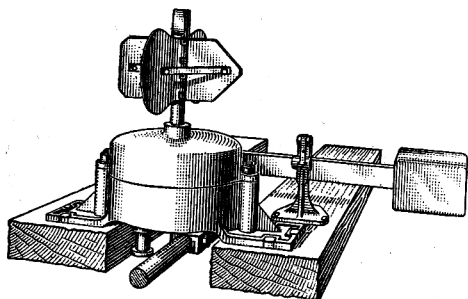


FIG. 6

is the lever, m is the connecting-rod, g is the head-rod, and F is the headblock. In a better design, shown in Fig. 6, the lever moves parallel with the rails.

9. Safety, or Automatic, Switches and Switchstands.—

It is sometimes desirable to arrange a point switch so that trains may trail through it when misplaced without breaking it. This may be provided for by placing a spring in the head-rod con-

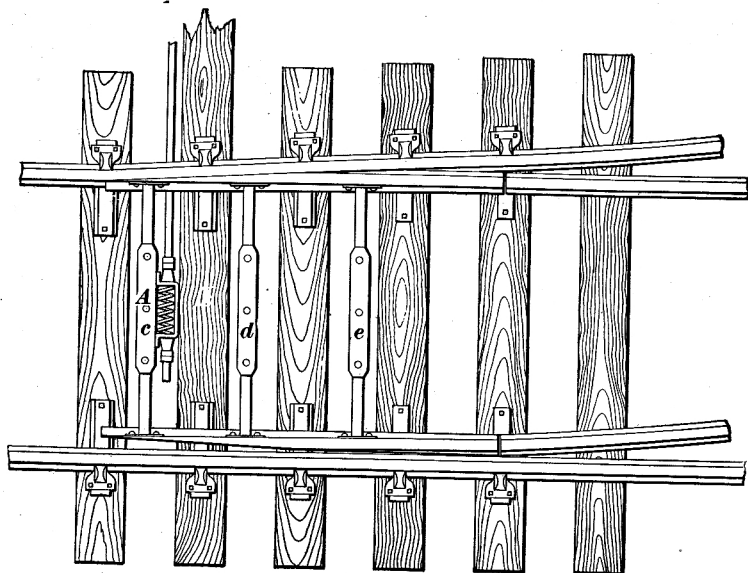


FIG. 7

nections, as at A , Fig. 7. The spring is stiff enough to throw the switch in ordinary operation, but allows the connection to

be moved by the severe force applied by the wheels of trains. This device is known as a *safety switch*. The spring returns the switch rails to position after each wheel has trailed through the switch and, therefore, the following wheel must force the switch rail open again. After the train has passed the switch is in the same position as before. Automatic switchstands have springs between the shaft and the connecting-rod, and may be so arranged that when the wheels force the switch rails over, the springs will throw the switch to the open position, the target and lamp also indicating the new position. In this case all the following wheels have an unobstructed passage through the switch, instead of having to force the switch rail open. After the train has passed, the switch is in the opposite position to what it was before.

10. Stub Switch.—The stub switch, shown in Fig. 2, is now used little, especially in important tracks, its limited use being confined mainly to the cheaper kind of work in yard and industrial tracks. No tapered switch rails are used, but at the turnout the two stock rails BA' and CD' are left loose on slide plates so that their ends may be shifted laterally to line up with either the main track or the turnout rails.

At the heel the switch rails are spliced to the main-track rails E and G . Their toes rest on plates, called *head-chairs*, which are spiked to the headblock F , and are formed with sockets to receive the ends of the bases of the main-track rails at A and D and the turnout rails at A' and D' . In Fig. 2, the switch is shown in position for the turnout WS . To set it for the main track MN the rails are thrown to the right to the positions indicated by the dotted lines. The rails are connected by tie-rods T , so that they move as a unit when the switch is thrown.

11. Comparison of Switches.—The point switch has great advantages over the stub switch in stability and safety. When a point switch is set for either track, the guiding rails are held firmly against the stock rails and form an unbroken

path in the desired direction. Thus, since there is little vibration and no slackness or lost motion, trains may pass at full speed in safety. For the turnout track, the speed will be limited to that which is safe for the turnout curve. A misplaced point switch does not lead to derailment. If a train trails through a misplaced switch the wheel flanges will usually force the switch rail open, while, if it runs through a misplaced facing switch, it will only be diverted to the wrong track.

A stub switch is necessarily much less finely adjusted than a point switch. A fairly wide gap must be left between the ends of the fixed and switch rails to allow for variations in temperature, and, even if the two rails are in good line, there will be a severe shock as each wheel crosses this gap. As a result, there is much vibration and noise, the cars are jolted, the switch parts are loosened, and the rail ends are battered so that the rails must be cut and refitted frequently. As the switch rails are less securely held than in the point switch, the stub switch is less safe for high-speed trains. The most serious objection, however, is the danger of derailment by a misplaced switch. It will be seen that when a main-line train comes from *N*, Fig. 2, the wheels will run off the ends of the rails at *A* and *D*. Or with the switch set for the main track, a train from the siding would be derailed.

12. Tie-Rods and Head-Rods.—Five switch rods or tie-rods *g* to *m* are shown in Fig. 3 (*a*), but it is more general practice to use only one or two rods in addition to the head-rod *g*. As shown in (*b*), the head-rod *g* is attached to the switch rails by means of sockets *n* and *n'* so shaped that the rod can pass under the rails for attachment to the extension rod or connecting-rod *q*, view (*a*). This rod connects the switch with the crank *r* on the shaft of the switchstand shown in (*d*). Common forms of tie-rods are shown in Fig. 8; the lugs *m* and *n* are about 5 inches long and are bolted firmly to the webs of the switch rails. The tie-rod shown in (*a*) is hinged, so as to cause it to operate more easily; an unhinged form is shown in (*b*). The tie-rod in (*c*) is shown in position in the track at *d* and *e*, Fig. 7. This form is bent downwards nearly to a level

with the top of the tie, where it is less exposed to injury from derailed cars or from broken parts of the cars, such as brake rods or beams, which, dragging on the ties, frequently catch in switch rods and do much harm. The form shown in Fig. 8 (d) is used only with stub switches; the tie-rods are slipped over the ends of the rails, and fastened into place by hammering down the free ends of the prongs on the rail flanges.

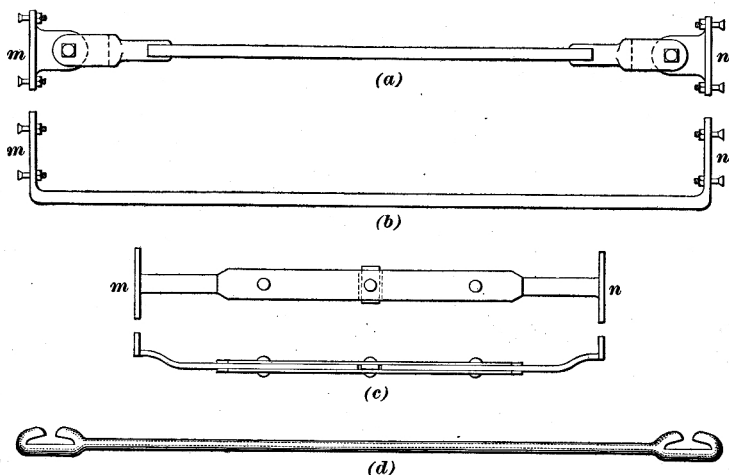


FIG. 8

When the form in (a) or (b) is used for the tie-rods, the head-rod may be of the form shown in Fig. 3 (b); when the form in Fig. 8 (c) is used for the tie-rods, the head-rod is as shown at c in Fig. 7, but the spring is used only for automatic switches. A stub-switch head-rod is shown in position at g, Fig. 2.

13. Lead Rails.—It will be observed that the right-hand stock rail, *GV*, Fig. 1, continues unbroken along the main track, while the left-hand stock rail *EU* continues unbroken along the side track or turnout. The lead rails *KB* and *KC* connect the frog *ab* with the switch rails and complete the two continuous tracks; they are known as the *straight lead rail* and *curved lead rail*, respectively. Obviously, the curved lead rail must be slightly longer than the straight rail. Ordi-

narily, the rails must be cut to different lengths, but in spring-rail frogs, the difference in length may be made up in the frog. The difference in length will usually be from 1 to $4\frac{1}{2}$ inches.

FROGS

14. Frog Construction.—At the intersection of the rails in a turnout, as at *K*, Fig. 1, it is necessary to provide gaps or openings to permit the wheel flanges to pass through or across either line of rails, and at the same time to give as nearly as possible a continuous bearing for the treads of the wheels. These requirements are effected by a combination of rails and castings built up to form a *frog*, the main elements of which are shown in Fig. 9. To guide the wheels and hold them in

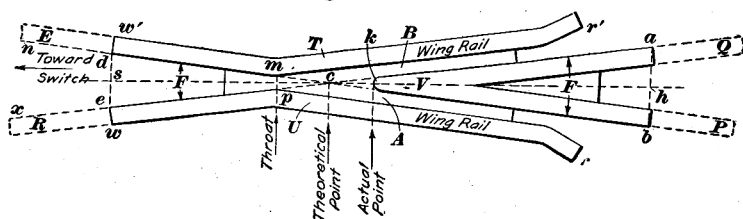


FIG. 9

line so that their flanges will pass through the proper opening of the frog, guard-rails *R*, Fig. 1, are provided opposite the frog. Thus with a car moving on the diverging branch or turnout to *S*, the left guard-rail will hold the flange of each left-hand wheel close against the rail *EU* and insure that the flange on the opposite wheel will pass in the groove to the left of the frog point. On the other hand, if the switch is set for the main track, the right guard-rail will hold the flange of each right-hand wheel close against the rail *GV*, so that the flange on the opposite wheel will pass in the groove to the right of the frog point.

In Fig. 9, *RQ* is the line of the inner rail of the main track and *EP* is the line of the outer rail of the side track or turnout. The two lead rails *E* and *R* stop at the frog, their ends being bent out to form flaring wings on either side of the pointed piece *V* that is connected to the ends of the two track rails *P* and *Q*.

With a main-track train coming from the switch, at the left, the wheel flanges ride against the gauge side of the rail head from x to p , the tread of the wheel rolling on top of the rail. From p the flange is forced to pass through the groove or flangeway B along the line pa , being prevented from entering the channel A or striking the point V by the guard-rail which holds the wheel on the other end of the axle against the opposite rail. The tread rolls across the rail head at U and across the groove A to the point V . The wheel then continues along to the main rail Q , with its flange riding along the side a of the rail head.

If a train is entering the turnout, the flanges of the outer wheels ride against the gauge side of the rail head from n to m , passing through the groove A , while the treads of the wheels pass across the rail head at T and the other groove B to the point V and continue on to P . Each wheel is kept in line as it passes through the frog by means of the wheel on the other end of the axle, which is held against the opposite rail by the guard-rail.

15. Parts of Frog.—In Fig. 9, the wedge-shaped or triangular center portion of the frog at V is known as the *tongue*, or *frog point*. Its blunt end k is called the *actual point of frog*, while the intersection of the gauge lines ac and bc at c is the *theoretical point of frog*. The bent ends wr and $w'r'$ of the lead rails are the *wing rails*. The *throat* is the narrowest part of the flangeway or groove at mp ; it is usually $1\frac{3}{4}$ or $1\frac{7}{8}$ inches wide. The *toe of frog* is the end ww' nearer the switch, and the opposite end ab is the *heel of frog*.

16. Types of Rigid Frogs.—In rigid frogs there are no movable parts. As a rule, the frog is built up of rails of the same section and weight as those of the main track, planed and bent to shape and bolted or clamped together. The rails forming the point are riveted. Fillers in the throat and flangeways fit between the webs of the rails and give the proper width of groove. A filler block is also fitted between the rails that form the frog point. As the point and throat are subjected to severe wear, they are often made of hard

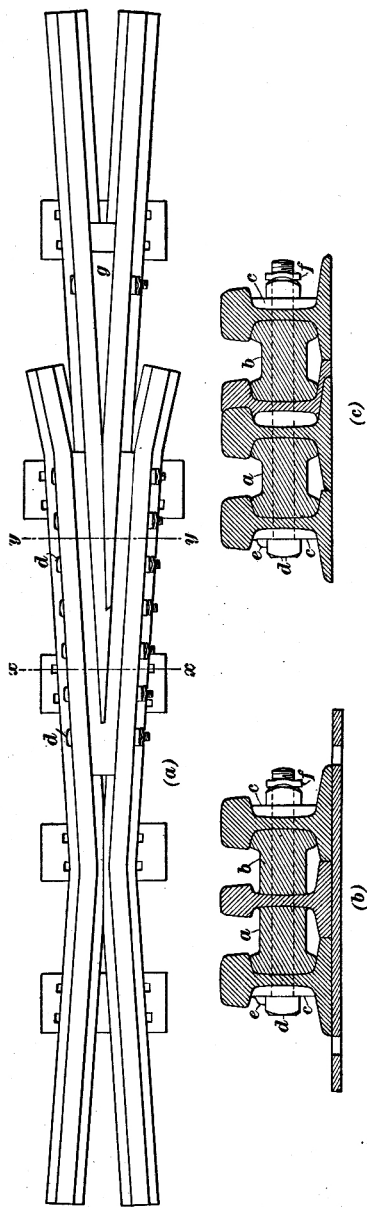


FIG. 10

manganese-steel castings, the rails forming the remainder of the frog being shaped to fit the castings, and the parts are securely bolted together.

Frogs which are put together with bolts through the rail webs and the fillers, as shown in Fig. 10, are the most widely used. In (a) is a plan view; and in (b) and (c) are the sections at xx and yy , respectively. The fillers a and b and the washers c are shaped to fit against the rails, and the parts are held together by means of the bolts d . Nutlocks e and f are used to prevent the bolts from becoming loose. Bolted frogs may be strengthened by base plates riveted under the rails.

Clamped or keyed frogs, Fig. 11, are also used extensively. In this type of frogs the pieces of rails a and b in (a), forming the tongue, are dovetailed together and secured by heavy rivets. To retain the full strength and durability of the steel, the parts except the wings are fitted without heating; the wings, however, are bent at a very

low heat. The parts are bound by heavy wrought-iron clamps *c* and *d*; a cross-section through the first clamp is shown in (b), and one through the second clamp, in (c). Each clamp is bent at one end to fit the brace-block *k* on the outside of the rail, and at the other end to fit the beveled key *e*, which is driven into the space between the end of the clamp and the smaller brace-block *l* to tighten the clamp. The keys lie on the flange of the rail, which prevents them from dropping down in case they loosen. The flangeway between the frog point and the wing rails is maintained by iron throat-pieces *g*, *h* that fit the rails per-

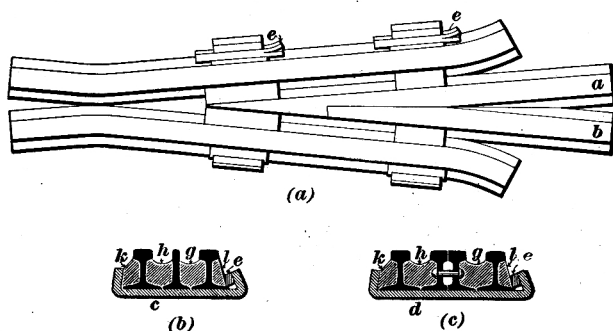


FIG. 11

fectly and, extending to the point, thoroughly brace it against lateral stresses. After the keys are driven to the extent necessary to bind the parts solidly together, the split ends are spread to prevent the keys from working out.

A stiffer form of a clamp is a thin deep plate notched out for the rails and placed on edge in a vertical plane instead of laid flat as in Fig. 11. For light track, a *plate frog* having the rails riveted directly to a base plate the full length and width of the frog is sometimes used. Flangeway fillers are dispensed with in the plate frog.

17. Spring-Rail Frogs.—At many turnouts one track is used much more than the other or carries faster trains than the other, and, therefore, it is desirable to reduce the shock and wear on one side of the frog. In such cases a spring-rail frog is used, in which the main-track rail *pr*, Fig. 9, is hinged between *w* and *p* and is held normally in contact with the side

cb of the frog point by means of a spring. The wheels of main-line trains have then a continuous bearing, with no gap or

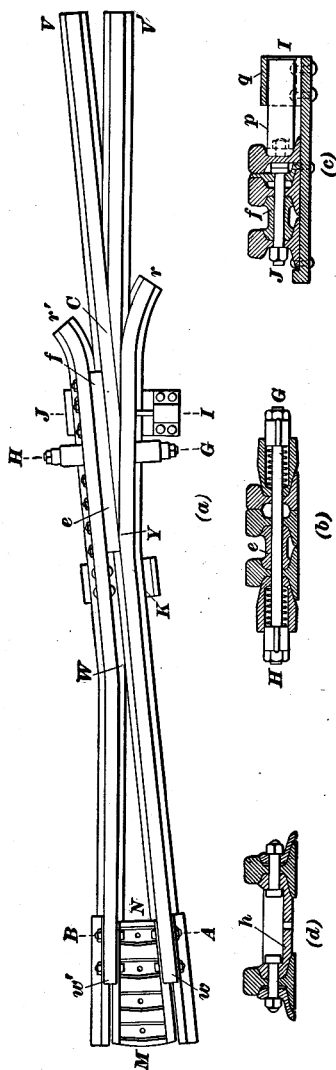


FIG. 12

flangeway to be crossed between the spring rail and the frog point. This causes the trains to ride more smoothly and relieves wear of the track and wheels. When a train on the turnout reaches the frog, the wheel flanges force out the wing rail pr and thus open the flangeway A .

In the spring-rail frog shown in Fig. 12 (a), the frog point is at Y . The fixed wing rail $w'r'$ has the usual flangeway filler ef ; sections through GH and IJ are shown in (b) and (c). On the opposite side is the spring rail or movable wing rail wr , which is normally held against the frog point Y by the two springs and the through bolt GH as shown in (b). When a train comes from V' , the flange of each wheel will wedge between C and r , forcing the spring rail outwards so that the wheel flange can pass on to W , the throat of the frog. As soon as the wheel has passed the frog point, the springs return the wing rail into position. With a train running from w' to V' , each

wheel flange will strike the wing rail at W and force it open so that the flange can pass on the right-hand side of the frog

point. The flange cannot travel from w' to V , since the wheel on the other end of the axle is held over toward the right by the guard-rail, as explained in the discussion on rigid frogs.

At the toe of the frog, the ends of the frog rails and the lead rails are bolted to the anchor block MN in (a) as shown in (d), which is a section through AB . The anchor block, which is the U-shaped frame h , is spiked to the ties to hold the frog in place. Vertical movement or play of the spring rail is prevented by the lug p in (c) that is riveted to the rail web and slides in the collar or socket q on the base plate. A stop or lug, K in (a), limits the movement of the spring rail so that the width of opening or flangeway cannot exceed $1\frac{7}{8}$ inches at the frog point.

18. Frog Guard-Rails.—As already explained, guard-rails are placed close to the track rails opposite the frog in order to hold the wheels in line to pass through the frog properly. The length is usually 10 or 15 feet, the rails being bent out at the ends to give an easy entrance to the flangeway. It is well to have the guard-rail resting on tie-plates that also carry the track rail, and to bolt the two rails together with the necessary spacing blocks between the webs in order to insure a permanent and uniform width of flangeway of $1\frac{7}{8}$ inches. The outer flange of the guard-rail must be cut away so that the proper flangeway may be secured.

19. Continuous-Rail Frogs.—Since the frog is a weak point in the track and a cause of wear and expense to track and rolling stock, different forms of construction have been devised to provide continuous or unbroken rails in the main track at turnouts where the branch track is relatively less important. In general, this is done by raising the curved or turnout lead-rail CK , Fig. 1, beyond the heel of switch at such an inclination as to carry the wheels high enough to allow the flanges to pass over the main rail. The turnout rail beyond the frog is raised to the same height. The gap left in the turnout rail may be closed by a hinged rail or casting, which stands clear of the main rail when the switch is set for the main track. This device is operated in connec-

tion with the switch, so that when the switch is thrown for the turnout the hinged rail is swung across the main rail to provide a continuous bearing for wheels on the turnout.

20. Easer Rails.—The treads of the wheels wear down rapidly near the flanges and, as a result, the outer edge of the tread on an old wheel forms a projection similar to a flange which is termed a *false flange*. When the wheel crosses a frog this projection strikes the wing rail, as at T or U in Fig. 9, and jars the rail and the rolling stock. In order to carry the projection across the wing rail and thus reduce the battering, a short rail called an *easer rail*, is bolted outside of, and close against, the wing rail.

21. Heel Blocks.—The false flange on the edge of a worn wheel also causes trouble when it drops between the rails forming the tongue of the frog and tends to wedge them apart. This difficulty is relieved by bolting a heel block g , Fig. 10, between the tongue rails. The surface of this block slopes downwards toward the heel of the frog so that the wheels are raised or lowered gradually.

DIMENSIONS OF TURNOUTS

FROG DIMENSIONS

22. Frog Angle and Frog Number.—The angle acb , Fig. 9, between the gauge lines of the tongue of the frog is called the *frog angle*. This is also equal to the angle dce between the gauge lines produced beyond c . The frog angle is represented by F .

Since xca is the gauge line of the inner rail of the main track, and $n cb$ is the gauge line of the outer rail of the side track, the frog angle is also equal to the angle between the two tracks.

The distance ab between the gauge lines at the end of the tongue is called the *heel width* or *spread at heel*; the distance de is called the *toe width* or *spread at toe*. If sch is the bisector of the angle F , the distance ch is called the *length of frog*.

The ratio of the length to the heel width is called the *frog number*, and is usually denoted by N ; that is,

$$N = c h \div a b$$

The relation between N and F is found as follows:

$$N = \frac{c h}{a b} = \frac{\frac{1}{2} c h}{a h}$$

But in the triangle $a c h$,

$$\cot a c h = \cot \frac{1}{2} F = \frac{c h}{a h}$$

Therefore, if this value is substituted in the expression for N ,

$$N = \frac{1}{2} \cot \frac{1}{2} F \quad (1)$$

Then,

$$\cot \frac{1}{2} F = 2 N \quad (2)$$

Frogs are designated by their numbers; thus, a No. 8 frog is one in which $N = 8$.

Although formulas 1 and 2 are easily applied, it is convenient to make use of a table such as Table II, that gives the frog angle

TABLE II

FROG NUMBERS WITH CORRESPONDING FROG ANGLES AND THEIR TRIGONOMETRIC FUNCTIONS

Frog Number N	Frog Angle F Deg. Min. Sec.	Nat. sin F	Nat. cos F	Log sin F	Log cos F	Log cot F
4	14 15 00	.24615	.96923	9.39120	9.98642	.59522
5	11 25 16	.19802	.98020	9.29670	9.99131	.69461
6	9 31 38	.16552	.98621	9.21884	9.99397	.77513
7	8 10 16	.14213	.98985	9.15268	9.99557	.84288
8	7 9 10	.12452	.99222	9.09522	9.99660	.90138
9	6 21 35	.11077	.99385	9.04442	9.99732	.95289
9½	6 1 32	.10497	.99448	9.02107	9.99759	.97652
10	5 43 29	.09975	.99501	8.99891	9.99783	.99892
11	5 12 18	.09072	.99588	8.95770	9.99820	1.04050
12	4 46 19	.08319	.99653	8.92007	9.99849	1.07842
15	3 49 6	.06659	.99778	8.82343	9.99904	1.17561
16	3 34 47	.06244	.99804	8.79544	9.99915	1.20371
18	3 10 56	.05551	.99846	8.74438	9.99933	1.25494
20	2 51 51	.04997	.99875	8.69869	9.99946	1.30076
24	2 23 13	.04165	.99913	8.61959	9.99962	1.38003

corresponding to each frog number, and also the trigonometric functions of this angle.

EXAMPLE 1.—Find the frog angle of a No. 7 frog.

SOLUTION.—In this case $N=7$, and from formula 2,

$$\cot \frac{1}{2} F = 2 \times 7 = 14$$

Therefore, $\frac{1}{2} F = 4^\circ 5' 8''$, and $F = 8^\circ 10' 16''$. Ans.

The same result can be taken directly from Table II.

EXAMPLE 2.—If the frog angle is 7° , what is the frog number?

SOLUTION.—From formula 1,

$$N = \frac{1}{2} \cot \frac{7^\circ}{2} = \frac{1}{2} \cot 3^\circ 30' = 8.2$$

However, standard frogs are made in whole numbers and, unless a special frog is to be made to order, a No. 8 frog would be used.

This problem can be solved directly by Table II. In the second column it is found that 7° lies between $6^\circ 21' 35''$ and $7^\circ 9' 10''$, the angles corresponding to a No. 9 and a No. 8 frog, respectively. However, as a standard frog is to be used, it is not necessary to interpolate in the table. The standard frog angle nearest to 7° is $7^\circ 9' 10''$; this corresponds to a No. 8 frog. Ans.

23. Finding Number of Frog by Measurement.—The number of a frog may be found by measurement, as follows. In Fig. 9,

$$ch = ah \cot \frac{1}{2} F$$

$$cs = ds \cot \frac{1}{2} F$$

Therefore, by addition,

$$ch + cs = (ah + ds) \cot \frac{1}{2} F$$

$$= \left(\frac{ab}{2} + \frac{de}{2} \right) \cot \frac{1}{2} F$$

But $ch + cs = sh$; and, from the preceding article, $\frac{1}{2} \cot \frac{1}{2} F = N$. Therefore,

$$sh = (ab + de)N$$

whence

$$N = \frac{sh}{ab + de}$$

If the whole distance sh and the widths ab and de are measured on the frog and their values substituted in this formula, the result will be the frog number. By this method, N may be found much more accurately than by attempting to measure

ch and ah on the frog, because the theoretical point c cannot be accurately found in practice.

EXAMPLE.—The distance sh was measured on a frog and found to be 17 feet 6 inches. The heel width ab was $12\frac{1}{2}$ inches, and the toe width de was $6\frac{1}{2}$ inches. What was the frog number?

SOLUTION.—When the values are substituted in the formula,

$$N = \frac{17 \text{ ft. } 6 \text{ in.}}{12.5 \text{ in.} + 6.5 \text{ in.}} = \frac{210 \text{ in.}}{19 \text{ in.}} = 11. \quad \text{Ans.}$$

24. Selection of Frog Numbers.—Although there is a great range in frog numbers, it is best to use as few numbers as possible for simplicity and for economy in renewals. Numbers 8, 10, and 12 are used largely in main-track turnouts; number 16 is used if trains move at high speed, as where switch and signal interlocking plants are installed. Numbers 18

TABLE III
LENGTHS OF SWITCH RAILS

Frog Number	Length of Switch Rail, in Feet
4 to 7 or 8	11 or 15
8 to 10	15 or $16\frac{1}{2}$
12 to 16	22 or 24
20 to 24	30 or 33

and 20, or even 24, are used at the ends of double tracks or where trains pass from one track to a nearby parallel track at high speed. Numbers 6, 7, and 8 are used largely in yards and industrial tracks. Numbers less than 7 should be used only where necessary.

The length of the switch rail varies with the frog number about as given in Table III.

EXAMPLE FOR PRACTICE

Solve the following problems both by the formulas and by the table:

(a) If $N=6$, find F .

(b) If $N=9$, find F .

(c) If $F=5^{\circ} 44'$, find N .

(d) If $F=5^{\circ}$, find N .

Ans. $\left\{ \begin{array}{l} (a) 9^{\circ} 31' 38'' \\ (b) 6^{\circ} 21' 35'' \\ (c) 10 \\ (d) 11 \end{array} \right.$

TABLES FOR TURNOUTS

25. Lead.—The *lead* is the distance measured along the center line of the main track from the actual point of switch to the point of frog; sometimes the theoretical point of frog is considered and sometimes the actual point is used. The length of the straight lead rail from the heel of switch to the toe of frog is called the *closure of straight rail*, and the length of arc of the curved lead rail from the heel of switch to the toe of frog is the *closure of curved rail*.

Theoretically, the curved lead rail should be bent to a simple circular curve, to which the switch rail is tangent at the heel of switch and the frog rail is tangent at the toe of frog. For such a condition the lead is called the *theoretical lead*. However, if the theoretical lead were used, the closure of both straight and curved rails would be a number of feet and a fraction or decimal of a foot. In order to make one of the closure rails full feet without a fraction, and thus avoid cutting one of the rails, the theoretical lead is modified. If it is desired to increase the lead, a short tangent is introduced at the heel of switch; if it is desired to decrease the lead, a short tangent is placed at the toe of the frog. For the modified condition the lead is called the *practical lead*. The curved lead rail is bent to a simple circular curve, but its radius is slightly different from that for the theoretical lead.

26. Table for Turnouts With Split Switches.—Computing the dimensions of the several elements of a turnout involves such complicated and tedious work that it is usual to obtain these dimensions from prepared tables. Theoretical and practical leads and other dimensions for split-switch turnouts with frog numbers from 4 to 24 are given in Table IV. These values, which are for track with a standard gauge of 4 feet 8½ inches, have been adopted by the American Railway Engineering Association.

In columns 1 to 7 are given the dimensions of the frogs corresponding to the various frog numbers. The thickness of the actual frog point *k*, Fig. 9, is taken as ½ inch in all cases. The values in columns 8 to 14 are for the theoretical lead.

The thickness at the point of switch and the heel distance are assumed to be $\frac{1}{4}$ inch and $6\frac{1}{4}$ inches, respectively. For these conditions, the closures of both straight and curved rails contain decimals of a foot. The distance in column 12 from the point of switch rail to the theoretical point of frog is the theoretical lead.

In columns 15 and 16 are given the radius and the degree of curve for the practical lead, while the values in columns 17 to 22 are for use in bending the curved lead rail to the desired curvature. For instance, for a No. 8 frog, one quarter point of the curved lead rail is placed by measuring 28.37 feet from the point of switch, and 1.02 feet from the gauge side of the stock rail; the center point is located by measuring 39.91 feet from the point of switch and 1.78 feet from the stock rail; and the other quarter point is found by measuring 51.45 feet from the point of switch and 2.91 feet from the stock rail.

The other values required to lay out a turnout are also given in the table. In columns 23 and 24 are found the tangent distances, introduced at the heel of switch or at the toe of frog, to give the practical leads. The practical leads to the theoretical point of frog and to the actual point of frog are in columns 25 and 26, respectively. The difference between the theoretical lead and the practical lead can be seen by comparing columns 12 and 25. When the practical lead is greater than the theoretical lead, the tangent distance T_s is introduced at the heel of switch; on the other hand, when the practical lead is less than the theoretical lead, the tangent distance T_f is introduced at the toe of frog. Columns 27 and 28 give the lengths of lead rails to be used. Thus, for a No. 8 frog, the straight lead rail is composed of one rail 30 feet long and one rail 16.40 feet long, and the curved lead rail consists of one rail 30 feet long and one rail 16.60 feet long. It is desirable to have the rails of approximately equal length, and rails shorter than 10 feet should not be used.

EXAMPLE.—Find the dimensions of a split-switch turnout with a No. 12 frog.

SOLUTION.—From column 25 of Table IV, the length of lead from the point of switch to the theoretical point of frog is found to be 100.30 ft.

TABLE IV—DIMENSIONS OF TURNOUTS WITH SPLIT SWITCHES

Properties of Frogs							Properties of Switches			Theoretical Leads					
Frog Number <i>N</i>	Frog Angle <i>F</i>	Length Theoretical Point to Toe <i>W</i>		Length Theoretical Point to Heel <i>K</i>		Total Length of Frog	Spread at Toe	Spread at Heel	Length of Switch Rail <i>S</i>	Switch Angle <i>A</i>	Radius of Center Line <i>R</i>	Degree of Lead Curve <i>D</i>	Distance From Point to Theoretical Point of Frog	Closure for Straight Rail	Closure for Curved Rail
		Ft.	In.	Ft.	In.										
1	2	3	4	5	6	7	8	9	10	11	12	13	14		
	Deg.	Min.	Sec.	Ft.	In.	Feet	Ft.	In.	Deg.	Min.	Sec.	Feet	Feet		
4	14 15 00	3 2	5 4	8 6	.79	1.32	11 0	2 36 19	112.26	52 53 56	37.05	22.88	23.29		
5	11 25 16	3 7	6 5	10 0	.71	1.28	11 0	2 36 19	183.22	31 40 24	42.77	28.19	28.55		
6	9 31 38	4 0	7 0	11 0	.66	1.16	11 0	2 36 19	273.95	21 01 58	48.11	33.11	33.38		
7	8 10 16	4 5	8 1	12 6	.63	1.15	16 6	1 44 11	364.88	15 47 19	61.94	41.02	41.24		
8	7 09 10	4 9	8 9	13 6	.59	1.09	16 6	1 44 11	488.71	11 44 40	67.47	46.22	46.42		
9	6 21 35	6 0	10 0	16 0	.67	1.11	16 6	1 44 11	616.27	9 18 27	72.24	49.74	49.92		
9½	6 01 32	6 0	10 0	16 0	.63	1.05	16 6	1 44 11	699.97	8 11 33	74.90	52.40	52.58		
10	5 43 29	6 0	10 6	16 6	.60	1.05	16 6	1 44 11	790.25	7 15 18	77.51	55.01	55.17		
11	5 12 18	6 0	11 6	17 6	.54	1.05	22 0	1 18 8	940.21	6 05 48	92.06	64.06	64.20		
12	4 46 19	6 5	12 1	18 6	.53	1.01	22 0	1 18 8	1,136.34	5 02 38	97.25	68.83	68.96		
15	3 49 06	7 8	14 10	22 6	.51	.99	33 0	0 52 5	1,744.45	3 17 06	130.50	89.83	89.94		
16	3 34 47	8 0	16 0	24 0	.50	1.00	33 0	0 52 5	2,005.98	2 51 24	135.95	94.95	95.05		
18	3 10 56	8 10	17 8	26 6	.49	.98	33 0	0 52 5	2,587.66	2 12 52	146.38	104.54	104.61		
20	2 51 51	9 8	19 4	29 0	.48	.97	33 0	0 52 5	3,262.98	1 45 22	156.35	113.68	113.76		
24	2 23 13	11 4	23 2	34 6	.47	.97	33 0	0 52 5	4,932.77	1 09 42	175.09	130.66	130.77		

TABLE IV—(Continued)

Practical Leads										Practical Leads									
Frog Number	Radius of Center Line R	Degree of Lead Curve on Center Line D	Rectangular Coordinates to the Quarter and Center Points on Gauge Side of Curved Rail, Referred to Point of Switch Rail as Origin						Tangent Adjacent to Switch Rail T_s	Tangent Adjacent to Frog T_f	Lead Actual Point to Theoretical Point of Frog L_t	Lead Actual Point to Actual Point of Frog L_a	Closure for Straight Rail	Closure for Curved Rail					
			X	X ₁	X ₂	Y	Y ₁	Y ₂											
1	15	16	Feet	17	18	19	20	21	22	23	24	25	26	27	28				
	Feet	Deg. M'n. S'c.	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Number and Length of Rails	Number and Length of Rails				
4	110.69	53 42 24	17.74	23.44	29.75	.97	1.67	2.79	1.03	.00	37.77	37.94	1-23.60	1-24	1-24				
5	174.34	33 19 57	17.78	24.54	31.27	.95	1.61	2.62	.00	.82	42.26	42.47	1-27.68	1-28	1-28				
6	265.39	21 43 04	19.07	27.13	35.15	1.01	1.74	2.72	.00	.66	47.73	47.98	1-32.73	1-33	1-33				
7	362.08	15 52 29	26.72	36.93	47.11	.97	1.71	2.74	.00	.19	61.81	62.10	1-13.89	1-27	1-14.11				
8	487.48	11 46 27	28.37	39.91	51.45	1.02	1.78	2.91	.30	.00	67.65	67.98	1-16.40	1-30	1-16.60				
9	605.18	9 28 42	28.75	40.98	53.19	1.02	1.76	2.75	.00	.57	71.91	72.28	1-16.41	1-33	1-16.59				
9½	695.45	8 14 45	30.31	43.35	56.37	1.06	1.82	2.83	.76	.00	75.32	75.71	1-25.82	1-27	1-26				
10	790.25	7 15 18	30.28	44.05	57.81	1.06	1.84	2.85	.00	.00	77.51	77.93	1-27	1-28	1-27.17				
11	922.65	6 12 47	40.74	56.47	72.19	1.08	1.84	2.87	2.99	.00	93.85	94.31	1-32.85	1-33	2-33				
12	1,098.73	5 12 59	43.99	60.65	77.28	1.15	1.90	2.91	5.33	.00	100.30	100.80	1-23.88	2-24	3-24				
15	1,743.80	3 17 10	55.49	77.98	100.45	1.01	1.78	2.84	.09	.00	130.56	131.19	1-29.89	2-30	3-30				
16	1,993.24	2 52 29	58.16	81.76	105.35	1.04	1.82	2.87	1.56	.00	136.90	137.57	1-29.90	2-33	1-30				
18	2,546.31	2 14 31	58.73	84.46	110.10	1.04	1.82	2.86	.00	1.08	145.76	146.51	1-25.93	3-26	4-26				
20	3,257.26	1 45 32	61.84	90.21	118.59	1.08	1.88	2.93	.44	.00	156.59	157.42	1-26.92	2-27	3-27				
24	4,886.16	1 10 21	67.82	100.21	132.59	1.27	1.97	3.00	2.43	.00	176.22	177.22	1-32.89	3-33	4-33				

The length of frog from the point to the toe is 6 ft. 5 in. or 6.42 ft. (column 3), and the length of switch rail is 22 ft. (column 8). As given in columns 27 and 28, the straight lead rail will be made up of two rails 24 ft. long and one rail 23.88 ft. long, and the curved lead rail will be made up of three 24-ft. rails. The tangent distance at the heel of switch is 5.33 ft. (column 23), and the coordinates of the quarter and center points for bending the curved lead rail can be taken from columns 17 to 22.

27. Table for Turnouts With Stub Switches.—Dimensions for turnouts with the little-used stub switch are given in Table V. In a stub switch, it is assumed that the switch rail, lead rail, and frog form a continuous circular curve from the

TABLE V
DIMENSIONS OF STUB-SWITCH TURNOUTS

Track Circular From Heel of Switch to Point of Frog. Throw = 5½ Inches							
Frog Number N	Frog Angle F	Lead to Theoretical Point of Frog L	Radius of Center Line R	Degree of Lead Curve D	Chord From Heel of Switch to Point of Frog Q	Length of Switch Rails S	Length of Frog Theoretical Point to Toe W
1	2	3	4	5	6	7	8
	Deg. Min. Sec.	Feet	Feet	Deg. Min.	Feet	Feet	Feet
4.0	14 15 00	37.67	150.67	38 46	37.96	11.73	3.17
5.0	11 25 16	47.08	235.42	24 32	47.32	14.65	3.58
6.0	9 31 38	56.50	339.00	16 58	56.69	17.64	4.00
7.0	8 10 16	65.92	461.42	12 26	66.08	20.53	4.42
8.0	7 9 10	75.33	602.67	9 31	75.48	23.48	4.75
9.0	6 21 35	84.75	762.75	7 31	84.88	26.43	6.00
9.5	6 1 32	89.46	849.85	6 45	89.58	27.97	6.00
10.0	5 43 29	94.17	941.67	6 5	94.28	29.37	6.00
11.0	5 12 18	103.58	1,139.42	5 2	103.68	32.31	6.00
12.0	4 46 19	113.00	1,356.00	4 14	113.10	35.17	6.42

heel of switch to the point of frog. The frog angle F is the same as for a split switch. The lead L is the distance from the heel of switch to the theoretical point of frog. The radius R and degree D of the center line of the lead curve are given in the fourth and fifth columns. The sixth column gives

the length Q of the chord from the gauge side of the outer rail at the heel of switch to the point of frog. When the switch is set for the main track the switch rails are straight, and when the switch is thrown for the turnout the switch rails are assumed to conform to the curvature of the lead curve. The length S of the switch rails required to join the lead curve with a throw of $5\frac{1}{2}$ inches is given in column 7. A switch rail longer than 30 or 33 feet is impracticable. For a shorter switch rail, the rail may be of standard length but left free only for the given distance from the head-chair, the remaining part of the rail being securely spiked to the ties. The last column of the table gives the length of frog from the theoretical point to the toe.

EXAMPLE.—Find the dimensions of a stub-switch turnout with a No. 6 frog.

SOLUTION.—From the third column of Table V the lead is 56.5 ft., and, from the fourth column, the radius of the center line of the turnout curve is 339 ft. The length of the switch rails from column 7 is 17.64 ft., and the distance from the point of frog to the toe is 4 ft. Therefore, the length of straight lead rail equals $56.5 - 17.64 - 4 = 34.86$ ft. As this is longer than the usual length of rail, two rails of approximately equal length should be used. The chord of the turnout rail from the heel of switch to the point of frog is found from column 6 to be 56.69 ft. The length of the curved lead rail equals $56.69 - 17.64 - 4 = 35.05$ ft. As the rails are assumed to form a continuous circular curve, the curved lead rail can be laid out by quarter and middle ordinates from the chord.

EXAMPLES FOR PRACTICE

1. Find from Table IV the dimensions of a point-switch turnout with a No. 16 frog.

$$\text{Ans. } \begin{cases} L_1 = 136.9, W = 8, S = 33, T_s = 1.56, \text{ straight} \\ \text{lead rail (1-29.9 and 2-33), and curved lead} \\ \text{rail (1-30 and 2-33).} \end{cases}$$

2. Find from Table V the dimensions of a stub-switch turnout with a No. 8 frog.

$$\text{Ans. } \begin{cases} L = 75.33, R = 602.67, S = 23.48, W = 4.75, \\ Q = 75.48, \text{ straight lead rail} = 47.1, \text{ and} \\ \text{curved lead rail} = 47.25. \end{cases}$$

TURNOUT CONSTRUCTION

28. Turnout Ties and Switch Timbers.—Occasionally a turnout is laid on ordinary ties alternating with the main-track ties, but the usual plan is to use timbers long enough to carry all four rails. The long ties should be used from the point of switch to a point far enough beyond the frog to allow the side track to be laid on ordinary ties, clear of the main-track ties. Headblocks may be 9 in. by 12 in., 16 feet long, and the switch timbers are 7 in. by 9 in. These timbers are usually spaced 19 or 20 inches between centers, and under the frog the spacing is 18 inches. The ties increase in length as they get farther from the switch, the ends of all being in line outside of the unbroken rail of the main track. The lengths usually increase by 6 inches, several ties in a group having the same length. For ordinary track-ties $8\frac{1}{2}$ feet long, the maximum length of switch timber is 16 feet 6 inches and for 8-foot ties, the longest timbers are 15 feet 6 inches. In a turnout with a No. 11 frog and $8\frac{1}{2}$ -foot track-ties, the list of timbers recommended by the American Railway Engineering Association is given in Table VI.

TABLE VI
SWITCH TIMBERS FOR NO. 11 TURNOUT

Timbers	Length Ft. In.	Timbers	Length Ft. In.	Spacings
2 headblocks	16 0	4.....	13 0	10 of 19 in.
12 timbers....	9 0	4.....	13 6	21 of 20 in.
10.....	9 6	3.....	14 0	9 of 19 in.
8.....	10 0	3.....	14 6	13 of 20 in.
5.....	10 6	2.....	15 0	5 of 18 in.
5.....	11 0	3.....	15 6	(5th at frog)
5.....	11 6	3.....	16 0	10 of 20 in.
3.....	12 0	3.....	16 6	4 of 21 in.
3.....	12 6	—		5 of 20 in.
		78		

Heel of switch for 22-foot switch rail is between timbers 14 and 15. Point of frog is on timber 59. Spacings begin at center of first headblock. The fifth 18-inch spacing is in front of the tie under the point of frog.

No exact rule is used for the distance from the point of frog to the last long timber, but its value in inches for $8\frac{1}{2}$ -foot track-ties is approximately equal to 36 times the frog number. For example, by the rule, the distance for a No. 11 frog equals $36 \times 11 = 396$ inches; from the spacings of the timbers given in the last column of Table VI, the distance equals $10 \times 20 + 4 \times 21 + 5 \times 20 = 384$ inches. Obviously, the distance from the headblock to the last long timber is equal to the lead of the turnout plus the distance from the point of frog to the timber; for a No. 11 frog, it is equal to $93.85 \times 12 + 396 = 1,522$ inches, or 126 feet 10 inches.

29. Rules for Switch Timbers.—Approximate rules for the number and length of switch timbers are as follows:

1. To find the number of long ties required for any turnout, reduce to inches the distance from the headblock to the last long timber beyond the frog, and divide this distance by the average number of inches from center to center of timbers.

2. To find the lengths of switch timbers, determine the length of the tie next to the headblock and the length of the last long tie behind the frog. Subtract the former length from the latter and divide the difference, in inches, by the number of long timbers in the turnout. The quotient will be the theoretical increase in length for each timber to bring the ends of the timbers in proper line on both sides of the track. However, as explained in the preceding article, it is general practice not to vary the length with every timber, but to have several ties of the same length in a group.

EXAMPLE.—Find the number of long ties required for a turnout with a No. 8 frog; the average distance from center to center of ties is $19\frac{3}{4}$ inches and the track ties are 8 feet 6 inches long.

SOLUTION.—The lead is 67.65 ft., or 812 in., and the distance from the point of frog to the last long timber equals $36 \times 8 = 288$ in. Hence, the distance from the headblock to the last timber equals $812 + 288 = 1,100$ in. Since the average distance between centers of timbers is $19\frac{3}{4}$ in., the number of long timbers equals $\frac{1,100}{19.75} = 56$. Ans.

30. Placing Turnout.—When putting a turnout in an existing track, the first step is to locate the point of frog and

the point of switch, the distance between them being equal to the lead. It will avoid the cutting of a rail if the toe of frog or the heel of frog is placed at a joint in the existing track and, therefore, if possible, such a location of the frog should be selected. However, another important consideration is that the rail joints in the main track must be clear of the switch point and guard-rail; if the existing joints of the main track interfere with the work, new rails must be laid with the joints properly placed.

After the positions of the point of switch and point of frog have been selected, the ballast between the ties is removed to a sufficient depth to permit placing of the turnout ties, the foreman having a list of their lengths and spacings. The headblock is placed with its center line about $1\frac{1}{2}$ inches back of the point of switch and with its end in line with the ends of the main-track ties. If the headblock is composed of two pieces, they are placed in position to allow the head-rod to come between them. The main-track ties should not be disturbed more than is necessary to locate the headblock properly. The slide plates are then placed on the headblock under the rails, and a rail brace is spiked outside of the unbroken main-track rail. A spike is partly driven against the inner side of the rail so as to prevent the headblock from slipping outwards. All the ties for the switch and frog are next placed, the main-track ties being shifted when necessary to obtain proper spacing. Then the rest of the slide plates, tie-plates, and guard-rail base plates are placed under the rails and spiked, and the necessary rail braces are spiked against the main rails. While this is being done the old ties are adzed to a level bearing where necessary. The guard-rail is next placed opposite the location for the point of frog and is secured with clamps and braces or bolts.

After a rail has been bent to form the knuckle on the turnout side, and the lead rails have been cut to the required lengths, as taken from Table IV, the turnout stock rail, the straight lead rail, and the frog are bolted together and laid on the ends of the ties, ready to be installed. When all is in readiness, a flagman is sent out in each direction to stop trains. The old track is

then cut, the old main rail being thrown outwards. The switch rail, turnout rail, and straight lead rail are then put in place. At the point of switch a track gauge is placed on the rails and the switch rail and turnout rail are brought together, a rail brace being spiked outside the turnout rail and the switch point being held in position by a spike partly driven on its inner side. The gauge is then placed at the heel of the switch rail, which is spiked. With a lining bar the turnout rail is shifted outwards and spiked at the heel to give the required heel distance, usually $5\frac{1}{2}$ or $6\frac{1}{2}$ inches over gauge lines of the rails. The remainder of this rail is then fully spiked. The old ties are now removed, the new switch ties are tamped, and the main track is brought to proper line and surface. Trains may then be allowed to pass.

The curved lead rail and its connecting switch rail are next placed, and the tie-rods are bolted up and adjusted to give the proper throw at the head-rod. When this is done, the switch is thrown for the turnout, trains being flagged and stopped, and the heel of the turnout switch rail is spiked in proper position through the plate on which it rests. The switch is thrown for the main track and the rails are spiked in position to insure safety for trains until the switchstand is placed. The curved lead rail is then lined and held temporarily by spikes partly driven while the tie-plates are slipped under it and fully spiked. The curved lead rail can be lined by using the coordinates for the quarter and center points given in columns 17 to 22 of Table IV. Subtract from the values of Y , Y_1 , and Y_2 the distance from the gauge of the rail head to the outside of the rail flange, mark the points on the ties, and spike the rail to these marks. The turnout stock rail is adjusted at track gauge from the curved lead rail, and is spiked in position. The rails of the turnout are laid to exact gauge as far as the point of frog, unless the gauge has been widened owing to the sharpness of the curve. Beyond the point of frog the curve may be allowed to vary in gauge a little to prevent a kink from showing opposite the frog.

Placing the guard-rail, with its base plate and braces, completes the side-track connection. The side of the guard-

rail that comes in contact with the car wheels should be placed 4 feet $6\frac{5}{8}$ inches from the gauge line of the frog. This gives a space of $1\frac{7}{8}$ inches between the main rail and the guard-rail. In case the gauge is widened at the frog the flangeway between the main rail and the guard-rail is widened an equal amount. If the gauge is widened $\frac{1}{2}$ inch, the guard-rail is placed 4 feet $6\frac{1}{8}$ inches from the gauge line of the frog.

In placing the switchstand, it is first set on the headblock and the connecting-rod is connected to the shaft and the switch head-rod. The switch is then opened so that the points are equally distant from the gauge sides of the turnout stock rail and main stock rail, the switchstand drop-lever being held in a vertical position while making the measurements of these distances. After insuring that the stand is parallel with the main track, it is spiked to the headblock, and any necessary adjustments are made in the switchstand connections to make the rails fit properly against the stock rails.

EXAMPLE FOR PRACTICE

If ties are 8 feet 6 inches long and the average distance between their centers is $19\frac{1}{2}$ inches, how many long timbers are required for a turnout having a No. 10 frog?

Ans. 66

TURNOUTS FROM CURVED TRACKS

31. General Remarks.—The theoretical formulas for the dimensions of point-switch turnouts from curved tracks are necessarily complicated. However, a turnout from a sharp curve is used only under special conditions; then each case is treated as an individual problem, and the dimensions of the turnout are adjusted to suit those conditions. The best way to solve the problem is to make a drawing of the layout to a very large scale, such as 1 inch = 10 feet, or 1 inch = 20 feet, and measure the various dimensions. A fairly considerable variation in the length of lead is of little importance and, on existing track, the location is governed to a large extent by the position of rail joints, so that unnecessary cutting of rails may be avoided.

The frog rails are straight, but for practical purposes it is sufficiently accurate to consider both the main track and

turnout as continuous curves from the point of switch to the point of frog. The switch rails are usually laid straight, and it is left for traffic to bend them approximately to the curvature of the stock rails. In furnishing materials for the lead rails, and bending them, the necessary values are determined according to the assumptions discussed in the following articles.

32. Degree and Radius of Lead Curve.—For practical purposes, the difference in sharpness between a curved main track and the lead curve of a turnout may be taken equal to

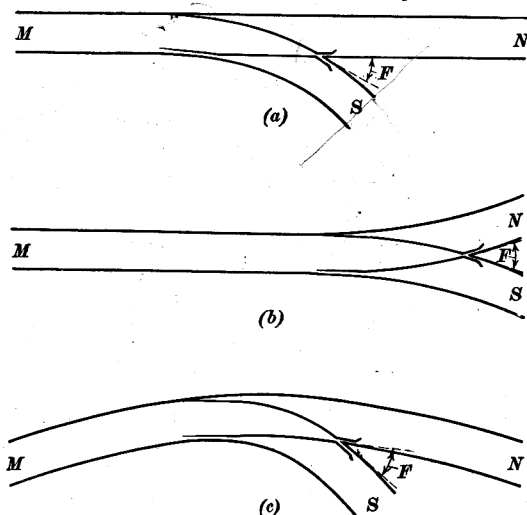


FIG. 13

the degree of the practical lead curve for a turnout from a straight track with the same frog number. Thus, if MN , Fig. 13, is the main track, MS is the turnout, and F is the frog angle, then the degree of the lead curve can be found by one of the following formulas:

$$D' = D - D_m \quad (1)$$

$$D' = D + D_m \quad (2)$$

in which D' = required degree of lead curve;

D = degree of lead curve taken from Table IV for given frog number;

and D_m = degree of curve of main track.

Formula 1 is used when the turnout is from the outer side of the main track as in Fig. 13 (b), and formula 2 is for a turnout from the inner side of the main track as in (c). If D_m is equal to D in (b), the degree of curve of the turnout is zero and the turnout is straight. Then the conditions will be as shown in (a), but MS will be the main track and MN , the turnout. If the main-track curve is so sharp, or the frog angle is so small, that D_m is greater than D , the turnout in (b) will curve in the same direction as the main track; the condition is represented in (c), but MS is the main track and MN , the turnout. For example, if a turnout with a No. 8 frog is to be run from the outside of a 4° curve, as in (b), the degree of the lead curve is approximately $11^\circ 45' - 4^\circ = 7^\circ 45'$. If a turnout with a No. 12 frog is to be run from the inside of a 2° curve, as in (c), the degree of the lead curve may be taken as $5^\circ 15' + 2^\circ = 7^\circ 15'$. It is sufficiently accurate to take the curvature to the nearest quarter of a degree. In all cases the radius R' of the lead curve can be found from the degree of curve D' by the formula $R' = \frac{5730}{D'}$, since the degree of curve is only approximately correct.

33. Lead.—There is a difference between the theoretical lead for a turnout from a curved track and that for a turnout from a straight track with the same frog number. In practice, however, most roads use the same dimensions for turnouts on curved track as for those on straight track, except in the rare case of a very sharp main-track curve; then the lead would be determined by plotting the layout.

When the turnout is from the inside of a curve, as in Fig. 13 (c), the closures of the lead rails can be taken from columns 27 and 28 of Table IV. But if the turnout is from the outside of a curve, as in (b), the main-track lead rail is longer, and the turnout lead rail is shorter than for a turnout from a straight track, even though the lead remains unchanged. The difference between the lengths of the straight and curved lead rails for a turnout from a straight track is small and, therefore,

the adjustment of the lengths for a turnout from a curve can be made by means of the formula

$$c = \frac{D}{D + D'} \times e$$

in which c = correction to be added to length of main-track lead rail and subtracted from length of turnout lead rail;

D = degree of main-track curve;

D' = degree of lead curve;

e = difference between lengths of straight and curved lead rails for turnout from straight track.

In the first example of the preceding article, the frog number is 8, the degree D of the main-track curve is 4° , and the degree D' of the lead curve is $7^\circ 45'$, or 7.75° . From columns 27 and 28 of Table IV, the difference e between the lengths of the straight and curved lead rails for a turnout from a straight track is .2 foot. Hence, the increase in the length of the main-track lead rail and the decrease in the length of the

turnout lead rail is $c = \frac{4}{4 + 7.75} \times .2 = .07$ foot. The main-

track lead rail would be composed of one 30-foot rail and one 16.47-foot rail and the turnout lead rail would consist of one 30-foot rail and one 16.53-foot rail. In this case, since $16.47 + 16.53 = 33.00$, these two partial rail lengths can be obtained by one cut of a 33-foot rail. Sometimes, in order to avoid decimals of a foot in one of the partial rail lengths, the lengths of the leads may both be changed an equal amount. For instance, if the calculated lengths are 32.97 and 32.88, it would be convenient to add .03 to each and make them 33 and 32.91, respectively. This change would not appreciably affect the lead or curvature.

The lead rails are usually bent to shape by sighting without measurements. Sometimes, a few points on each lead rail are located by ordinates from the chords between the heels of switch and toes of frog; the chord lengths are equal to the closures for the lead rails, the radius R of the main track is known, and the radius R' of the lead curve is found by the method explained in the preceding article.

EXAMPLES FOR PRACTICE

1. A turnout with a No. 11 frog is to be run from the inside of a 3° curve. Find (a) the degree and (b) the radius of the lead curve.

$$\text{Ans. } \begin{cases} (a) 9^\circ 15' \\ (b) 619 \text{ ft.} \end{cases}$$

2. A turnout with a No. 10 frog is to be run from the outside of a 6° curve. Find (a) the degree and (b) the radius of the lead curve.

$$\text{Ans. } \begin{cases} (a) 1^\circ 15' \\ (b) 4,584 \text{ ft.} \end{cases}$$

3. In example 2, find (a) the calculated closures for the lead rails and (b) the practical closures.

$$\text{Ans. } \begin{cases} (a) \begin{cases} \text{Main-track rail, one 28, one 27.14} \\ \text{Turnout rail, one 28, one 27.03} \end{cases} \\ (b) \begin{cases} \text{Main-track rail, one 28, one 27.11} \\ \text{Turnout rail, one 28, one 27} \end{cases} \end{cases}$$

CONNECTING TRACKS

CONNECTING CURVES

34. Connecting Curve Between Two Parallel Straight Tracks.—Let WA , Fig. 14, be a main track and WM , a turnout. If the turnout is to be connected with a side track EB parallel to the main track, a curved track HE ,

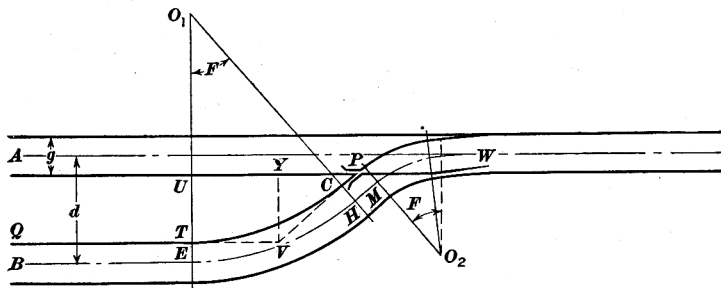


FIG. 14

called a *connecting curve*, must be introduced. The frog number N and the distance d between the center lines of the parallel tracks must be known; it is required to compute the radius r of the center line of the connecting curve and the

distance PU from the theoretical point of frog to the point on the main track opposite the end of the connecting curve. The distance d is usually 13 feet. Produce the inner rail QT of the side track and the frog rail PC to intersect at V . Since TV and CV are tangents to the connecting curve, and F is the angle between the tangents,

$$CV = O_1C \tan \frac{F}{2}$$

If g is the gauge of track, $O_1C = r - \frac{g}{2}$ and $CV = \left(r - \frac{g}{2}\right) \tan \frac{F}{2}$.

By formula 2, Art. 22, $\cot \frac{1}{2} F = 2N$, from which $\tan \frac{1}{2} F = \frac{1}{\cot \frac{1}{2} F} = \frac{1}{2N}$. Hence,

$$CV = \left(r - \frac{g}{2}\right) \frac{1}{2N}$$

The distance from the theoretical point to the heel of frog is PC or K . Then $PV = PC + CV = K + \left(r - \frac{g}{2}\right) \frac{1}{2N}$, and

$$VY = PV \sin F = \left[K + \left(r - \frac{g}{2}\right) \frac{1}{2N} \right] \sin F$$

But VY is also equal to $d - g$. Therefore,

$$K \sin F + \frac{r}{2N} \sin F - \frac{g}{4N} \sin F = d - g$$

$$\text{and} \quad r = \frac{2N(d - g)}{\sin F} - 2NK + \frac{g}{2} \quad (1)$$

$$PU = PY + YU$$

$$\text{but} \quad PY = VY \cot F = (d - g) \cot F$$

$$\text{and} \quad YU = TV = CV = \left(r - \frac{g}{2}\right) \frac{1}{2N}$$

$$\text{Hence,} \quad PU = (d - g) \cot F + \left(r - \frac{g}{2}\right) \frac{1}{2N} \quad (2)$$

EXAMPLE.—The distance between the center lines of two parallel, straight, standard-gauge tracks is 13 feet. The tracks are to be connected by a turnout with a No. 8 frog, and a connecting curve. Find the radius of the connecting curve and the distance PU , Fig. 14.

SOLUTION.—In formula 1, $N=8$, $d=13$, $g=4.708$, $\sin F=.12452$ (Table II), and $K=8.75$ (Table IV).

$$\text{Then, } r = \frac{2 \times 8 \times (13 - 4.708)}{.12452} - 2 \times 8 \times 8.75 + \frac{4.708}{2} = 927 \text{ ft. Ans.}$$

By formula 2,

$$P U = (13 - 4.708) \times 7.969 + (927 - 2.35) \times \frac{1}{16} = 123.87 \text{ ft. Ans.}$$

35. A connecting curve between parallel curved tracks is never used if it can be avoided. In an occasional instance where it is necessary, the dimensions are found best by plotting the layout to a large scale.

EXAMPLE FOR PRACTICE

The distance between the center lines of two parallel, straight, standard-gauge tracks is 13 feet. Find the radius of the connecting curve and the distance PU , Fig. 14, (a) if a No. 12 frog is used and (b) if a No. 16 frog is employed.

$$\text{Ans. } \begin{cases} (a) \ r=2,105 \text{ ft., } P U=186.94 \text{ ft.} \\ (b) \ r=3,740 \text{ ft., } P U=249.35 \text{ ft.} \end{cases}$$

CROSSOVERS

36. Definition of Crossover.—A *crossover* is a diagonal track connecting two parallel tracks and enabling trains to pass from one track to the other. It consists of two turnouts

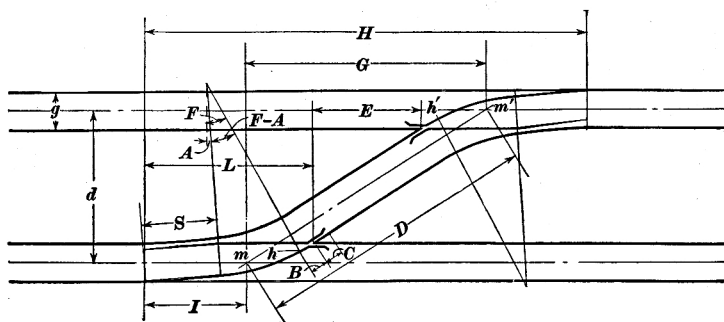


FIG. 15

placed in opposite directions with the frogs connected preferably by a straight track tangent to both turnout curves, as shown in Fig. 15. A short crossover is made by continuing

the turnout curves beyond the frogs to form a reversed curve as in Fig. 16. Although a reversed curve requires less length of track and may be used to meet special conditions, the

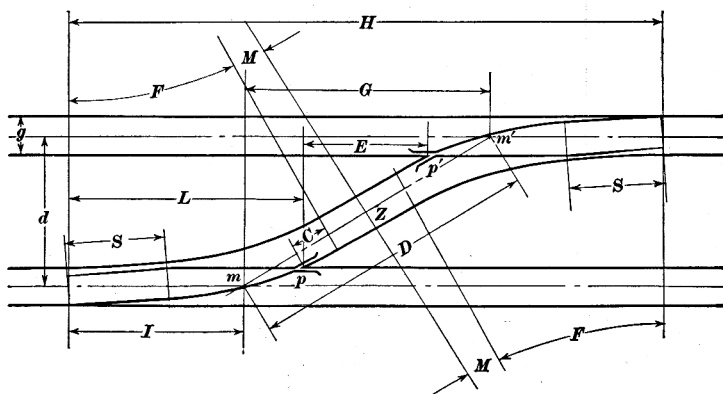


FIG. 16

straight track makes riding easier and reduces wear because of the fact that the car trucks, after passing one curve, adjust themselves on the tangent and thus take the second curve more smoothly.

37. Crossover With Straight Connecting Track.—When the frogs of a crossover are connected by a straight track, as in Fig. 15, the two turnouts must have the same frog angle; therefore, the two halves of the crossover are alike. The dimensions of the turnouts from the points of switches to the heels of frogs can be taken from Table IV. All the other values required for the layout are given in Table VII. The distances are measured from the actual point of switch and the actual point of frog, and all distances are in feet.

The values of D , E , G , and H in the table are for tracks spaced 13 feet between the center lines; that is, the distance d in Fig. 15 is 13 feet. For each foot of wider spacing, add to the dimensions E , G , and H the correction given in line 8 and to dimension D the correction in line 13; for each foot of closer spacing subtract the corrections. For example, if the spacing is 15 feet, add twice the corrections in the table; and if the spacing is 12 feet 6 inches, subtract half the corrections.

TABLE VII
DIMENSIONS OF CROSSEOVERS

Dimension	Frog Number								
	6	7	8	10	11	12	16	20	24
Toe to actual $\frac{1}{2}$ -inch point, <i>B</i>	4.25	4.71	5.08	6.42	6.46	6.92	8.67	10.50	12.33
Heel to actual $\frac{1}{2}$ -inch point, <i>C</i>	6.75	7.79	8.42	10.08	11.04	11.58	15.33	18.50	22.17
Total length of frog, <i>B</i> + <i>C</i>	11.00	12.50	13.50	16.50	17.50	18.50	24.00	29.00	34.50
Length of switch rail, <i>S</i>	11.00	16.50	16.50	16.50	22.00	22.00	33.00	33.00	33.00
Distance between points of frog, <i>E</i>	20.47	24.04	27.60	34.68	38.20	41.74	55.82	69.85	83.88
Distance between intersections, <i>G</i>	77.46	90.54	103.59	129.68	142.71	155.73	207.80	259.84	311.86
Distance between points of switch, <i>H</i>	116.43	148.24	163.56	190.54	226.82	243.34	330.96	384.69	438.32
Correction for <i>E</i> , <i>G</i> , and <i>H</i>	5.96	6.96	7.97	9.98	10.98	11.98	15.98	19.99	23.99
Point of switch to intersection, <i>I</i>	19.49	28.85	29.99	30.43	42.06	43.81	61.58	62.43	63.23
Lead to actual point of frog, <i>L</i>	47.98	62.10	67.98	77.93	94.31	100.80	137.57	157.42	177.22
Actual point to theoretical point of switch.....	.46	.69	.69	.69	.92	.92	1.38	1.38	1.38
Diagonal distance between center lines, <i>D</i>	78.54	91.47	104.40	130.33	143.30	156.27	208.21	260.16	312.14
Correction for <i>D</i>	6.04	7.04	8.03	10.03	11.02	12.02	16.02	20.01	24.01

EXAMPLE.—Find the dimensions of a crossover between two straight tracks, 13 feet center to center, if the turnouts have No. 11 frogs and they are connected by a straight track.

SOLUTION.—From Table IV, the frog angle F is $5^{\circ} 12' 18''$, the length S of switch rail is 22 ft., the switch angle A is $1^{\circ} 18' 8''$, the radius R of the center line of the practical lead curve is 922.65 ft., the lead L to the actual point of frog is 94.31 ft., and the closures of the straight and curved lead rails are found in columns 27 and 28. From Table VII, the distance E between the actual frog points measured parallel to the main tracks is 38.20 ft., the distance H between the actual switch points is 226.82 ft., and the distance I from the point of switch to the intersection of the main track and the connecting track is 42.06 ft. The distance D between the points of intersection can be used as a check on the work and should be 143.30 ft.

38. Crossover With Reversed-Curve Connection.—A reversed-curve crossover, Fig. 16, is especially adaptable when the frog angle is small and the two parallel tracks are far apart. Usually, the two turnouts have the same frog number and the two branches of the curve have the same radius, which is that of the lead curves. The central angle of each half of the reversed curve, from the heel of frog to the point of reversal Z , is denoted by M . Hence, the angle between each main track and the line mm' , which is tangent to the reversed curve at Z , is equal to $F+M$. For such conditions the dimensions of the crossover can be determined by the following formulas in which R , the radius of the center line of the reversed curve, is taken from Table IV; r , the radius of the outer rail, is equal to $R + \frac{g}{2}$.

$$\cos (F+M)=\frac{r \cos F+K \sin F-\frac{d-g}{2}}{R} \quad (1)$$

$$E=2\left[R \sin (F+M)-r \sin F+C \cos F\right] \quad (2)$$

$$D=\frac{d}{\sin (F+M)} \quad (3)$$

$$G=\frac{d}{\tan (F+M)} \quad (4)$$

$$H=2 L+E \quad (5)$$

$$I=\frac{H-G}{2} \quad (6)$$

EXAMPLE.—Compute the dimensions of a crossover between two tracks, 15 feet center to center, using turnouts with No. 20 frogs and a reversed-curve connecting track.

SOLUTION.—The dimensions for the turnouts can be taken from Table IV. In this case, $F=2^{\circ} 51' 51''$, $R=3,257.26$ ft., $g=4.71$ ft., $r=3,259.61$ ft., $K=19.33$ ft., and $L=157.42$ ft. Then by formula 1,

$$\cos (F+M) = \frac{3,259.61 \cos 2^{\circ} 51' 51'' + 19.33 \sin 2^{\circ} 51' 51'' - \frac{15-4.71}{2}}{3,257.26}$$

whence, by the use of a table of natural functions, $F+M=3^{\circ} 27'$.

By formula 2, $E=2(3,257.26 \sin 3^{\circ} 27' - 3,259.61 \sin 2^{\circ} 51' 51'' + 18.5 \cos 2^{\circ} 51' 51'')=103.23$ ft.

By formula 3, $D=\frac{15}{\sin 3^{\circ} 27'}=249.25$ ft.

By formula 4, $G=\frac{15}{\tan 3^{\circ} 27'}=248.80$ ft.

By formula 5, $H=2 \times 157.42 + 103.23 = 418.07$ ft.

By formula 6, $I=\frac{418.07-248.80}{2}=84.64$ ft.

If a straight connecting track were used, the distance E would be $69.85 + 2 \times 19.99$ or 109.83 ft. Hence, by using a reversed curve, the length of track saved equals $109.83 - 103.23 = 6.60$ ft.

39. Crossover Layout.—In laying out a crossover, the location of one turnout is first selected to suit the existing track. After one frog point has been placed, the other can be readily located by measuring the distance E parallel to the main tracks. Each turnout can be put in separately according to the method described in Art. 30.

It is customary to use very long ties laid perpendicular to the main tracks for the part of the crossover between the toes of the frogs, as from h to h' in Fig. 15. Then the main tracks and the connecting track all rest on the same ties. For tracks 13 feet apart, the length of these ties should be 21 feet 6 inches. If the connecting track is straight its center line can best be located by measuring the distance I from each actual point of switch along the center line of the main track to m and m' , Fig. 15, and then joining the two points thus found by a straight line. When the connecting track is a reversed curve, the distance I is measured along the center line of each main track as in the case of a straight connection.

The line mm' , Fig. 16, joining the two points thus located is tangent to the center line of the reversed curve at the point of reversal Z . The point Z is then located on this line at a distance $\frac{D}{2}$ from either m or m' . Both branches of the reversed curve can then be laid out best from Z and the common tangent mm' , rather than from the frog points p and p' .

40. A crossover between parallel curved tracks is not good practice and should be used only when absolutely necessary. Since the theoretical formulas for the dimensions are too complicated for practical use, the problem would be best solved by making a plot of the layout to a large scale as in the case of a turnout from a curved track.

EXAMPLES FOR PRACTICE

1. Find the dimensions of a crossover between two tracks, 13 feet 6 inches from center to center, if the turnouts have No. 8 frogs, and the connecting track is straight.

Ans. $\begin{cases} F=7^{\circ} 9' 10'', S=16.5 \text{ ft.}, A=1^{\circ} 44' 11'', R=487.48 \text{ ft.}, L=67.98 \text{ ft.} \\ E=31.59 \text{ ft.}, H=167.55 \text{ ft.}, I=29.99 \text{ ft.}, \text{ and } D=108.42 \text{ ft.} \end{cases}$

2. Compute the dimensions of a crossover between two tracks, 14 feet apart, if the turnouts have No. 16 frogs and the connecting track is a reversed curve having the radius of the turnout curves.

Ans. $\begin{cases} F=3^{\circ} 34' 47'', S=33 \text{ ft.}, A=0^{\circ} 52' 5'', R=1,993.24 \text{ ft.}, L=137.57 \text{ ft.}, \\ F+M=4^{\circ} 8', E=68.74 \text{ ft.}, D=194.23 \text{ ft.}, G=193.72 \text{ ft.}, H=343.88 \\ \text{ft.}, \text{ and } I=75.08 \text{ ft.} \end{cases}$

3. Find the difference in the dimension H if a straight connecting track had been used in example 2.

Ans. 3.06 ft.

LADDER TRACKS

41. In yard layouts it is a common requirement to connect a straight main track with a number of parallel and equally spaced side tracks, or *body tracks*, on which cars can be switched or stored. This is done by means of a straight diagonal track, called a *ladder track*, which has a series of turnouts to the body tracks. In Fig. 17, MN is a main track, MV is a ladder track, and CD and ER are body tracks. As

a rule, the ladder is at the ends of the body tracks, but in some cases it may intersect them.

According to the recommendations of the American Railway Engineering Association, the distance between the centers of adjacent body tracks should be from 13 to 14 feet, and the center of the first body track should not be less than 15 feet from the center of the main or other important track; that is, d_1 , Fig. 17, should not be less than 15 feet, and d_2 should be from 13 to 14 feet. Ladder tracks should not be less than 15

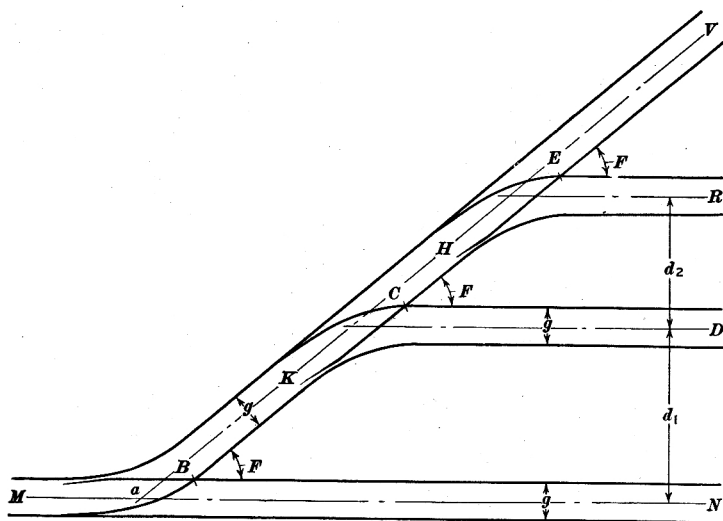


FIG. 17

feet center to center from any parallel track. Frog numbers less than 8 should not be used on ladder tracks.

Since all the body tracks are parallel, all the frogs have the same number, and all the turnouts are similar; the turnout from the main track to the ladder is included, but, of course, it is in the opposite direction to that of the turnouts to the body tracks. The distance between body tracks along the ladder track is equal to the distance D , Table VII, for a cross-over. It is evident from Fig. 17 that the distances between successive points of frog, as CE , and between successive points of switch, as KH , are also equal to D .

To lay out the ladder, first measure the distance I , Table VII, from the point of switch along the center line of the main track; from the point a thus located, run the ladder BV at an angle F with the main track. Then locate along BV the switch points and frog points for the turnouts to the body tracks as follows: BC is equal to the distance D in Table VII for a distance center to center of tracks equal to d_1 , and BK is equal to BC minus the lead L ; CE is equal to distance D for tracks whose distance between centers is d_2 , and CH is equal to $D-L$ for that condition. The dimensions for all the turnouts are the same and can be taken from Table IV. The body tracks are straight beyond the frogs.

EXAMPLE.—In a yard layout the first body track is 15 feet from the main track and the body tracks are 13 feet center to center. If the turnouts have No. 12 frogs, find the distances BK , BC , CH , and CE in Fig. 17.

SOLUTION.—From Table VII, for tracks 13 ft. apart and No. 12 frogs, $D=156.27$; since the correction is 12.02, the distance D for tracks 15 ft. apart equals $156.27+2\times 12.02=180.31$ ft. Hence BC is 180.31 ft. Ans.

The lead L for a No. 12 frog is 100.80 ft., and, therefore, $BK=BC-L=180.31-100.80=79.51$ ft. Ans.

The distance CE , which is equal to D for tracks 13 ft. apart, is 156.27 ft. Ans.

Distance $CH=CE-L=156.27-100.80=55.47$ ft. Ans.

EXAMPLE FOR PRACTICE

The first body track in a yard is 15 feet 6 inches from the main track, and the body tracks are 13 feet 6 inches apart. Find the distances BK , BC , CH , and CE in Fig. 17 if the turnouts have No. 10 frogs.

Ans. $BK=77.48$ ft., $BC=155.41$ ft., $CH=57.42$ ft., $CE=135.35$ ft.

TRACK CROSSINGS

CONSTRUCTION

42. Crossings.—At grade crossings of railway tracks special frogs are required at the four rail intersections to provide openings for the passage of wheel flanges along both tracks. These are known as *crossing frogs*, and the entire arrangement of rails and frogs, as shown in Fig. 18, is called a *crossing*. With this construction all wheel treads have to jump two gaps, causing severe pounding at the frogs; con-

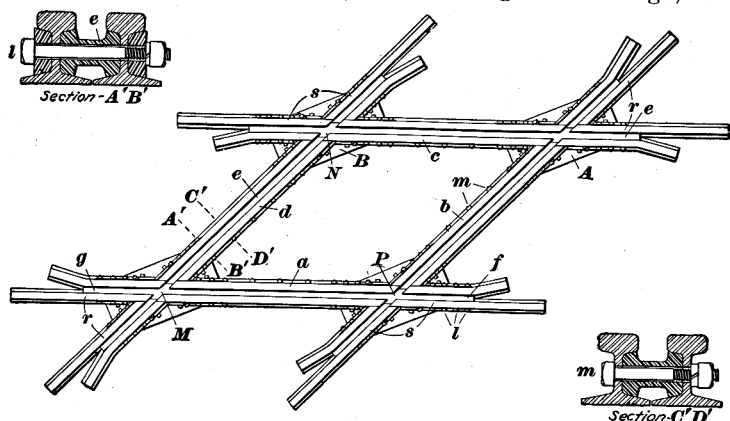


FIG. 18

sequently heavy construction and rigid connection of parts are necessary in order to resist the shocks and vibration. It is usual to rivet a steel base plate under each frog, but at right-angle crossings the plates are sometimes continuous. The guard-rails *a*, *b*, *c*, and *d* extend on all four sides of the crossing, the fillers *e*, *f*, and *g* being fitted between the webs of the guard-rails and track rails to give the necessary width of groove or flangeway, and the rails being bolted together through the

webs by the bolts *l* and *m*; the details are shown in sections *A'B'* and *C'D'*. At each frog the guard-rails and track rails have base plates *A* and *B* riveted under the flanges. The two sharp end frogs *r* are similar to turnout frogs and the center frogs *s* are blunt, as shown. In a right-angle crossing all four frogs are alike.

43. Ties and Ballast Under Crossings.—Ties and long switch timbers may be used to support crossings when the tracks intersect at angles less than 50 or 60 degrees, the ties being laid parallel with the short diagonal of the crossing, as *NP* in Fig. 18. For angles between 50 and 90 degrees, ordinary track ties laid in the usual way may be placed in one track, with two heavy timbers or stringers under the rails of the other track. More rarely, crossings of 90 degrees have framed together four timbers corresponding to the rails, or even four steel stringers. Plenty of good ballast and a well-drained roadbed are essential for keeping crossings in condition; where the ground is soft or traffic is heavy, it may be an advantage to carry the ballast on a concrete slab in the roadbed.

44. Crossing Construction.—The crossing usually is built up of steel rails. The rails of one track may be continuous, flangeways for the intersecting track being cut through the head only, thus leaving the web and base intact. Inserts of hard manganese-steel castings are often used in crossing frogs to reduce the wear and thus lengthen the life of the crossing. A single casting may comprise the frog points and wings. For very heavy traffic the entire crossing may be a single casting, or it may be built up of castings.

For intersection angles from 90 to 30 or 25 degrees, four complete guard-rails are used as shown in Fig. 18, two of these being continuous (with flangeways planed across the heads) and the others framed to them with heavy braces and bolts. Where the traffic is heavy, easer rails are placed against the outside of the track rails and in contact with their heads. These carry the false flanges of wheel treads which have worn hollow and thus reduce the battering and jolt as the wheels

pass over the frogs. For intersection angles between 18 and 25 or 30 degrees the guard-rails are usually short or not continuous, and for angles less than 18 degrees the easer rails are used only at the frogs. Long oblique crossings at angles less than 25 or 30 degrees are undesirable and should be avoided.

45. Special Crossing Devices.—For intersection angles not greater than 8 degrees, the points of the two center frogs are almost directly opposite, and, therefore, it is impossible to place the guard-rails properly. Hence there is a possibility of derailment by wheels striking the frog or taking the wrong side of the frog point. To meet this condition *movable-point frogs* may be installed, as shown in Fig. 19. In this

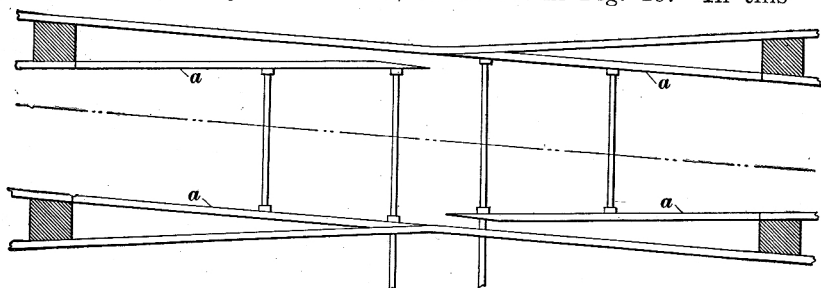


FIG. 19

form of a crossing, short point rails *a*, like those of a split switch, are operated from a switchstand or tower, one set of points being opened as the other set is closed.

In yard work, particularly in the yards of passenger stations, it is sometimes desirable to connect a diagonal ladder track with parallel tracks which it intersects, but no room is available for a series of ordinary turnouts. The connection can be made, however, by a *diamond*, or *slip switch* having all parts contained between the end frogs of the crossing, as shown in Fig. 20. Here *A* and *B* are the switch rails for one track, and are connected by the tie-rod *E*; the switch rails *C* and *D* for the other track are connected by the tie-rod *F*. At *G* is one of the end frogs, and *H* is one of the center frogs. By throwing the switches to the proper positions, a train can be

directed to any desired track. Slip switches may be either single or double, for connection in one or both directions, the arrangement shown by the drawing being a double switch. In occasional cases slip switches are used on main tracks, as at the connection of a double track with a four-track line.

For crossing angles near 90 degrees an arrangement has been invented, in which movable frogs are operated by mechanism interlocked with the signal apparatus. When the signals for one line are put into position to indicate *proceed*, the movable parts of the crossing frogs are shifted so as to close the flangeways of the other track, and thus give an unbroken rail surface. These devices have not yet come into extensive use.

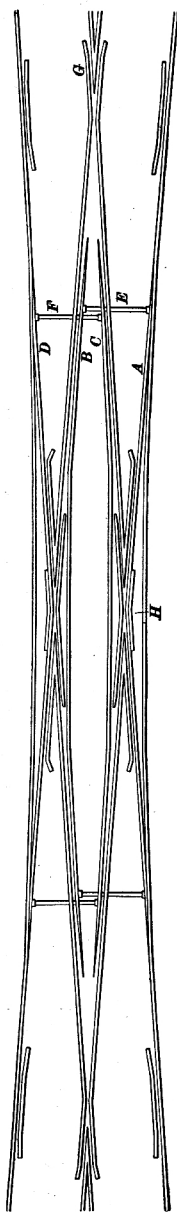


FIG. 20

DIMENSIONS OF CROSSINGS

46. Dimensions of Straight Crossings.

The dimensions of a crossing are the angle between the intersecting center lines and the distance measured parallel to one track between the gauge lines of the other track,

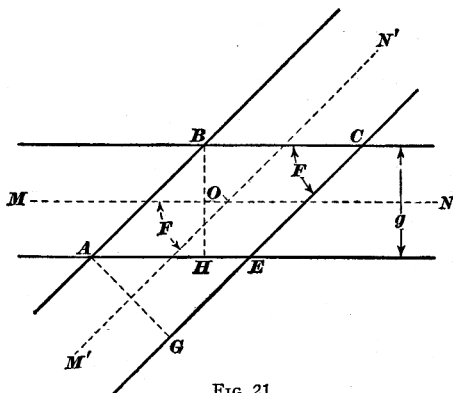


FIG. 21

which is also the distance along a rail between the theoretical frog points, one center and one end, on that rail. Let MN and $M'N'$, Fig. 21, be the center lines of two tracks intersecting at O , and let F be the angle between the center lines. Then, since the sides of each end frog are respectively parallel to the two center lines, each frog angle will be equal to F .

From the triangle ABH ,

$$AB = EC = \frac{BH}{\sin BAH} = \frac{g}{\sin F} \quad (1)$$

Similarly, from the triangle AGC ,

$$AE = BC = \frac{AG}{\sin AEG} = \frac{g}{\sin F} \quad (2)$$

The lengths of the crossing rails are therefore all equal; that is, $AB = EC = AE = BC$.

EXAMPLE.—If two straight tracks intersect at an angle of 30° , what are the dimensions of the crossing?

SOLUTION.—Each end frog angle F will be 30° . From formulas 1 and 2,

$$AB = BC = CE = EA = \frac{g}{\sin F} = \frac{4.708}{.5} = 9.416 \text{ ft. Ans.}$$

47. Curved-Track Crossings.—When one or both intersecting tracks are curved the frog angles are all different and the frog rails are curved for their entire lengths. Crossings of curved tracks should be used only when absolutely unavoidable; then the dimensions are best determined by plotting the layout to a large scale.

EXAMPLE FOR PRACTICE

Find the dimensions of a straight-track crossing if the angle between the center lines of the intersecting tracks is 60° .

Ans. $F = 60^\circ$, $AB = AE = 5.44 \text{ ft.}$

RAILWAY STRUCTURES AND TERMINALS

Serial 3060

Edition 1

RAILWAY BUILDINGS

RAILWAY STATIONS

PASSENGER STATIONS

1. Main Considerations.—In the design of a passenger station the general layout, including the track and platform arrangement, is mainly in the hands of the engineer. The architect takes a large part in the design of the building itself, the importance of his work increasing with the size and importance of the structure. However, the general plan of the building, and especially the arrangement of the station facilities, is subject to the approval of the engineer and the operating officers, in order to insure convenience and efficiency in conducting the station business. The size of the building and the character of the facilities to be provided will vary with the size of the town or city, and the amount of business to be handled at the station.

For operating purposes a railway is divided into divisions that are generally about 100 miles long. Stations at division points usually have an upper floor with rooms for the division officers.

2. Arrangement of Station Facilities.—For passenger stations of the smaller class, the principal requirements are the waiting room, ticket office, baggage room, and express room. A common arrangement consists of two waiting rooms, one

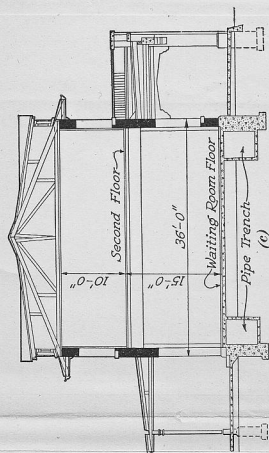
2 RAILWAY STRUCTURES AND TERMINALS

for men and one for women, partly or entirely separated by the ticket office. If the waiting rooms are only partly separated by the ticket office, a single ticket window may be placed in the corridor or passageway between them; but, if they are entirely separated, a ticket window is required in each room. The American Railway Engineering Association recommends a single general waiting room having at one end two toilet rooms and a women's room; one toilet is entered from the waiting room and the other from the women's room. At the other end of the building is the ticket office, located on the track side, with the baggage and express room in the rear of the ticket office. Certain Southern states require separate accommodations for white and for colored people. Toilet rooms should be provided at stations when sewer connections are available. Small country stations have outhouses with cesspools or chemical toilets, the latter being preferable. Small stations are usually heated by stoves, while large ones have steam or hot-water systems with radiators.

As a rule the ticket office projects beyond the track front of the building and has side windows in order that the station agent, who is usually also the telegraph operator, may have a good view of the platform and trains, and may be able to talk to trainmen on the platform. A train-order signal is placed either on the roof of the building or on a post in front of the station, and is operated by the agent in accordance with orders from the train dispatcher. This signal is installed even where the block-signal system is employed, its use being to notify enginemen of trains when the station agent has orders for them.

Frame construction is generally used for small stations, but brick, tile, concrete, concrete blocks, and cement or stucco on steel lathing are also used extensively for both small and medium-sized stations. Cost, convenience, comfort, and pleasing appearance are points to be considered in the design of a station.

3. Medium-Sized Stations.—A typical station of medium size is shown in Fig. 1; in (a) is an elevation of the side



SECTION
THROUGH TWO STORY
BUILDING

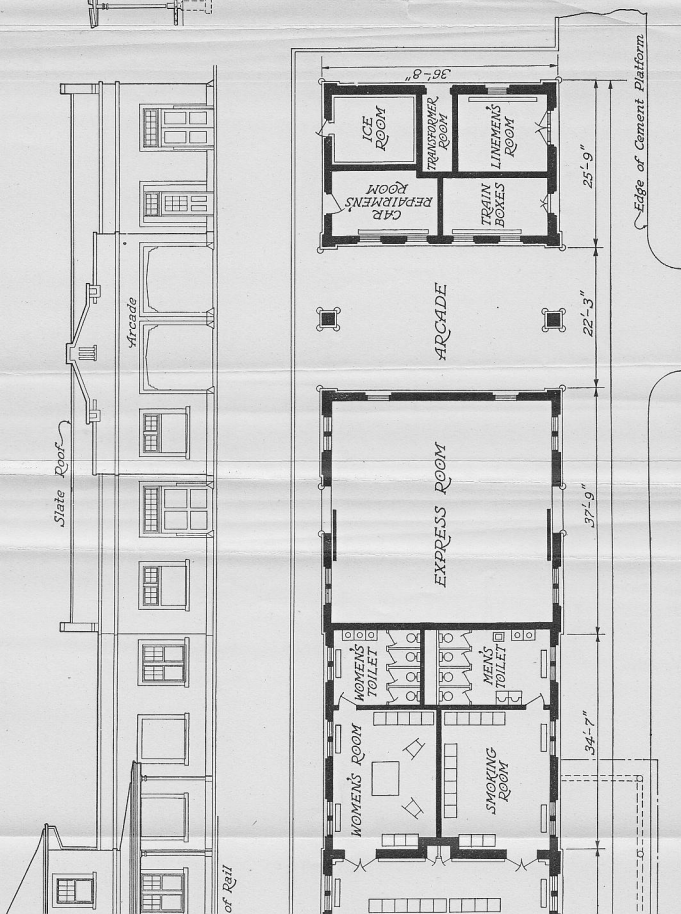
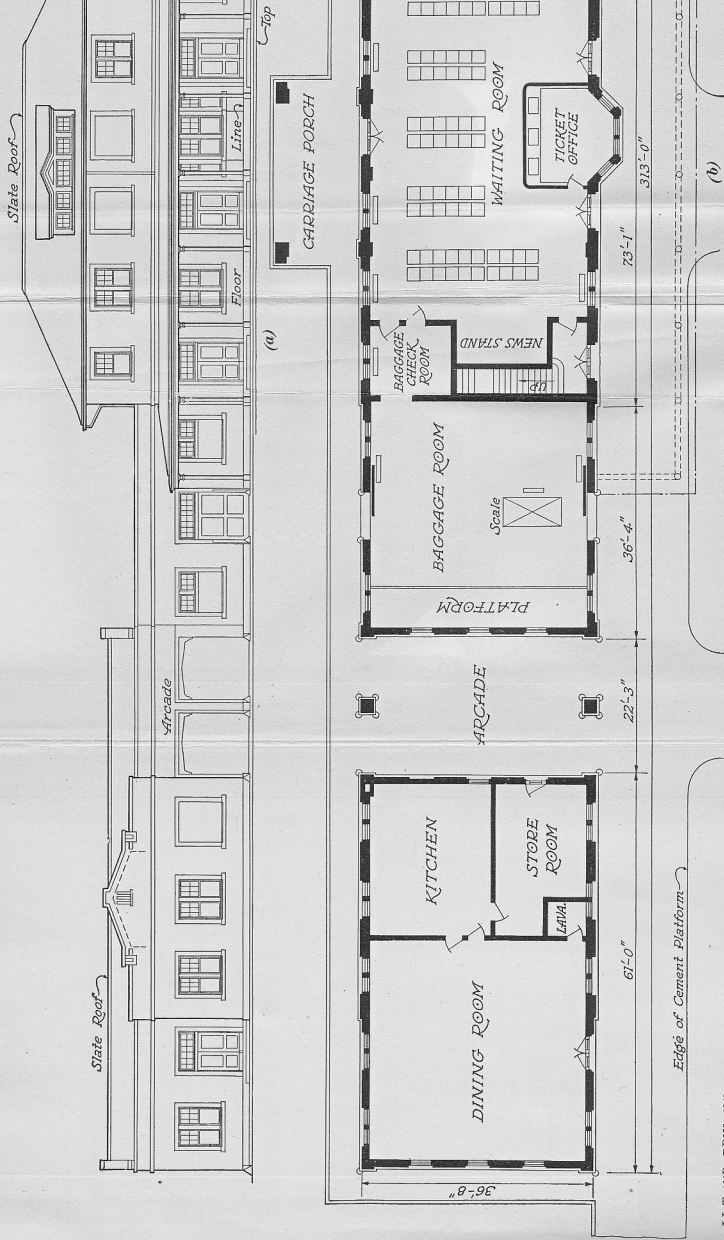


FIG. 1



of the station facing the track, in (b) is a plan view of the station, and in (c) is a cross-section through the central portion that is two stories high. The station has brick walls which carry wooden roof trusses covered with a slate roof. The building has a uniform width of about 37 feet; its length of 313 feet is divided into three portions by two covered passages, or arcades. The central portion contains the main waiting room, with the ticket office on the track side (and projecting beyond the building), the baggage room, women's room, smoking room, two toilet rooms, the express room, a baggage check room, a news-stand, and a stairway leading to the second floor. The left-hand portion contains the dining room, kitchen, and store room. The right-hand portion contains the ice room, rooms for the linemen or telegraph-repair men, and rooms for the car-repair men who inspect passenger trains and freight cars.

Tile flooring is used in the waiting room and toilet rooms, maple plank floors in the baggage and express rooms, and cement floors elsewhere. On the driveway side of the building is a vehicle porch, and on the track side is a concrete platform 15 feet wide, extending the full length of the building. In front of the central portion of the building, this platform is covered by a porch roof. Ordinarily such a station would not have an upper floor, but in this case the central part of the building is two stories high to provide office room for the division superintendent and other officers. The floor of the second story is a concrete slab supported on reinforced-concrete beams, resting on the brick walls.

4. Small Stations.—The small station shown in Fig. 2 has the double waiting room arrangement previously mentioned, but with a ticket window for each room instead of a single window in the passageway. Toilet rooms are not included in the design, outhouses being provided in this case. The roof extends 10 feet beyond the walls of the building and furnishes a broad shelter on all sides.

5. Shelter Sheds.—At roadside stops, as on interurban or country lines, a simple shelter shed is usually provided to

4 RAILWAY STRUCTURES AND TERMINALS

protect waiting passengers from the weather. Such a struc-

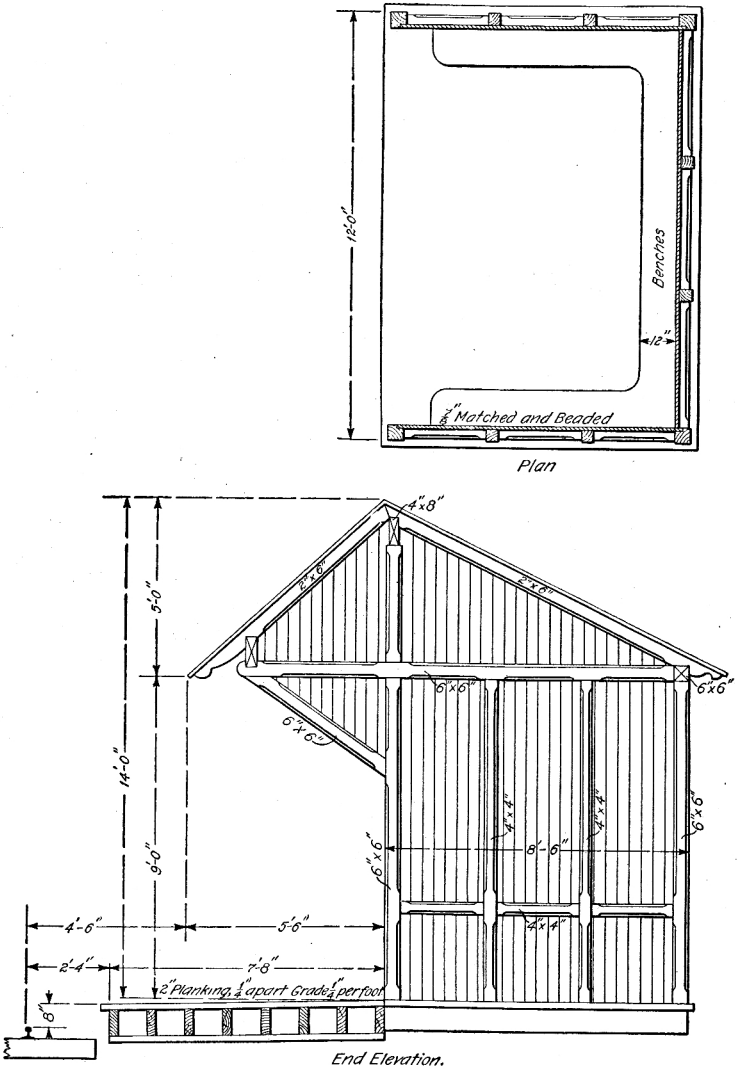


FIG. 3

ture is shown in Fig. 3. Many railroads have standard designs for small stations and shelter sheds.

6. Trainsheds.—In stations of large cities the tracks and platforms are usually covered by a trainshed. Formerly lofty steel arch spans extending over the entire width to be covered were favored, but the type of trainshed now in more general use has a low roof supported on cross-girders and intermediate columns as illustrated in Fig. 4. The transverse plate girders *a*, used in this case, are slightly arched and are sup-

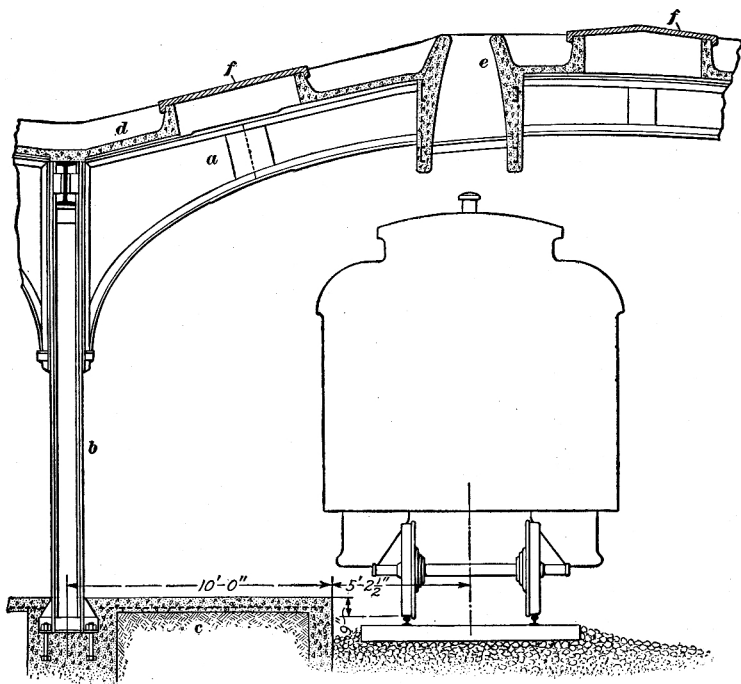


FIG. 4

ported on the columns *b*, located along the centers of the platforms *c*. The reinforced-concrete roof *d* is supported on steel purlins attached to the girders. Over each track is a slot, or smoke opening, *e*, which provides for the escape of smoke and steam from the locomotives. These openings are continuous from girder to girder and have vertical sides extending above and below the roof, as shown, to prevent snow and rain from driving on the platforms. Such trainsheds

6 RAILWAY STRUCTURES AND TERMINALS

usually have skylights *f* in the roof to provide adequate lighting.

At smaller places and in warm climates the tracks are uncovered and each platform has a low shelter roof.

7. Platforms.—In large stations the platforms are usually 14 to 20 feet wide and the tracks are arranged in pairs with an alternate spacing of 15 feet and 25 to 31 feet between centers. The platforms are placed between the tracks that are spaced 25 to 31 feet between centers. The edge of the platform is usually about 5 feet from the center line of the track and 6 to 9 inches above the rail heads. A slope of $\frac{1}{4}$ inch toward the track provides for drainage of side platforms, while those between tracks are crowned so as to drain to both sides.

High platforms level with the floors of the cars are used in a few large terminals, generally on elevated and subway lines and on some suburban lines. They are usually placed 3 feet 10 inches above the top of the rail, with the edge 5 feet 6 inches from the center line of the track. Station platforms are commonly constructed of concrete, with a cement sidewalk finish if outdoors, or covered with asphalt if inside a trainshed. Wood plank platforms are used to some extent, especially for small stations. Brick laid on a layer of sand on a concrete base and with the joints filled with cement or asphalt is also used in some sections, while plank or concrete is employed for the platforms of elevated lines. Filled platforms, used at smaller stations, have cinders, gravel, or stone screenings placed between curb walls of longitudinal timbers, or concrete or stone slabs set on edge. These curb walls may be braced on the outside by posts or small stakes, but usually they are anchored into the filling by tie-rods. Where there are curbs on each side of the filling, the rods may pass through both lines of curbs. Plank platforms will have a longer life if raised far enough above the ground to allow free circulation of air. The planks may be nailed to sleepers or sills embedded in a cinder filling.

FREIGHT HOUSES

8. Introductory Remarks.—At small stations, the passenger and freight business may be included in one building, but as a rule there is a separate freight house. This house is located on a siding, termed the *house track*, where cars can be placed in position for loading and unloading without occupying the main track. A house track is also used with a combination freight and passenger station, and is generally placed in the rear of the building.

At most large freight stations there is a team yard, where bulk or carload freight can be handled directly between the wagons or trucks and the freight cars that are being loaded or unloaded. The tracks may be in pairs, spaced alternately 12 feet and 40 or 50 feet between centers, the wide spaces providing for 30- to 40-foot paved driveways between tracks. A lifting device or crane should be provided for transferring heavy or bulky articles.

9. Typical Freight House.—An example of a typical freight house for a division point is shown in Fig. 5. This building is about 40 feet wide and 180 feet long; it has brick walls supporting timber roof trusses for a pitched slate roof, although a flat-roof design is used almost as extensively. The floor of the building is 4 feet above the top of the rails and is level with a platform on the track side. This platform extends along the full length of the building and for a distance of 250 feet beyond one end, being covered throughout its entire length by a shelter roof. The platform beyond the end of the building is 24 feet wide and is covered with a canopy roof to protect freight as it is handled in and out of the house. On the opposite side of the building is a paved driveway for wagons and motor trucks. Heavy bumping timbers are bolted along this side of the building, on a level with the floor, to protect the wall from damage by trucks. In each side wall there are doorways, 8 feet wide and 8 feet high, spaced 18 feet between centers and fitted with sliding doors. The door jambs are protected against damage in trucking by means of

cast-iron guards. To eliminate the necessity of *spotting cars*, or placing them opposite the doorways, the track side of the freight house may be composed entirely of sliding doors, forming panels between the posts which support the roof.

At the end of the building which fronts on the street are the entrance hall and foreman's office. A vehicle weighing machine or scale with a platform 9 feet by 22 feet is placed in the driveway, the scale beam and recording apparatus being inside the office of the foreman and under his care. The freight room is divided into two sections by a transverse fire-wall, which extends above the roof and has a doorway fitted on each side with a fireproof door that will close automatically in case the temperature rises above a certain point, as in a fire. A small over-freight room, in which freight held for orders or not accounted for may be stored, and a toilet room are located on opposite sides of the wall, as shown. As the freight house illustrated is for a division point, it has an upper story at one end, in which are located the division freight offices, a general office for the freight clerks, the freight agent's office, a cashier's office, and a record room. Two toilet rooms for men and women employes are also located in this story.

The floors in the toilet rooms are of cement. The remainder of the space on the first floor is covered with $1\frac{1}{4}'' \times 2\frac{1}{4}''$ maple flooring, laid on a subfloor of 2-inch plank. The subfloor is nailed to $2'' \times 4''$ sleepers, which are spaced 16 inches between centers and embedded in the sand fill between the foundation walls. The floor in the second story is of $\frac{7}{8}'' \times 2\frac{1}{4}''$ maple flooring laid on $2'' \times 8''$ ceiling joists spaced 18 inches apart. Wood blocks, asphalt blocks, and sheet asphalt on a concrete base are also used for the main floors of freight houses. Where the main freight room is over a basement, the floor is designed to support a load of 300 to 500 pounds per square foot. The office floor is designed for a load of 50 pounds per square foot; on account of the weight of filing cases, the record room is designed for a load of 150 pounds per square foot.

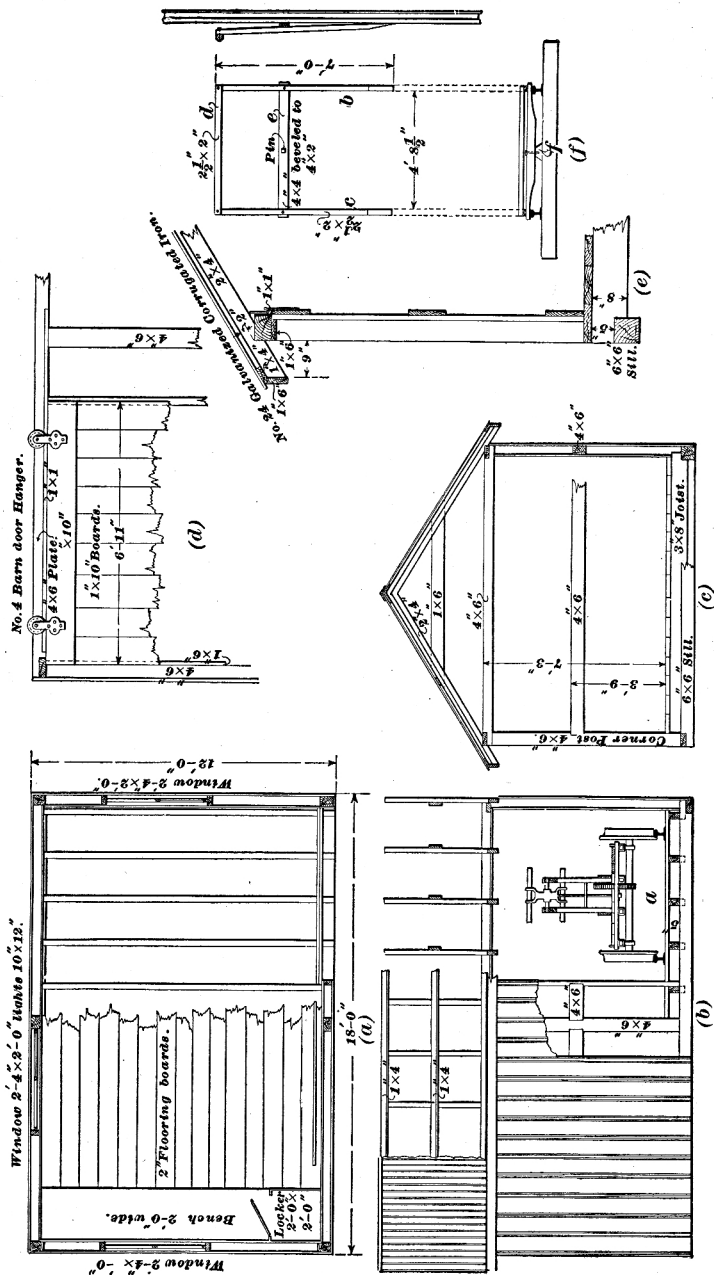
10. City Freight Houses.—Separate freight houses for inbound and outbound freight are required at large cities.

Usually, outbound freight houses are 30 feet wide, while inbound freight houses are 50 feet wide; more room is required for the latter because inbound freight may have to remain some time before being called for, while outbound freight is loaded and shipped promptly. Where the outbound freight business requires more than six tracks, the method of hand trucking along a side platform and through the cars, to reach the cars on the outer tracks, takes too much time; it is usually better to put the freight house across the ends of the tracks and to arrange the tracks in pairs with trucking platforms between them. In case the tracks are a considerable distance above or below the street level, ample elevator service should be provided to handle freight between the vehicle platforms and the train platforms.

Freight houses in large cities are frequently built several stories high. The ground floor is used for handling freight, while the remaining floors are either used by the railroad, or leased to others for warehouse purposes. Where the storage business is sufficient to warrant it, provision should be made for cold storage. In cities where the building laws prohibit the frame structures or at points where valuable freight is stored, some form of fireproof construction must be used.

MISCELLANEOUS BUILDINGS

11. Section Tool Houses.—For the purpose of track maintenance every railway division is divided into sections, each in charge of a foreman and a gang of laborers. A small tool house is provided on every section to house the hand car or motor car, the push car, and the various tools and small track materials used by the section gang, in order to protect them from the weather and from being stolen. A light timber-frame construction is usually employed and the building rests on masonry piers or wooden foundation posts. The building may be about 12 ft. $\times$ 18 ft. or 14 ft. $\times$ 20 ft. with an 8-foot doorway in one of the long sides, equipped with a sliding door. A smaller type of building is 10 ft. $\times$ 14 ft. and has double swinging doors in one of the narrow sides.



The building is placed with the door side facing the railroad track, and the section car is run into it on a short track. Sufficient space to accommodate a section car must be left between the building and the main track. If the floor is of wood plank laid on joists, the building should be slightly above the ground in order to allow air circulation under the floor and so prevent decay of the wood. Outside the building should be a clear space for piling large scrap iron, such as couplers and brake beams, that is picked up along the railroad. Smaller scrap, such as bolts, spikes, etc., may be placed in shallow bins in the building, where the scrap is ready for periodical collection by a work train or supply train.

12. Details of Tool House.—Details of a 12'×18' section tool house are given in Fig. 6. A plan is shown in (*a*), a side elevation and part section in (*b*), an end elevation in (*c*), and details in (*d*), (*e*), and (*f*). As illustrated in (*a*), at one end of the building is a work bench, fitted with a vise, and racks or shelves for the various tools used by the section gang. A locker for lanterns and oil cans is fitted under the work bench in this case, but the locker is more likely to be kept clean if it is on a level with the bench.

The section car and push car rest on a track *a* in (*b*). They are admitted through a sliding door, shown in detail in (*d*), and in section in (*e*). A portable turntable for transferring the cars back and forth between the tool-house track and the main-line tracks is shown in (*f*). It consists of a frame built of two oak strips *b* and *c*, which serve as rails and are held to the proper gauge by the cross-piece *d* and the bolster *e*, bolted to the strips. A pin passes through the bolster and enters a socket in the cast-iron pedestal *f*, on which the frame revolves. In operation, the pedestal is placed on a tie with the strips *b* and *c* resting directly on the rails upon which the car that is to be transferred is standing. The car is run onto the frame and the latter is revolved so as to connect the rails *b* and *c* with the rails of the track to which the car is being transferred.

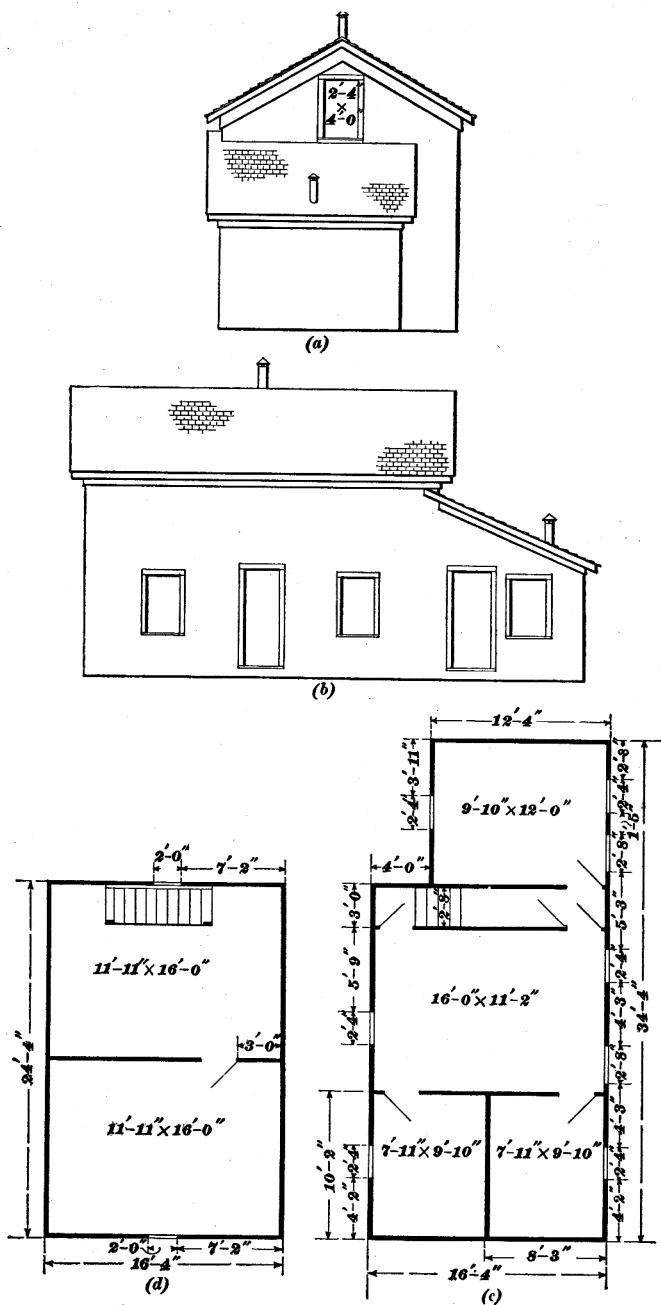


FIG. 7

The roof covering specified in (e) is corrugated iron. Various kinds of prepared roofing or shingles are also employed.

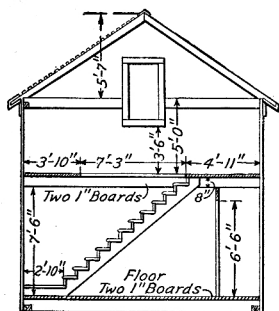
13. Section Dwelling House.—Where dwelling houses must be provided for the foremen and section gangs, they should be comfortable as well as of moderate cost. Various designs are used by different railroads. Details of a typical dwelling house are shown in Figs. 7 and 8. Such a building may be built by ordinary carpenters. It provides accommodations for eight persons. A separate wing or separate building is sometimes provided for the foreman and his family.

In the design illustrated here, the outer walls and partitions consist of two courses of 1-inch boards nailed securely to the frame. These boards are ship-lapped and surfaced on one side so as to take paint well. The floor boards are of similar material and are tongued and grooved to make a tight fit. The roof covering in this case is of corrugated iron, but various kinds of prepared roofing are also suitable for such buildings.

In Fig. 7 are shown an end elevation of the building in (a), a side elevation in (b), a plan of the first floor in (c), and a plan of the second floor in (d).

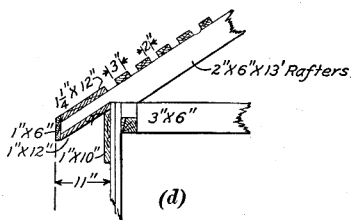
Complete framing details of the building are given in Fig. 8. A framing plan of the second floor is shown in (a) and of the first floor in (b). In (c) is given a cross-section along plane *A-A*, which shows the arrangement of the floors and stairs. A detail of the roof framing of the main body of the house is shown in (d), and of the roof of the addition in (e). In (f) is shown a detail of the sill and the floor joists, and in (g), a detail of a door casing.

14. Watchman's Shanty.—Shelter should be provided for watchmen at all road crossings and yards. The general design of a shanty for such purpose is shown in Fig. 9. A watchman's shanty should be large enough to accommodate one man comfortably and provide room for a stove. Adjacent to the shanty should be a coal bin.

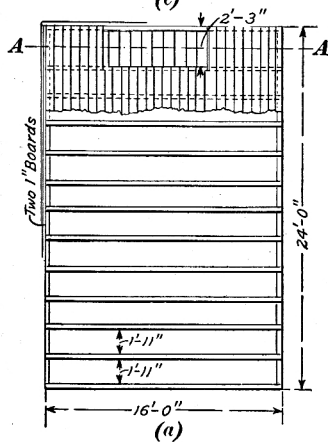


Section A-A

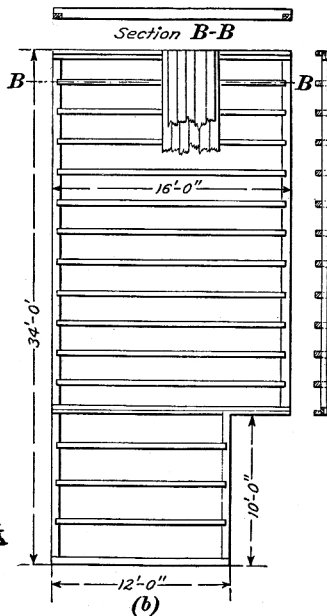
(c)



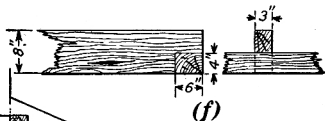
(d)



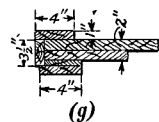
(a)



(b)



(f)



(g)

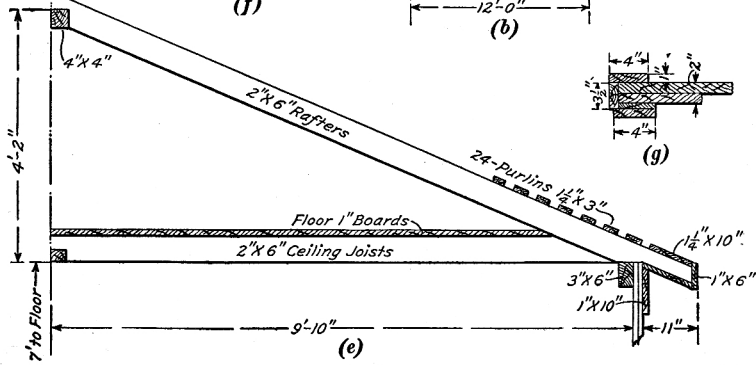


FIG. 8

15. Live-Stock Pens.—On lines having a heavy traffic in live stock, pens are provided at certain points for loading and unloading the animals. Since the law requires that live

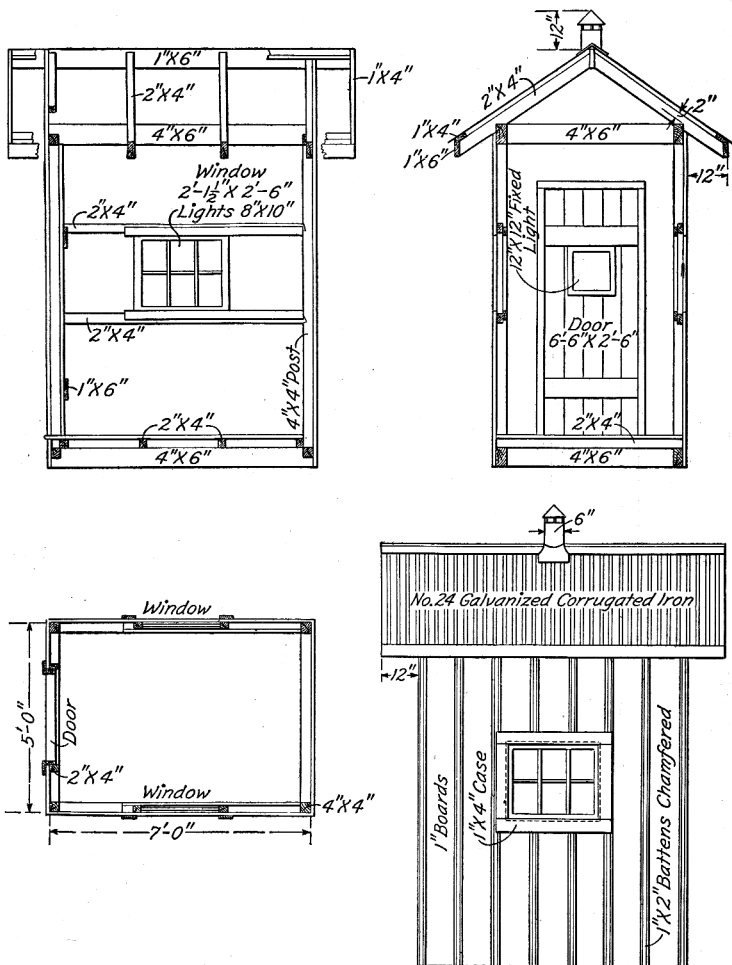


FIG. 9

stock must not be kept in the cars for more than a specified number of hours, yards must also be provided along the line so that animals being transported a considerable dis-

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tance can get exercise. At many country stations, small pens are required in which farmers may place live stock waiting to be loaded. A loading chute or runway, over which the animals are driven in loading or unloading, is required at all stations where live stock is handled.

16. Icing Platforms.—Where provision is made for refilling the ice tanks of refrigerator cars carrying fruit, vegetables, etc., a long icing platform is built with a track on one or each side. This platform is constructed so as to be level with the tops of the cars. Along the center of the

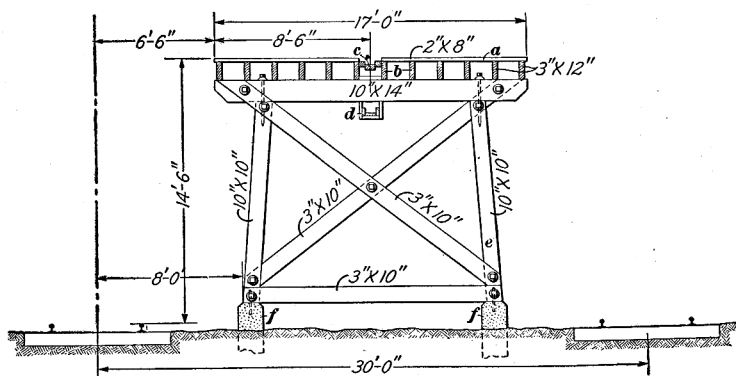


FIG. 10

platform is an ice conveyor that carries the cakes of ice, from an adjacent ice house, along the platform. Men with ice tongs pull the cakes of ice off the conveyor and slide them over hinged aprons or chutes to the roof hatches of the refrigerator cars. Double-deck platforms are constructed where crushed ice and salt are handled for repacking cars carrying meat products. The crushed ice is carried in wheeled carts or tubs along the upper deck of the platform and delivered to the cars through portable spouts.

The icing platform shown in Fig. 10 is constructed of 2" x 8" planks *a* spiked to 3" x 12" longitudinal joists *b*. It has a center opening extending the full length of the platform for the accommodation of the ice conveyor *c*. The trough *d* is for the return side of the conveyor. The plat-

form is 17 feet wide and its top is 14 feet 6 inches above the top of the rails. It is supported by timber bents *e* spaced 16 feet between centers. The posts of the bents rest on concrete piers *f*. This platform is built between two tracks and is long enough to serve a solid train of 40 cars on each track.

FENCES, CROSSINGS, AND SIGNS

RIGHT-OF-WAY FENCES AND RAILWAY CROSSINGS

RIGHT-OF-WAY FENCES

17. Types of Right-of-Way Fences.—The kind of fencing for railway right-of-way is specified by law in several states. The height required is usually not less than 4 feet 6 inches above the ground. Three types of fences in general use are *woven-wire fences*, *strand-wire fences*, and *board fences*. Woven-wire fencing consists of longitudinal galvanized steel wires having vertical stay wires woven across them or welded to them. Strand wire is obtainable in three shapes: round, ribbon or twisted, and barbed.

The posts for right-of-way fences are constructed of wood, concrete, or steel.

18. Wire Fences.—Right-of-way fences are usually of wire. The following four classes of wire fences are listed by the American Railway Engineering Association:

Class A is a woven-wire fence with nine longitudinal wires; the top and bottom wires to be of No. 7 gauge, and the intermediate and stay wires of No. 9 gauge. The spacing of the longitudinal wires, commencing at the bottom, should be 4, 4½, 5, 5½, 6, 7, 8, and 9 inches. The stay wires should be spaced 12 inches apart. This wire is hung with the bottom wire 5 inches above the ground, and may be made hog-tight by placing a strand of barbed wire 2½ inches below the woven wire.

Class B is a woven-wire fence with seven wires spaced $6\frac{1}{2}$, 7, $7\frac{1}{2}$, 8, $8\frac{1}{2}$, and 9 inches apart, and stay wires 12 inches apart. All wires should be of No. 9 gauge. This fencing is hung with the bottom wire 7 inches from the ground.

Class C is a combination fence consisting of woven-wire fencing $25\frac{1}{2}$ inches high with three strands of barbed wire above it. The wires of the woven-wire fencing should be of No. 9 gauge and the stay wires should be spaced 12 inches apart. The seven longitudinal wires should be spaced 3, $3\frac{1}{2}$, 4, $4\frac{1}{2}$, 5, and $5\frac{1}{2}$ inches apart. The spacing of the three strands of barbed wire above the woven wire should be $4\frac{1}{2}$, 10, and 12 inches.

Class D is a strand-wire fence consisting of five strands of round, ribbon, or barbed wire, the bottom wire being placed 10 inches above the ground and the others spaced 10, 10, 12, and 12 inches apart.

19. Board Fences.—A board fence is usually constructed five boards high. The fence boards are either 1 in. $\times$ 4 in. or 1 in. $\times$ 6 in. and 16 feet long. They are spaced 5 to 6 inches apart and are nailed to wooden posts spaced 8 feet apart.

20. Fence Posts.—Wooden posts may be of catalpa, cedar, chestnut, larch, locust, oak, pine, or any durable wood that can be obtained locally. In many cases such posts are either entirely treated with a preservative or have the lower portion dipped in some preservative. Three kinds of posts are used in a fence; namely, line posts, which carry the fence wire, and corner and gate posts, which are heavier posts placed at corners and gateways. Line posts are usually 4 or 5 inches in diameter at the top or small end, 7 to 8 feet long, and are set $2\frac{1}{2}$ to 3 feet in the ground. Corner and gate posts may be 7 or 8 inches in diameter at the top, 8 to 9 feet long, and set $3\frac{1}{2}$ to 4 feet in the ground.

Concrete fence posts are practical and economical and are extensively used. They may be square, round, or half round in section, and reinforced with four or six steel bars. Line posts vary from 3 in. $\times$ 3 in. at the top, tapering to 5 in. $\times$ 5 in. at the bottom, to 5 in. $\times$ 5 in. at the top, tapering to 6 in. $\times$ 6

in. at the bottom. The length runs from 6 feet 6 inches to 8 feet. Concrete line posts are shown in Fig. 11. Corner or gate posts are naturally heavier than line posts and are sometimes

cast in place in one piece with a corner brace and footing, as shown in Fig. 12. Fence wires are attached to the posts by means of lugs or hooks cast in the concrete or by tie-wires of the so-called Western Union twist, two types of which are shown in Fig. 11.

Steel posts are in use to some extent. They are usually formed of tubes or T bars. Ornamental iron fences are used around stations, yards, and shops.

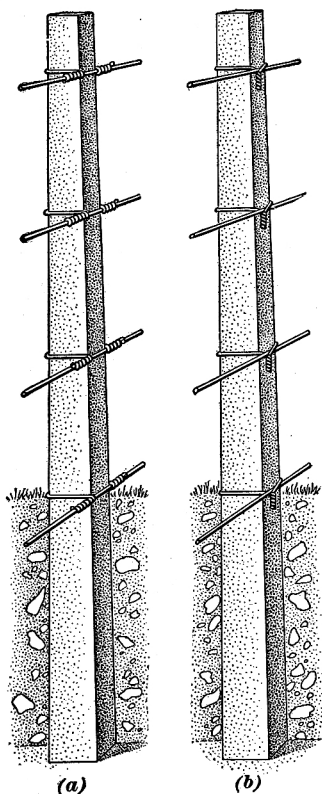


FIG. 11

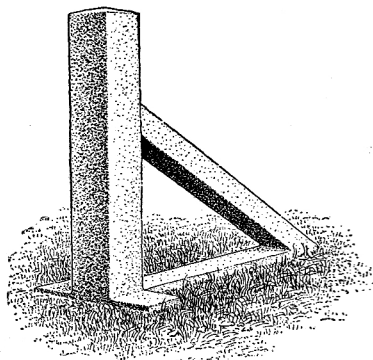


FIG. 12

21. Construction of Wire Fences.—In setting the posts for a wire fence, a start may be made at a fence post set on the right-of-way line, the post having been located by measuring the offset distance from the center of the track as shown on a plan. On curves, the offset distance for each post hole should be measured, but for a straight fence measurements may be taken at intervals of 100 to 200 feet and guide holes dug at these points. A chain or cord pro-

vided with tags for the proper spacing of posts is then stretched between these guide holes, and a man with a crowbar marks the positions for the intermediate holes. After the holes are dug the posts are placed and secured in position. The line posts for wire fences are spaced 16, 16½, or 20 feet apart; the posts of the braced panels at the ends, corners, or gates are spaced 8, 10, or 12 feet apart.

22. Wire fencing is placed on the outer, or farm, side of the posts, except that on the inner side of a curve it is placed on the inner, or track, side so as to bear against the posts. Before the wire is fastened to the posts, short braced panels are placed at gates, ends, and corners to hold

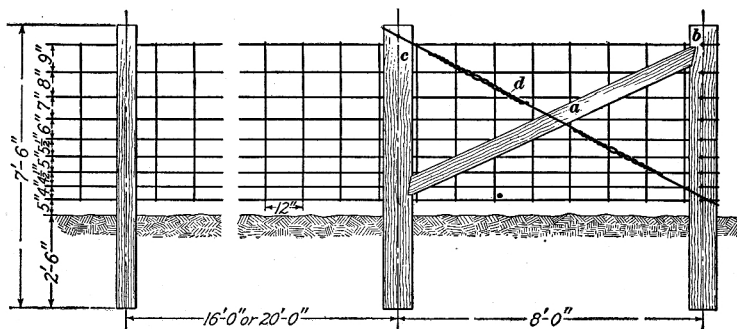


FIG. 13

the fence in the proper position. In Fig. 13 is shown an end panel constructed of wooden posts and Class A woven-wire fencing. A diagonal wooden brace *a* is gained into the end post *b* near its top and into the adjacent line post *c* near the ground. Three strands of heavy wire twisted together and looped around the posts *b* and *c* form the cross brace *d*.

When reinforced-concrete fence posts are used, a braced panel may be constructed by the method shown in Fig. 14, where two reinforced-concrete struts *a* are fitted into recesses in the gate post *b* and line post *c*, and the whole is effectively tied together by the two wire cross-braces *d*. In very long stretches of fence, braced panels should be introduced at intervals of a quarter of a mile.

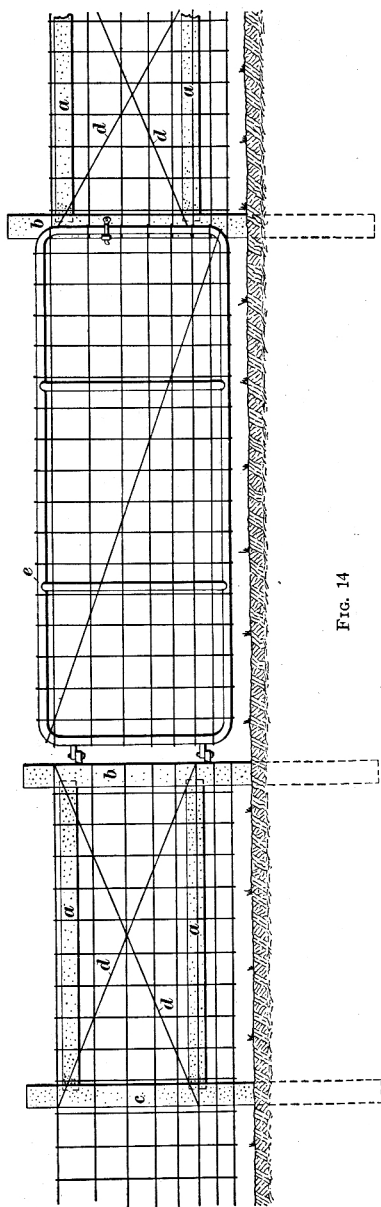


FIG. 14

In the construction of a strand-wire fence, each wire should be strung separately, as otherwise the wires are likely to get tangled, unless the ground surface is very regular. The wire is strung by fastening one end to the first, or starting, post, and the coil, or reel, on which the wire is rolled, is then carried forwards on a wheelbarrow or on a crowbar held by two men, the wire unwinding as it is taken forwards.

23. Fence Gates.—At farm crossings, gates must be provided to allow the live stock and farm vehicles to pass across the track. Farm gates are constructed either of boards or of a steel frame covered with woven wire. They should be hung so as to open away from the track, and if hinged, as is desirable, should close by gravity. The gate may be long enough to overlap the gate post so that it cannot be forced open toward the track. A steel-frame gate that meets these requirements is shown in Fig. 14 at *e*.

24. Wing and Apron Fences.—Since the railway owns no part of the public roads, the right-of-way fences

22 RAILWAY STRUCTURES AND TERMINALS

at grade crossings are turned in toward the track and placed parallel with the road, forming what are known as wing fences, as in Fig. 15. Sufficient clearance must be left between the ends of the wing fences *a* to permit trains to pass with-

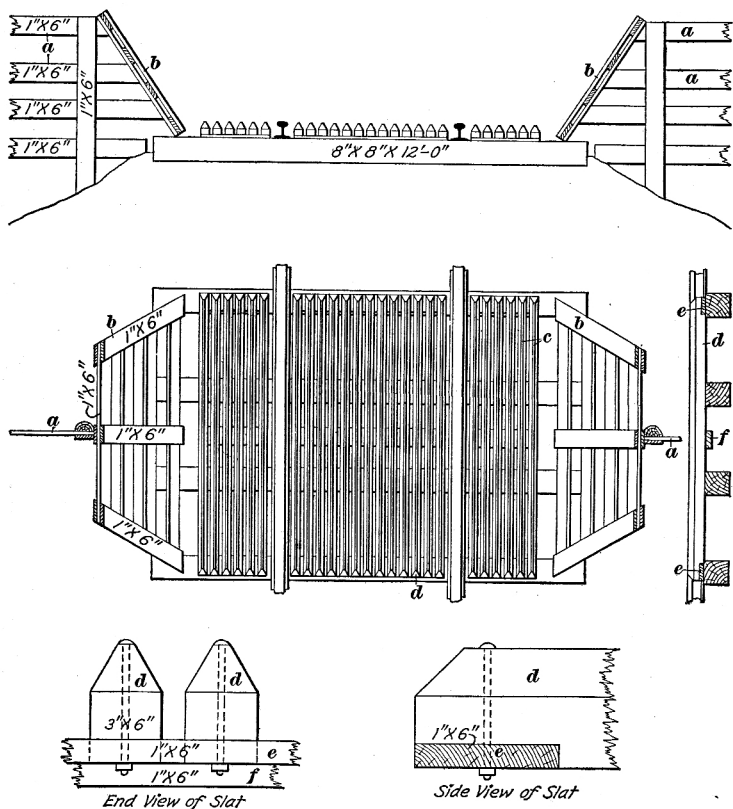


FIG. 15

out danger of striking the fence. This clearance distance is usually 12 to 18 feet for a single-track line. Wing fences are placed on both sides of the crossing and on both sides of the track. Lying against the end of each wing fence, is a single-panel apron fence *b*, laid parallel with the track. If the clearance is only 12 feet, the apron fence slopes away from the track so as to be clear of the cars

and trainmen riding on the sides of the cars; for 18 feet clearance the apron fence may be vertical. The space between the wing fence and apron fence is covered with the device *c*, called a *stock-guard* or *cattle-guard*, which will be described in the next article. Wing and apron fences and stock-guards may also be placed at farm crossings that are much used.

RAILWAY CROSSINGS

25. Stock-Guards.—At grade crossings of public roads some device must be placed which will prevent live stock from wandering along the track but will not interfere with the passage of trains. Formerly a pit or trench was dug across the track and lined with timber or masonry walls carrying stringers on which the rails were laid. A modified plan was to lay ties across the stringers, the sides of the ties being beveled so that they offered no foothold. However, pit guards are dangerous, because the timbers are liable to be burned by hot cinders falling from locomotives, and animals may get trapped in the pit and cause train wrecks.

It is now almost universal practice to have the ordinary ballasted roadbed and track continuous at crossings, but to place on the ties a surface stock-guard, formed of some kind of slats 6 to 8 feet long which offer no foothold and are too long to be jumped. The surface stock-guard shown at *c* in Fig. 15 is composed of 3"×6" wooden slats *d*, the sides of which are beveled for 2 inches below the top. They are spaced 2 inches apart and are bolted to two 1"×6" cross-pieces *e* resting on the ties. A cross-piece *f* is spiked under the middle of the slats. Metal stock-guards are usually constructed of flat bars, tee bars, or angle bars attached to metal cross-pieces.

26. Road Crossings.—Where the railway crosses roads and streets, the paving between rails must be so constructed as to provide flangeways or grooves for the passage of the wheel flanges and also to permit access to the track for maintenance and repair. Four types of road crossings are

shown in Fig. 16. In (a) wooden planks are laid parallel with the rails and spiked to the ties, filler pieces being placed on the ties to bring the planks level with the top of the rails. The outside planks are laid close to the rails but the inner planks are laid $2\frac{1}{4}$ inches away to form flangeways. Old rails are laid against the inner planks to protect the edges from wear. The method illustrated in (b) is the same as that in (a), except that steel angles are used to protect

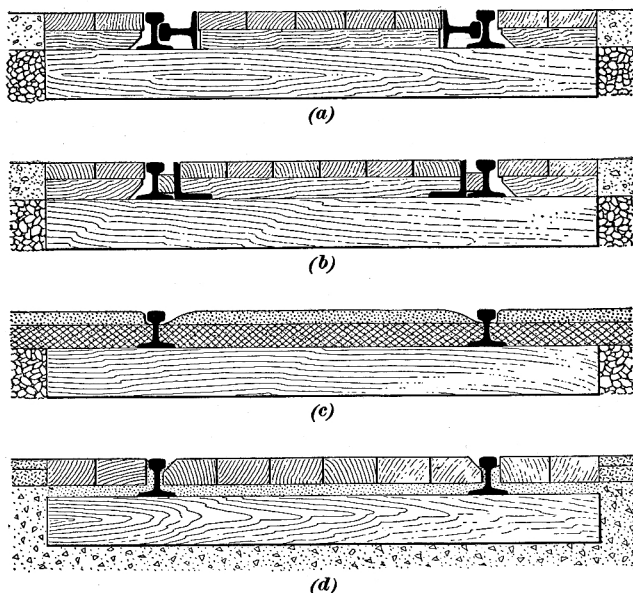


FIG. 16

the inner planks; wood fillers are placed between these angles and the webs of the rails.

In (c) is shown a comparatively new method, which consists of paving the entire crossing with cold bituminous macadam already prepared. After the track has been well surfaced a layer of ballast stone, previously mixed with about $\frac{1}{2}$ gallon of bituminous composition per cubic foot of stone, is laid and tamped to a finished thickness of about $2\frac{1}{2}$ inches. Upon this course is laid a similar layer of ballast

stone, $\frac{1}{4}$ to 1 inch in size, mixed with $\frac{3}{4}$ gallon of composition per cubic foot of stone. After this has been tamped and the flangeways formed, a coat of bituminous composition is flushed over the entire surface and covered with fine stone chips. Another modern method, used to a considerable extent, is to pave the crossing with broad concrete slabs or narrower concrete planks, which are spiked to the ties.

In the method shown in (d), for crossings of asphalt-paved streets, a sand cushion, 1 inch to 2 inches thick, is laid on the cross-ties, and wood paving blocks are placed on the sand cushion. The joints between the blocks are filled with asphalt and a wearing course of asphalt is sometimes placed over the entire crossing.

SNOW FENCES AND SHEDS

SNOW FENCES

27. Permanent Snow Fences.—To protect cuts from drifting snow, fences built of boards may be erected along the windward side of the railway cut. The snow fence checks

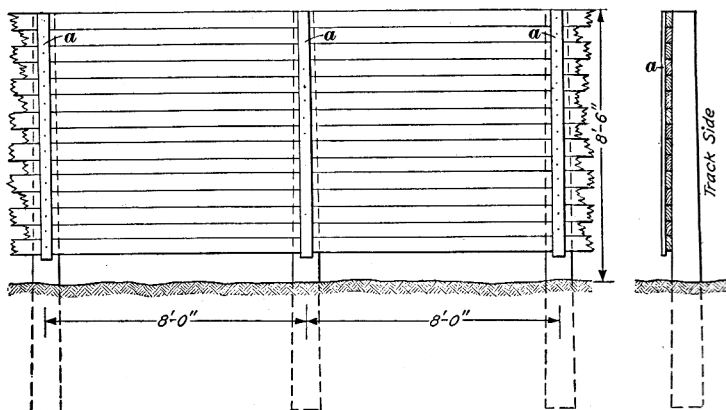


FIG. 17

the sweep of the windblown snow and causes the snow to be deposited along the fence instead of being carried into the cut and blocking traffic. The location of the snow fence

depends upon such local conditions as the topography of the ground, prevailing winter winds, amount of snowfall, etc. Where local conditions permit, a permanent snow fence located on the railway right-of-way is most economical. A type of permanent snow fence recommended by the American Railway Engineering Association is shown in Fig. 17. This fence is 8 feet 6 inches high and is constructed of 1-inch boards, 16 feet long and of any width, nailed to wooden fence posts spaced 8 feet apart. Battens *a* are nailed to the boards at every post.

28. Portable Snow Fence.—If the right-of-way is narrow, a permanent snow fence cannot be used, as it would be too close to the cut to give the desired protection. In

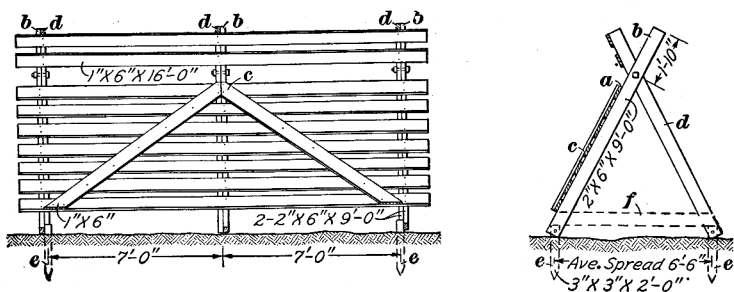


FIG. 18

this case, a portable snow fence may be placed on private property adjoining the cut, a small rental being paid for permission to occupy the land. These fences are made in separate folding panels so that they can be folded up and removed in the spring when farming operations begin. In Fig. 18 is illustrated one panel of a portable snow fence recommended by the American Railway Engineering Association. The panel is constructed of 1"×6" boards *a*, 16 feet long, spiked to three posts, and braced by the 1"×6" boards *c*; each post is made of two 2"×6" planks *b* and *d*, bolted together near the top so that they can be spread to form **A**-shaped supports. When not in use, the two planks are folded together so that the panels can be stacked flat. These panels are held in

position by the small guy stakes *e* driven into the ground. When guy stakes cannot be used, as in rocky soil, cross-boards *f* are nailed on the frames and old ties or rocks are loaded onto planks laid on these cross boards, so as to hold the fence panels in place.

SNOW SHEDS

29. Use of Snow Sheds.—In mountainous districts subject to heavy snowfall or avalanches of snow which are often accompanied by rocks and earth, the track is sometimes protected for long distances by snow sheds built over it. Snow sheds are also used to some extent on level ground where the snowfall is excessive. Two typical snow sheds are illustrated in Fig. 19.

30. Timber Snow Sheds.—A snow shed usually consists of heavy timber bents, placed 4 to 10 feet apart, connected by longitudinal bracing, and with the sides and roof formed of planks. In order to provide ventilation, the sides are left open for a distance of about 2 feet below the eaves. Since the passage of a train through such a shed is almost as objectionable as through a tunnel, some roads have what is called a *summer track*. This is a track outside the shed, for use when there is no snow. A timber snow shed suitable for flat country is shown in Fig. 19 (*a*).

31. Concrete and Timber Construction.—Concrete and a combination of concrete and timber are used to a great extent in the construction of snow sheds. A combination concrete and timber snow shed for a double-track road in mountainous country is shown in Fig. 19 (*b*). In this case the space behind the concrete retaining wall is filled with rock and earth, which eliminates the large amount of timbering necessary to carry the roof back to the natural slope of the ground.

32. Fire Protection.—In long stretches of timber construction the danger from fire is considerable and the sheds are often equipped with pipes supplying water from an elevated tank. To prevent the spread of fire, the shed is sometimes

28 RAILWAY STRUCTURES AND TERMINALS

broken by open spaces about 100 feet long. These open stretches of track may be protected by V-shaped fences or

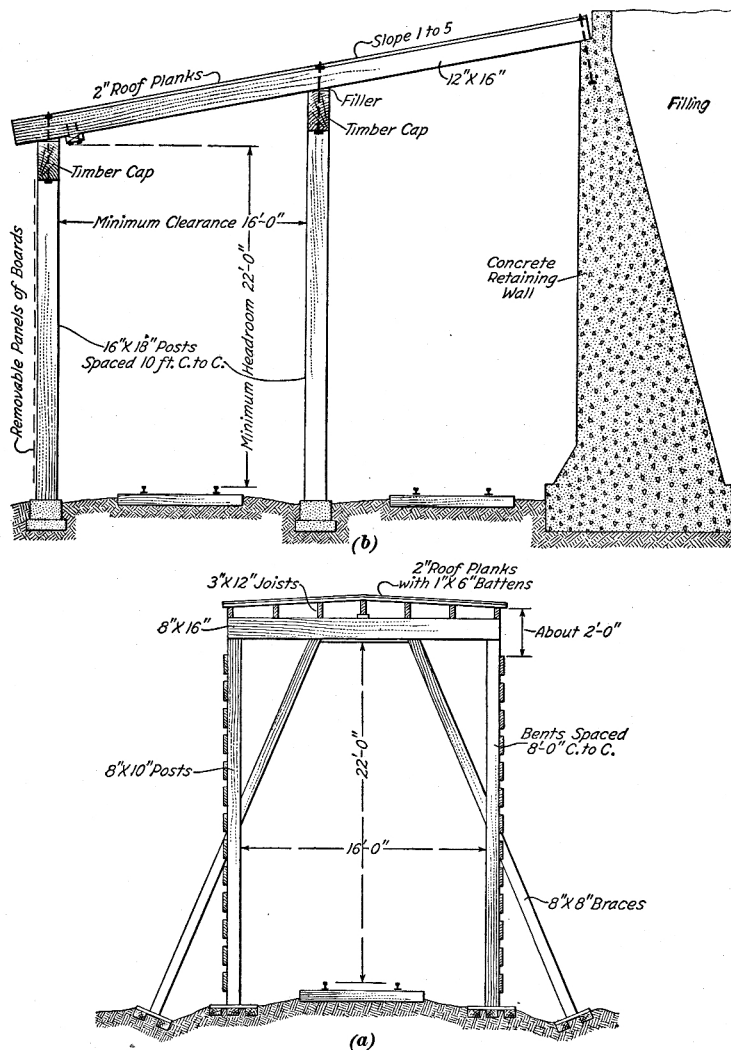


FIG. 19

deflectors on the hillside above the railway. In level country, movable sections 100 feet long, traveling on wheels, are some-

times provided at intervals in long snowsheds, and in case of fire these sections are removed, thus preventing the fire from running the full length of the shed.

SIGNS AND BUMPING POSTS

33. Signs.—Various marking and warning signs are required along a railway for the guidance of trackmen, engineers, brakemen, and the public, to indicate distances, special points, danger points, highway crossings, etc. Signs should be strong and durable, simple in design, economical in construction; conspicuous, and easily recognized.

In Fig. 20 are shown some of the various signs used by railways. In (a) is a highway crossing sign, erected to warn the public to look out for trains. The blades are painted white with black letters and a $\frac{1}{2}$ -inch black border. In (b) is a reinforced-concrete property post; it is used to mark the railway property line, or right-of-way line; similar posts may be set opposite the P. C. and P. T. of all curves and at every 1,000 feet on tangents for checking the alinement of the track. The exact location of the point through which the line passes is indicated by a cross cut in the top of the post. In (c) is a concrete mile post; the numbers 181 and 152 mean that one terminal station is 181 miles to the right of the post and another is 152 miles to the left of the post. The trespass or warning sign shown in (d) is to warn people to keep off the railway's property. The *slow* and *stop* signs shown in (e) are used at the approaches to track crossings, drawbridges, etc.

In Fig. 21 is shown a bridge tell-tale or tickler, which is placed on each side of a tunnel or a low bridge to warn brakemen on the top of cars that they must stoop or lie down.

34. Bumping Posts.—The ends of tracks in yards and stations, on elevated lines, at docks, etc., should be equipped with some sort of bumper or bumping post to prevent cars from running off. There are several different types of bumping posts in use and they are constructed of wood, steel, or concrete, or combinations of these materials.

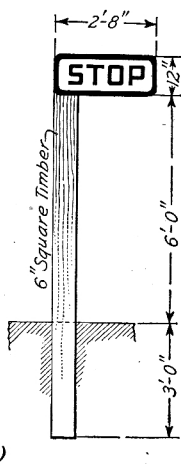
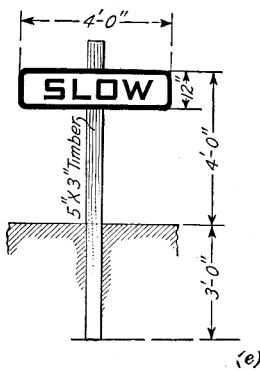
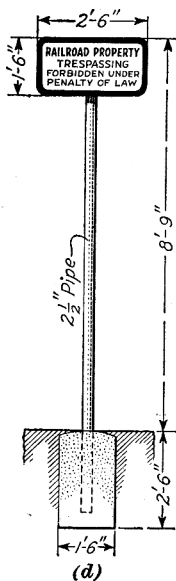
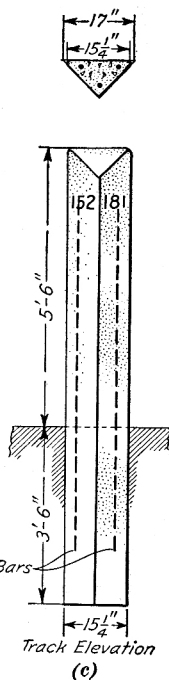
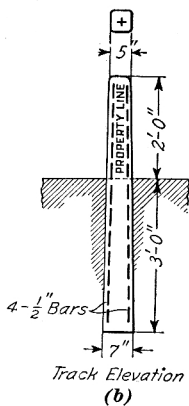
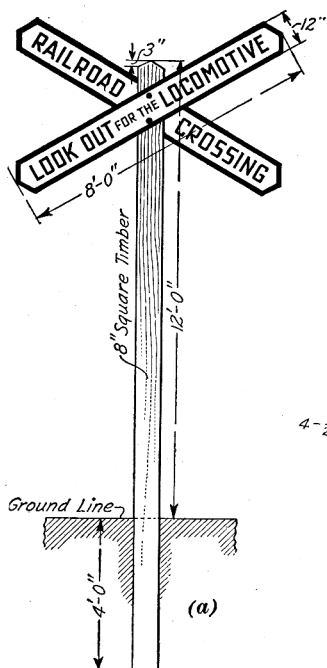


FIG. 20

A typical wooden bumping post is shown in Fig. 22, in side elevation in (a) and end elevation in (b). This device consists of two vertical posts *a*, mounted on the frame work *b*, and

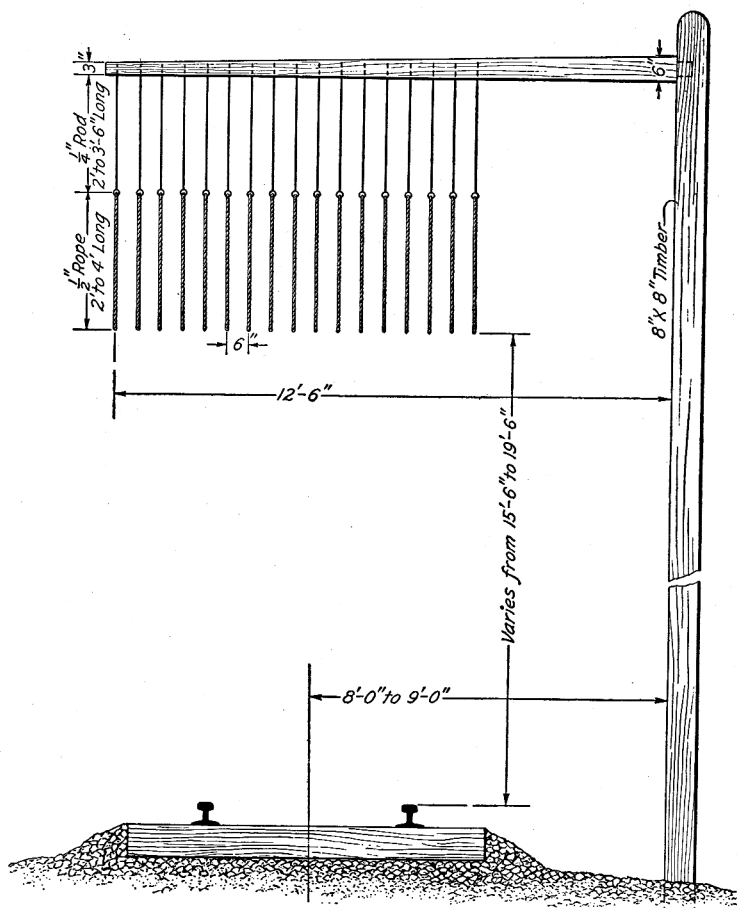


FIG. 21

effectively braced by two back braces *c* and two tie-rods *d*. At the top the vertical posts carry heavy cross-timbers *e*, which are faced with the steel bumping plate *f*.

YARDS AND TERMINALS

FREIGHT YARDS

DESIGN AND LAYOUT OF YARDS

35. Purpose of Freight Yards.—An outbound or outgoing freight train made up at any terminal or division yard consists of cars for various destinations and with varied classes of freight. At the next junction or division point, therefore, the inbound or arriving train must be *broken up*; that is, the cars must be separated or classified for different destinations or for different kinds of commodities. Cars for transfer to local industries, or those that are to be forwarded over branches and connecting railroads, must be separated from cars to be sent further on over the main line. At large terminals, cars may have to be distributed to freight houses, warehouses, factories, coal and ore docks or piers, grain elevators, etc.

A freight yard, consisting of an extensive and well-designed system of tracks, is required for the complicated work of breaking up inbound or arriving trains and making up or assembling outbound trains, in order that such work may proceed rapidly, efficiently, and economically. The freight yard, however, must not be regarded as an independent machine for shifting and storing cars. It must be recognized as simply one factor in the general work of railway transportation or operation. Its highest efficiency will be reached when cars are delayed as little as possible and when the work is done at a minimum cost; mere rapidity of movement of cars in a yard, however, may not mean economy, as it may be done at the expense of damage to cars and freight. The aim should be for general speed in yard operations, with due regard to ultimate efficiency.

36. Yard Design.—No standard design of a yard is feasible owing to varying local and traffic conditions; nor is it practicable to have the ideal yard layout at any point, since topography and property boundaries are likely to influence the design. This is specially true of yards in and near large cities; and, hence, there is a growing tendency to locate yards in the open country where land sufficient for a desirable layout can be obtained at a relatively low cost.

The yard itself is made up of a series of connected groups of tracks, the parallel or body tracks of each group being connected at one or both ends by a diagonal or ladder track. Certain fundamental features must be included in any freight-yard design. Thus, provision is required for taking inbound trains from the main track before they reach the yard, so that if a train cannot be admitted to the yard immediately it will stand on a side track or yard lead instead of blocking the main track. Receiving tracks are required where the inbound trains stand while the cars are inspected and marked for destination. Next will be the classification tracks, where cars for the same destination or cars with the same kind of commodities are placed together. On some of these tracks or on separate advance or departure tracks, outbound trains are made up for the trip over the next division. These departure tracks should be equipped with compressed-air piping, so that the air brakes can be tested when the train is ready but the locomotive has not yet been coupled on. A group of repair tracks is needed, where cars can be repaired, and also a bad-order track, on which cars requiring repairs can be set ready for removal to the repair tracks. At least one thoroughfare or through track is required in a freight yard, which is to be kept open at all times to allow movements all the way through the yard. In determining the lengths of the various tracks in a yard, it is customary to allow 42 feet per car for all tracks except repair tracks, 50 feet per car being required for the latter to provide working space at the ends of cars.

37. Yard Layout.—A theoretical yard layout is shown in Fig. 23 (*a*), each track being represented by a single line.

In practice, the longitudinal arrangement of the groups of tracks in series is sometimes modified by topographical features, property boundaries, and other conditions. The separate groups may have to be arranged more or less side by side, thus forming a yard of shorter length but greater width. The main line tracks may pass along one side of the yard, or may be separated to include the yard between them. The yard is divided into two divisions for traffic in opposite directions.

Beginning at the left end of Fig. 23 (*a*), eastbound trains from the main line tracks are diverted onto the receiving tracks *a*; here the locomotive is cut off or detached and sent to the roundhouse *b*. The caboose also is cut off and shifted to the caboose track *c*, convenient for attaching it to an out-bound or westbound train. If repairs are necessary, the caboose is shifted to the caboose-repair track *d*. While on the receiving tracks, each car is inspected and marked for destination; two or more consecutive cars for the same destination may be handled together as a unit or *cut of cars*. The cars found defective are switched onto the bad-order track *e* for later removal to the repair tracks *f*. If a car needs extensive repairs, its load may have to be transferred to another car. Cars that have passed inspection and have been marked for their destination are then placed on the proper classification tracks *g* in groups as required for making up trains; cars for local orders are accommodated on the local-order tracks *h*. Outbound trains for the east are made up on the advance tracks *i*. Cars for fast-freight trains, which must be forwarded without delay, are placed on the group of fast-freight tracks shown at *j*, while cars that are not to leave promptly are placed on the hold or storage tracks *k*.

Beginning at the right end of Fig. 23 (*a*), westbound trains are diverted from the main line onto the receiving tracks *l*, where the locomotive is detached and sent to the roundhouse *b*; the caboose is shifted to the caboose track *m*, and if necessary to the caboose-repair track *n*. Defective cars are shifted to the bad-order track *o* and later removed to the repair tracks *p*. The two sets of car-repair tracks, *f* for eastbound

trains and p for westbound trains, are seldom used in practice; one set of car-repair tracks usually serves the entire yard. Cars that have been inspected and marked for destination are placed on the classification tracks q , and cars for local orders are shifted to the local-order tracks r . Outbound trains for the west are made up on the advance tracks s . Cars for fast-freight trains are made up on the fast-freight tracks t .

In each group of poling tracks u , the function of which will be explained later, two tracks are shown provided with track scales v . The arrangement shown is rarely used, there being generally only one scale for eastbound and one for westbound cars. The tracks w are local-freight and team-yard tracks, and the transfer platforms x are for transferring freight from lightly loaded cars to make full carloads. One of these platforms adjoins the freight station y , near which are the cattle pen z and the ice house a' . Another ice house a' is at the other end of the yard. Near the local-freight tracks is located the trainmen's building b' . Among the various structures in the yard are the coaling stations c' and the water columns d' .

In Fig. 23 (b) is shown a layout of an actual freight yard and engine terminal similar to that of the Michigan Central Railroad at Niles, Michigan. The westbound receiving and classification tracks are shown respectively at e' and f' , while the eastbound receiving and classification tracks are respectively at g' and h' . The caboose track i' is located near the westbound receiving tracks and the caboose track j' is near the eastbound receiving tracks. The repair tracks k' are used for both westbound and eastbound cars, light repairs for eastbound cars being made on the light-repair tracks l' . Engines from eastbound trains can move from the eastbound receiving tracks onto the lead track m' and from there get on the track n' that leads to the roundhouse o' . From the westbound receiving tracks, engines can get to the roundhouse by means of the track p' . The semicircular loop track q' passes under the tracks in its path, and thus allows outgoing westbound engines to get to the departure tracks r' without interfering with the movement of eastbound trains.

38. Yard Switches.—The body tracks of each group of tracks are spaced about 13 feet between centers and connect at each end with a ladder track. The two ladder tracks may be in the same direction, as in the receiving tracks *a*, repair tracks *f*, etc., of Fig. 23 (*a*), or they may be in opposite directions as in the fast-freight tracks *j* and the local-order tracks *h*. In the former case all the body tracks will be of the same length, while in the latter case the length will vary. In yard work, No. 7 frogs are often used, but the modern tendency is to use nothing less than No. 8, with No. 10 frogs for connections to running tracks and main-line tracks.

Convenience and safety require that the main-line tracks be kept entirely separate from the yard tracks. It will be noticed in Fig. 23 (*a*) that the only connection between the main tracks that surround the yard and the yard tracks is by the series of switches at the extreme ends of the yard. Even at small yards and stations, all yard and side tracks and all spur tracks to industrial plants should run out from a side track or lead track connected to the main track by a single switch. Such switches should be amply protected by signals. Large yards usually have interlocking switch and signal plants at the connections to the main tracks.

39. City Yards.—In large cities, local yards are provided at different points for the loading and unloading of cars that are moved to and from the main terminal yards, where trains are broken up and made up. Such a yard will usually have a team yard as previously described. Since these local yards are usually located on expensive property where enlargement is prohibitive, they must be laid out to utilize the space to best advantage, even if sharp curves and small frogs are required. In this connection it is well to note that single cars can be moved over curves of 50 to 75 feet radius, but a minimum radius of 150 feet is necessary when coupled cars are to be handled.

SWITCHING

40. Flat Switching.—In an ordinary level yard, switching for classification purposes may be done by one of several methods. One method is by means of a switch engine, which pulls the train backwards and forwards along the tracks; successive cars or cuts of cars are uncoupled from the rear end of the train, at each push or forward motion of the train, so as to run by their own momentum down the ladder track and onto the body track for which they are assigned. In another method the engine pulls out each car or cut separately and then pushes it quickly to the ladder track, thus giving it sufficient momentum to run to the desired point. These methods are slow and expensive, especially in large yards. An improved method is to have an engine running back and forth on a poling track, situated as shown at *u* in Fig. 23 (*a*). Each car or cut is uncoupled and pushed forwards by means of a horizontal pole, pivoted to the side of the engine or to a car attached to the engine, until it has attained sufficient speed to run onto its proper body track. Poling may be assisted materially by giving the ladder track a descending grade of about $\frac{1}{2}$ per cent., and extending this grade into the body tracks. In all these methods a brakeman usually rides the car that is being switched in order to stop it at the proper position and to avoid its striking heavy blows against other cars standing on the tracks.

41. Gravity Switching.—Gravity switching is now extensively used in large yards owing to the rapidity, facility, and economy in working. In this method, an incline of such grade is built that a car started down the incline gains sufficient speed to run onto the classification tracks. A brakeman rides the car to stop it, and in large yards an adjacent track is provided for a motor car that returns the brakemen promptly to the starting point. The topography will sometimes enable this incline to be formed as a drop in grade all the way from the receiving yard to the classification yard. As a rule, however, an artificial hill, called a *hump*, is required. This hump

has a long easy approach grade of 1 or $1\frac{1}{2}$ per cent. ascending to its summit. A yard engine pushes the train slowly up the approach grade of the hump to the summit, at which point the cars are uncoupled, one or more at a time, and allowed to descend by gravity down the hump to their desired destination. In very large yards of this type the switches of the classification track may be operated by electric or pneumatic apparatus controlled from a cabin, located on a bridge over the summit of the hump.

The actual profile of the hump for any yard must be adapted to the local conditions of traffic and climate. Loaded cars roll easier than empty ones and all cars roll easier in warm weather than in cold weather. The grades that can be used will vary, therefore, according to whether the cars are mainly loaded or empty. When there are extremes of summer and winter temperatures the grades are sometimes varied from time to time by increasing or decreasing the depth of ballast.

42. Making Up Trains.—To prepare an outbound train, cars are pulled successively from different classification tracks and pushed together on one departure track. Where there are no separate departure tracks, the trains are made up on some of the classification tracks. The cars are coupled automatically as they come in contact. A yard crew connects the brake hose and other pipes and inspects the journal-boxes for lubrication. When all the cars are in place the brakes are tested. With a caboose and a locomotive attached the train is ready to start on its run.

ENGINE TERMINALS

43. Care of Locomotives.—Each division of a railway system has its own locomotive equipment. A locomotive takes its train over the division and is then detached at the station or freight yard, after which it must be made ready for a return trip. The locomotive needs to be inspected, to have light or running repairs made, and to have its fire cleaned;

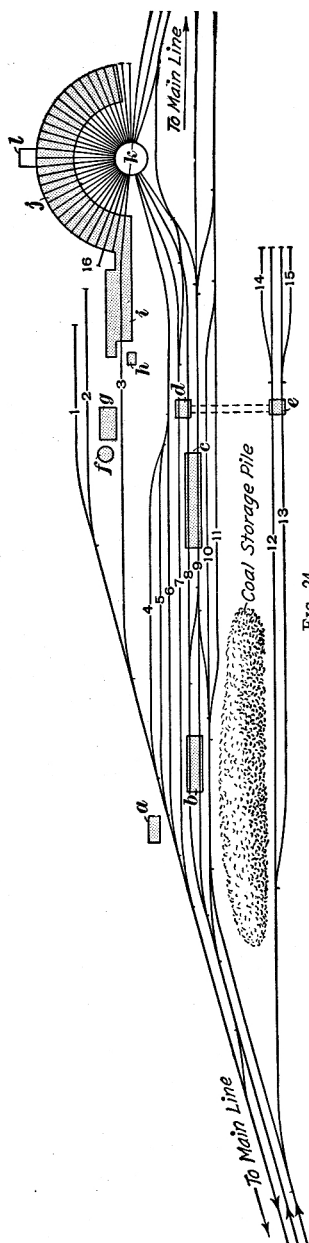


Fig. 24

the machinery must also be cleaned and lubricated, and the tender must be supplied with fuel and water. At times it will also be necessary to wash out the boiler in order to remove the dirt and scale. Provision for thus taking care of the locomotive is made at an engine terminal, which is located at the middle of a long freight yard, as in Fig. 23 (a), or more generally adjacent to the freight yard, as in (b).

After being inspected, cleaned, fueled, and watered, a locomotive that is to make a return trip promptly may be placed on a locomotive storage track, located outdoors in the engine terminal. If the locomotive is to be repaired or is not required to make a return trip at once, it must be placed in the roundhouse until needed. A locomotive in the roundhouse is usually dead; that is, its fire is out, and the fire must be kindled in sufficient time for the locomotive to start on its run.

44. Arrangement of Terminal Facilities.—The principal elements of an engine terminal are the inspection pits, the ash-pits, fuel and water stations, turntable, and roundhouse.

In the plan of a typical engine terminal, shown in Fig. 24, *a* is a two-story building for the accommodation of the train dis-

patcher and the train crews; *b*, the shed-covered inspection pits; *c*, the ash-pits; *d*, coaling station; *e*, track hopper for coal; *f*, elevated tank; *g*, the power house; *h*, an oil house; *i*, a machine shop and platform; *j*, a roundhouse with thirty stalls for locomotives; *k*, a turntable; and *l*, a house for the boiler-washing plant and ventilating fans. In this terminal the various tracks are assigned as listed below:

1. Wrecking-crane track.
2. Supply track to power house and machine shop.
3. Locomotive-repair track.
- 4, 5, 6, and 7. Locomotive-storage tracks.
- 8 and 9. Principal entrance tracks.
10. Ash-car track.
11. Run-around track.
- 12 and 13. Coal-supply tracks.
- 14 and 15. Coal-car storage tracks.
16. Storage tracks for wheels.

The coal-supply tracks are usually located close to the coaling station, but the arrangement shown here is to provide space for a large storage pile of coal alongside the tracks.

45. Application of Terminal Facilities.—In the plan of Fig. 24, a locomotive after being detached from its train enters the terminal on track 8 or 9. It first passes to the inspection pits *b*, which allow the men to get under it, and is thoroughly inspected. It then passes to the ash-pits *c* to have the ashes dumped and the fire cleaned or drawn; then it moves on to take coal and water at *d*. The locomotive is next run onto the turntable *k* and set in position either to run on one of the locomotive-storage tracks or into the roundhouse *j*, depending on whether it is to make a return trip at once or is to be stored or repaired.

YARD AND TERMINAL STRUCTURES

ENGINE HOUSES

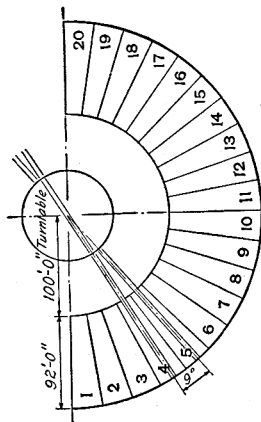
46. Types of Engine Houses.—A building called an engine house is provided at each division and terminal point in a railway system. Here the locomotives are housed, cleaned, repaired, and made ready for the next trip. Engine houses are of two types; namely, rectangular engine houses and roundhouses, the latter being generally used. Rectangular houses may be provided either with parallel stub tracks having switches at one end only or with parallel through tracks connected at each end with a diagonal ladder track.

47. Construction of Roundhouse.—A roundhouse is a building with curved walls, forming two parallel arcs of circles, and provided with from four to fifty or more radial tracks. These tracks are served by a device for turning the locomotives called a turntable, whose pivot is at the center from which the radial tracks and the curves of the walls are drawn. The angle between the center lines of the roundhouse tracks should be some even divisor of 180° , so that tracks at opposite ends of the turntable will simultaneously line up with the track of the turntable. To provide working space at each end of the locomotive, the width or depth of the building should be at least fifteen feet greater than the overall length of the largest locomotive and tender on the division. Heavy timber framing with brick walls is generally employed, but concrete also is largely used. Steel framing is used only where special care is taken to eliminate smoke, because otherwise the metal corrodes rapidly. To avoid interruption to traffic due to fire, it is often considered best to employ fire-proof construction, such as reinforced-concrete roof and framing with brick walls. Additional security may be obtained by dividing the roundhouse into units of about 10 tracks, or stalls, by means of walls of fireproof material.

The wall of the building facing the turntable is composed mainly of the entrance doors and the posts between them

on which the doors are hung and which support the roof. The entrance doorways are usually about 13 feet wide, not less than 16 feet high, and are fitted either with wooden swinging doors or steel rolling doors. The outer or rear wall should have a large area of windows. A monitor roof, that is, a raised roof having side openings fitted with windows, will improve the light and ventilation. Roof ventilators may also be used to help carry off the smoke and gases from the locomotives. Over each track or stall is placed a smokejack consisting of a large tapering hood, supported from the roof by hangers, with a flue or chimney passing through the roof. The hood of the smokejack should reach within a few inches of the top of the locomotive smokestack and should be of sufficient length to provide for slight variations in the position of the locomotive on the track. Smokejacks are made of metal or various special compositions. In many cases they are merely of wood, covered with a fireproof paint, as they soon become coated with a protective covering of soot. Between the rails of each stall is a concrete pit 50 to 60 feet long and about 3 feet deep to enable workmen to inspect, clean, and repair machinery. An annex to the roundhouse frequently accommodates a small machine shop for repair work and a heater for a boiler-washing plant.

48. Typical Roundhouse.—In Fig. 25 is shown a twenty-stall roundhouse, 92 feet wide, with concrete repair pits. Instead of having a monitor roof, one part of the roof of this roundhouse is higher than the other; the vertical face thus formed is fitted with windows, as shown in the longitudinal section in (*a*). Six lines of wooden posts or columns support the roof framing, which consists of wooden beams and girders arranged as indicated in the framing plan (*b*) for one stall. Knee braces stiffen the framing in both directions, and hangers and cross-pieces are provided to support the overhead piping systems. A ground-floor plan of one stall is illustrated in (*c*), and in (*d*) is shown a layout of the roundhouse, turntables, etc.



(d)
Fig. 25

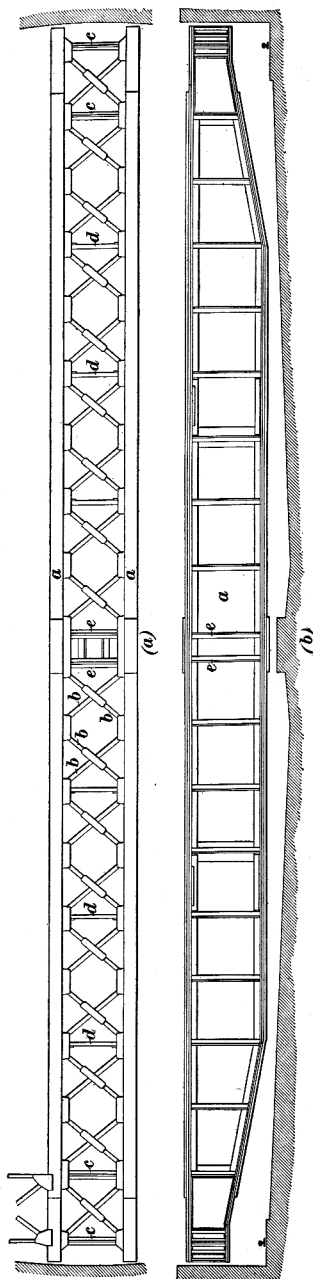


FIG. 26

49. Turntables.—To reverse the locomotives for their return trips and also to shift them to and from the radial tracks of the roundhouse, a device called a turntable is employed. A turntable consists of a pair of girders braced together, carrying a single track, and revolving in a circular paved pit, as shown in Fig. 26. In most cases these are deck girders, with track ties laid across them; in cases where the use of deck girders would necessitate very deep pits, they are either half-through girders, with ties carried between them by shelf angles on the girder webs, or through girders with the ties supported on the inside of the bottom flanges. These latter two arrangements permit of deeper and stiffer turntables without excessive depth of pit. The length of a turntable is from 70 to 100 feet, depending on the overall length of the largest locomotive and tender to be handled. The larger turntables usually have a central bearing or pivot and also a rim bearing at each end furnished by wheels running on a circular track. The wheels prevent the table from tilting too far as a locomotive moves on or off, and also carry part of the load. For such a design the table should be a little longer than the locomotive so that the locomotive may be moved to the proper position for balancing. A small turntable may be supported entirely at the center. In the most modern designs no balancing is necessary and the table need be only a little longer than the wheelbase of the engine and tender.

If only a few locomotives are handled daily, the turntable has long wooden levers projecting from each end so that it can be turned by men pushing against these levers. Where many locomotives are turned in a day, power operation is generally used, because of economy in time and expense. A one-wheeled tractor is coupled to one corner of the table and rides on the circular rail. This tractor is driven by an electric, gasoline, or compressed-air motor and in turn operates the table.

50. The steelwork for a typical deck-girder turntable is shown in Fig. 26, in plan view in (a) and side elevation in (b).

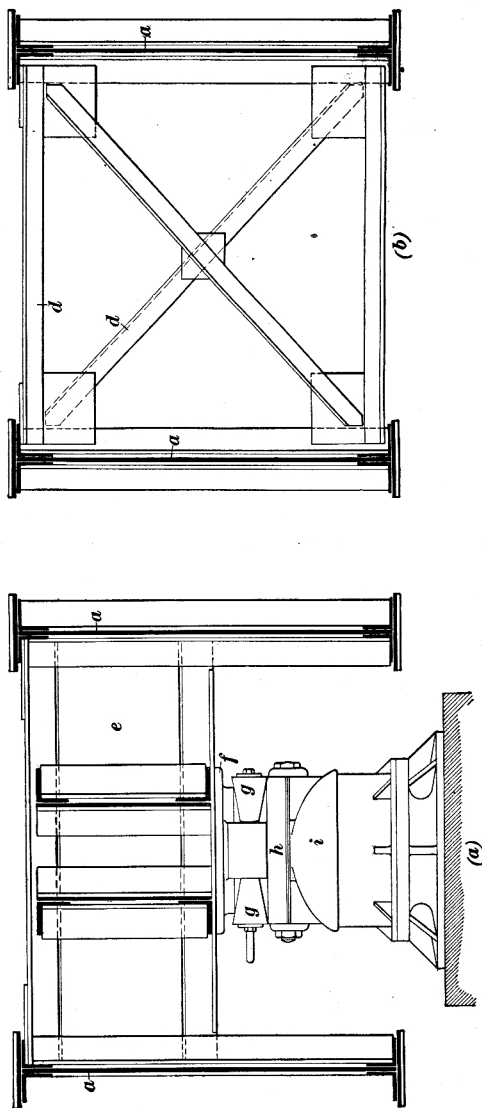


FIG. 27

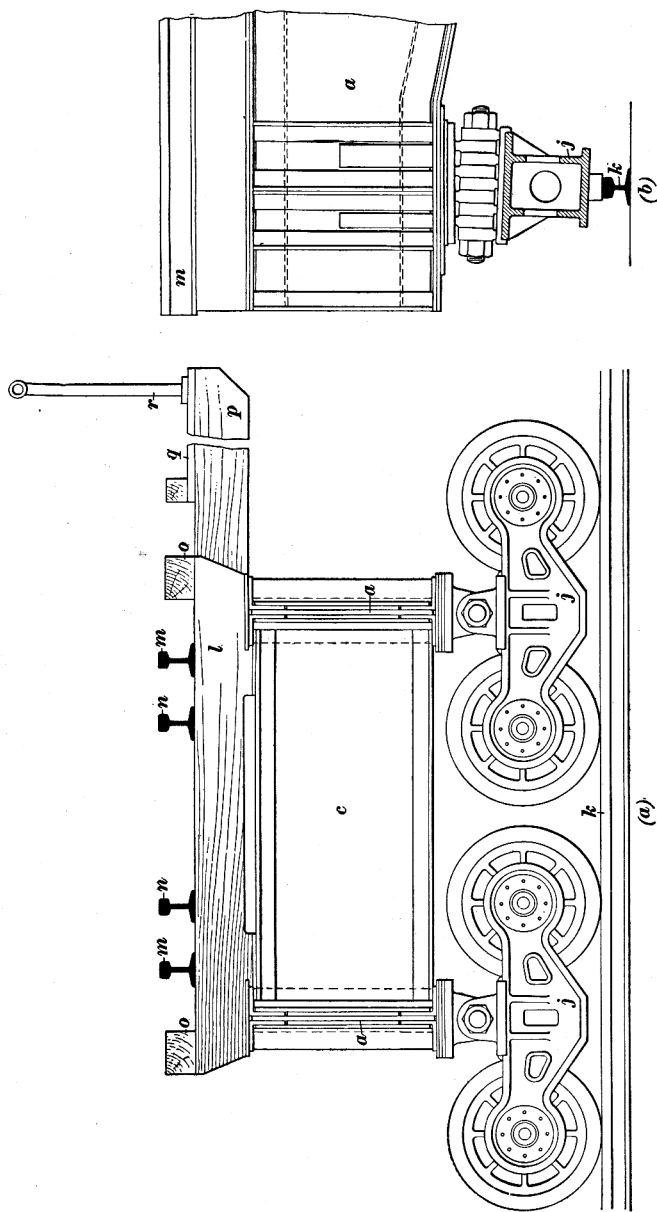
The two plate girders *a* are connected together at the top by means of the bracing members *b*; at each end by two transverse plate frames *c*, and at intermediate points by the cross-frames *d*. Near the center of the structure are two cross-girders *e*.

In Fig. 27 are shown cross-sections through the turntable, the one shown in (*a*) being taken near the center of the structure, and the one in (*b*) near the cross-frame *d*. As shown in (*a*), to the under side of the cross-girders is riveted the bearing plate *f* that rests on the ring of conical rollers *g*. These rollers ride on the bearing plate *h* of the pedestal *i*, which is supported by and anchored to a concrete pier.

Typical details of an end of the turntable are shown in Fig. 28, an end view of the turntable being shown in (*a*) and an elevation of the end of a girder in (*b*). Each end of the turntable rests on two 2-wheeled trucks *j*, one truck being provided at the end of each girder. The trucks ride on the circular rail *k*. Across the girders are laid the ties *l*, in (*a*), that carry the track rails *m*, guard-rails *n*, and guard timbers *o*. Long timbers *p* are laid at intervals across the girders to carry a footwalk *q* and railing *r*. The floor of the pit is paved and generally dished so that water will run to the center drain.

51. Transfer Tables.—At repair shops and car shops having a number of parallel transverse tracks, a traveling transfer table is used to shift a locomotive or car from one track to another. This table, shown in plan view in Fig. 29, consists of a platform *a*, carrying a single track *b*, long enough to hold the largest locomotive and tender operating in the division. The table is mounted on several pairs of wheels that ride on rails *c* in a shallow pit 15 to 24 inches deep, at right angles to the tracks of the shop or engine house. Some large rectangular engine houses, having parallel tracks, are served by transfer tables instead of by track connections and switches.

The operation of a transfer table can best be explained by referring to Fig. 29. Suppose a locomotive standing on track 1 is to be transferred to track 7. The transfer table



is run to the position shown in full lines where its track is directly in line with track 1; the locomotive is then moved forwards onto the table and the table is run to the left, until

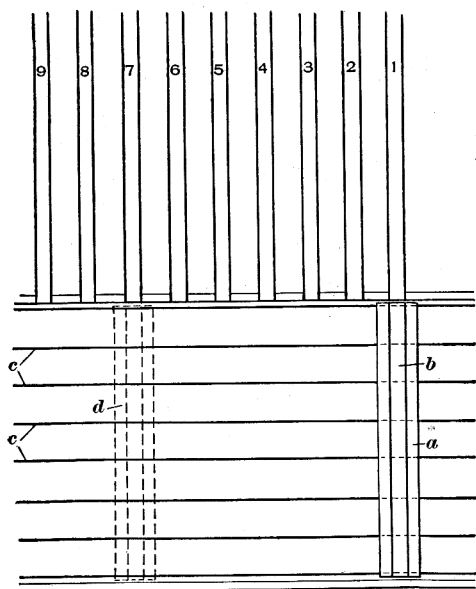


FIG. 29

it is opposite track 7, as shown in dotted lines at *d*. The locomotive can now be moved off the table onto track 7. Transfer tables are usually driven by electric or gasoline power.

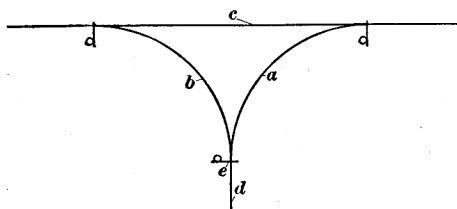


FIG. 30

52. Y Track.—At points where locomotives are turned only occasionally, and also at rectangular engine houses where no turntables are provided, a Y track will serve for turning locomotives. As shown in Fig. 30, a Y track consists of two

curves *a* and *b* running in opposite directions from a straight track *c* and uniting in a short stub-track *d*, which forms the stem of the **Y**. A locomotive entering one curve from track *c*, runs down that curve onto the stub *d*; the switch *e* is then shifted and the locomotive runs out on the other curve to track *c*. It is now facing in the opposite direction from which it entered the **Y**.

WATER SERVICE

53. Water Stations.—The tender tanks of locomotives need to be replenished with water during their runs and for this purpose water stations are provided at terminals, passenger stations, coaling plants, engine terminals, and intermediate points along the line. The average distance between water stations is from 15 to 30 miles. Their location is determined by the number of locomotives operating, the capacity of the tender tanks, and the sources of water supply; it is also determined by the profile of the line, since it would be undesirable to stop heavy trains on a steep grade or at the foot of such a grade in order to take water. Tender tanks hold from 6,000 to 15,000 gallons of water and a locomotive evaporates 20 to 150 gallons of water per mile, depending on the weight of the train, steepness of grades, and various other factors.

54. Sources of Water Supply.—The least expensive and most satisfactory water supply is that obtained from either springs or brooks that have sufficient elevation to deliver water into the supply tank by gravity and so avoid the expense of pumping. Water may also be obtained from wells, rivers, lakes, or city-supply systems. When the supply in times of drought is likely to run short, a reservoir is sometimes constructed to store surplus water for future use. Water from streams needs to be passed through screens to remove leaves and floating trash. Clear, pure water, as free as possible from mineral matter in solution, is greatly to be desired.

55. Water Softening.—Water often contains matter which, under the influence of heat, is deposited in the form

of a hard scale on the boiler tubes, or a soft sludge or mud in the boiler. The former is the more serious, since it retards the transmission of heat to the water, with consequent increased expenses for fuel, for cleaning out the boilers, and for boiler repairs. For these reasons, it is becoming the general practice to bring good water from a distance or to use a water-softening system in order to remove or neutralize the scale-forming elements.

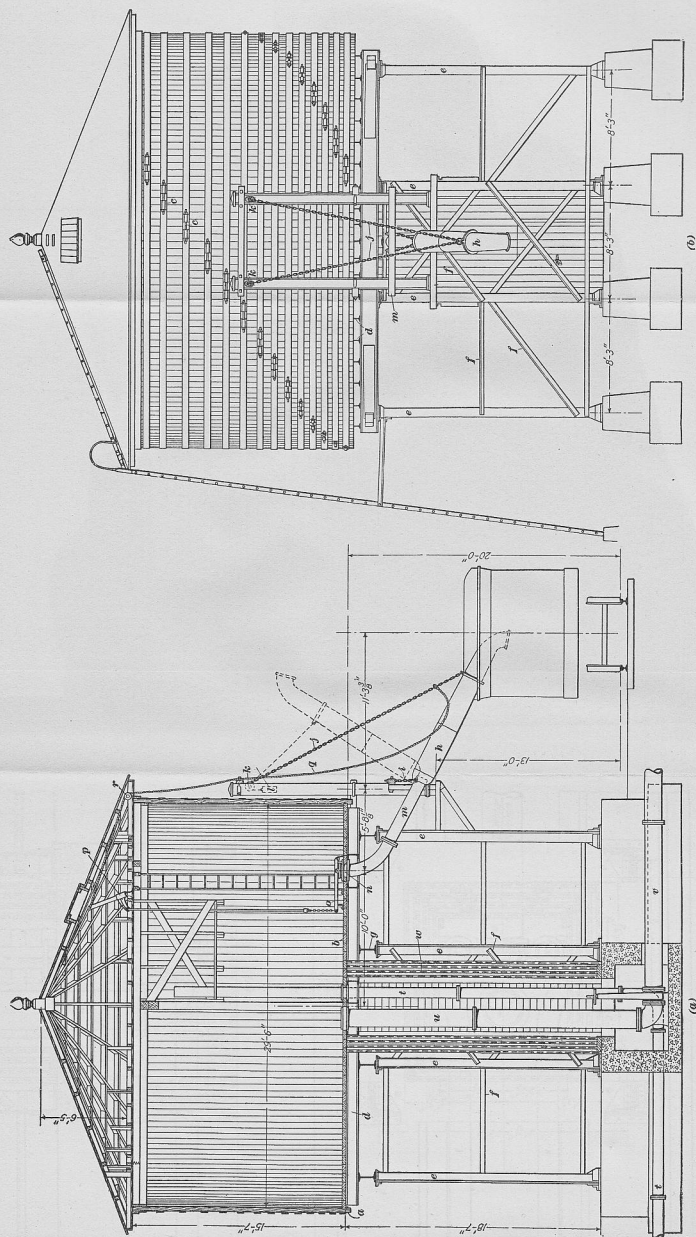
Where the hardness of water is due to sulphates of lime and magnesia, the treatment consists of adding carbonate of soda and hydrate of soda, either alone or together. Where the water contains carbonic acid and sulphates of lime and magnesia, it is customary to add sufficient soda to decompose the sulphates of lime and magnesia, and as much lime as is required to absorb the carbonic acid. Where the water contains bicarbonates of lime and magnesia, a lime solution is added. The strength of the solution to be added depends upon the chemical composition of the water, which varies greatly. In any case, the water is allowed to stand undisturbed while the chemical changes take place and the objectionable elements settle to the bottom. Water overflowing from the settling tank is pumped to the water-supply tank.

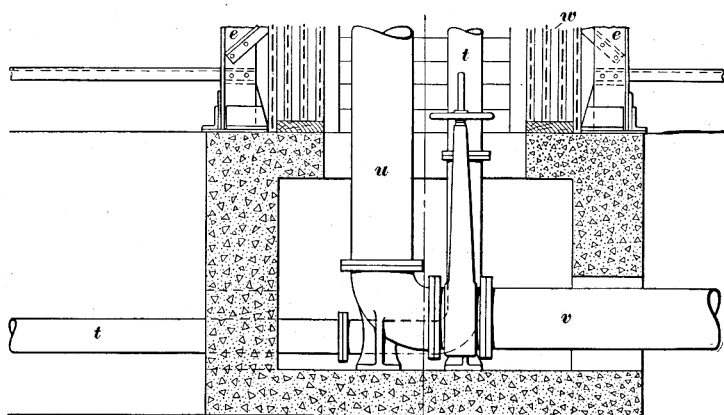
56. Pumping.—Since the source of supply is generally too low for the water to flow directly to the elevated tanks from which locomotives are supplied by gravity flow, resort is had to pumping. Steam, oil, or gasoline engines, or electric motors, may be used to operate the pumps, according to local conditions and the power available. Steam boilers and pumps require the most attention, but in many cases steam is available from boilers at repair shops. With electric operation, automatic control is practicable and economical, the motor being started automatically when the water reaches a certain low limit in the supply tank and then stopped automatically when the water reaches its upper limit. Windmill pumps have been used to some extent, particularly on the plains where steady winds prevail, but it is necessary to provide ample storage capacity to insure against periods of calm.

57. Water Tanks.—The elevated supply tank is usually placed close to the track and has a hinged spout that can be lowered to the manhole of the locomotive tender. It may also be placed a short distance from the track, in which case it has an underground main leading to a *water column*, which will be described later, from which the water is delivered to the locomotive. These supply tanks are constructed of wood, steel, or reinforced concrete, and have capacities ranging from 50,000 to 200,000 gallons. An outside indicator operated by a float is used on all tanks and shows the water level in the tank; this level should not be allowed to go below 5 feet in order to provide for an emergency.

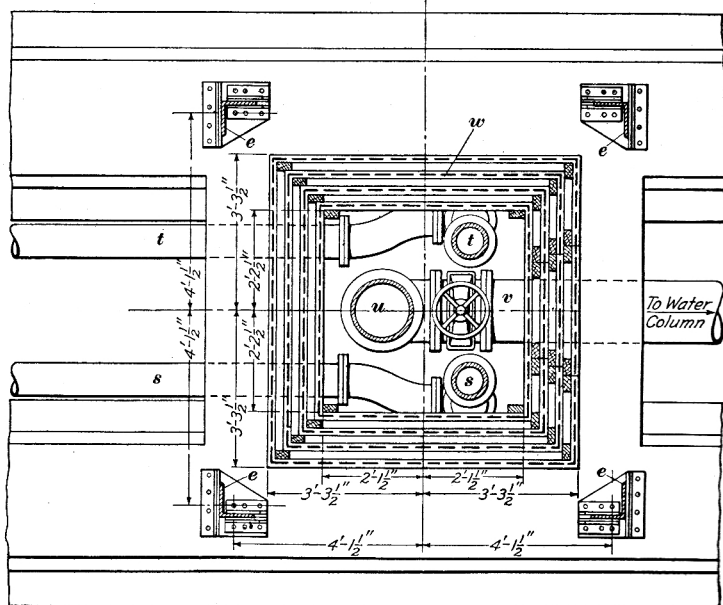
58. Wooden Tanks.—Wooden tanks are commonly made of cypress, cedar, redwood, or white pine. They are 24 to 30 feet in diameter, 16 to 20 feet high, and have capacities of 50,000 to 100,000 gallons. The tank consists of vertical staves and a plank bottom, the staves being bound together by hoops of wrought iron or steel. These hoops are either flat bands or round rods. Each stave is 6 to 8 inches wide, $2\frac{3}{4}$ to 3 inches thick at the edges, and is grooved near one end to receive the bottom planks. The outer side of each stave should be surfaced to the true circle of the tank and the edges accurately planed or sawed radially so as to make tight joints when put together. The planks for the bottom are 8 to 12 inches wide and 3 inches thick, and each plank has a 3-inch chamfer or bevel at the ends to fit the grooves in the staves. Planks for tanks 24 feet in diameter should be in one piece, but those over 24 feet in length may be spliced.

A wood-stave tank of 76,000 gallons capacity, bound with flat hoops and mounted on a steel tower, is shown in Fig. 31, in cross-section in (a) and in elevation in (b). The staves *a* of the tank are 6 inches wide, 3 inches thick, and 16 feet long. Near the bottom they are grooved, as shown in (a), to receive the planks forming the tank bottom *b*. On the ends of each hoop are riveted lugs *c* in (b), and a horizontal bolt is put through these lugs to draw the hoop tight. The spacing of the hoops is widest at the top and decreases toward





(a)



(b)

FIG. 32

the bottom, where the bursting pressure of the water is greatest. It should be noted that the staves do not rest on the tower but that the tank bottom is placed directly on the steel I-beam joists *d*; hence, no upward pressure comes on the staves. Details of the piping system, which will be described later, are shown in Fig. 32 in elevation in (*a*) and in plan in (*b*).

59. Steel Tanks.—Steel tanks are built up of structural-steel plates riveted together. They usually have either conical, hemispherical, or elliptical bottoms and are supported on steel towers riveted to the plates.

An example of a conical-bottom, steel tank is shown in Fig. 33. The circular steel plates *a*, forming the side walls of the tank, are securely riveted together and to the bottom *b*. The riser *c*, riveted to the bottom, acts as a settling basin for any sediment or foreign matter in the water. The float gauge *d* indicates the water level in the tank, and the revolving ladder *e* permits ready inspection of the tank at any point.

60. Tank Towers.—Flat-bottom tanks are supported on towers that carry the tank bottom at a height of 20 to 30 feet above the rails. Wooden towers are composed of wood posts, resting on stone or concrete pedestals, and tied together with diagonal braces of planks and horizontal tie-rods. In the steel tower of Fig. 31, the posts *e* are 6"×6" angles; they are laced with 3"×3" angles *f*. The posts carry caps *g* of 15-inch I-beams, across which are laid the 8-inch I-beam joists *d*.

The tower supporting the steel tank in Fig. 33 consists of latticed steel columns *f*, anchored to concrete pedestals, and tied together by steel rods *g*. Additional support is gained by the large riser *c* riveted to the bottom of the tank.

61. Tank Spouts.—The usual type of discharge spout for supplying the locomotives with water is shown in Fig. 31 at *h*. The heel of this spout is suspended by short chains *i*. To the end of the spout are attached two chains *j*, spreading apart like a V and passing over pulleys *k* to counterweights *l*.

When the spout is raised by means of the chains *j* and is not in use, it will stand clear of the tank pipe *m*, as shown dotted, and will thus drain itself. Any leakage from the pipe *m* will also fall to the ground and not accumulate or freeze in the

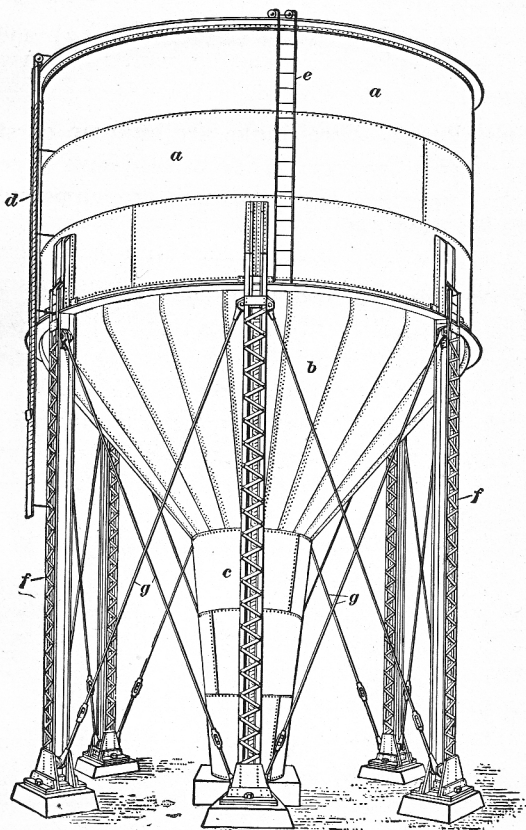


FIG. 33

spout. On the tank end of pipe *m* is a flat valve *n* with lever *o* connected by chain and rod to a lever *p* located near the top of the tank. A rope *q* attached to the lever *p* passes over a pulley *r* and hangs within reach of the fireman on the locomotive tender; by pulling this rope the fireman opens the valve *n* and allows the water to flow into the tender tank.

62. Tank Piping.—The piping system used with a water tank is shown in elevation in Figs. 31 (*a*) and 32 (*a*), and in plan in Fig. 32 (*b*). An 8-inch inlet pipe *s* and an 8-inch overflow pipe *t*, both of cast iron, extend up to the tank bottom and are continued to suitable heights inside the tank by 8-inch wrought-iron pipes bolted to their flanges. There is also a 14-inch pipe *u* connecting with a main *v* leading underground to a water column. The pipes are enclosed in a frost-proof box *w* built up of horizontal layers of planks and tarred paper, with air spaces between the layers and with an outside sheathing of beaded plank placed vertically. If a pump house or shop building is near at hand, steam can be piped into the frost box. In cold northern climates, the entire structure of tower and tank is sometimes enclosed by timber sheathing. The base of the tower may then be used as a pump room, and fitted with a stove in winter.

In the tank in Fig. 33, all the necessary piping is contained in the large riser *c*. To protect the pipes from frost, the entire outside surface of the riser may be covered and a stove heater placed in a chamber in the bottom of the riser.

63. Water Columns.—At terminals and yards, water is usually delivered to locomotives by water columns located at convenient points alongside or between the tracks. A water column, Fig. 34, consists of a vertical pipe *a*, 10 to 12 inches in diameter, and a horizontal branch or spout *b*. The pipe *a* is made so that it can be rotated in its base *c*, the lever *d* being used for that purpose. The spout normally stands parallel with the tracks. When a locomotive is to take water, the pipe is swung around so that the spout extends across the tender, and a flexible ball-and-socket joint *e* allows it to be pulled down, as shown in the dotted position *f*, to discharge water into the manhole of the tender tank.

When the spout is in this position the fireman standing on the tender pulls the lever *g*, raising the main valve *h* in the pipe pit, and thus admits water from the underground main *i* connected to an elevated supply tank. In the illustration the valve *h* is shown open. When the tender is full,

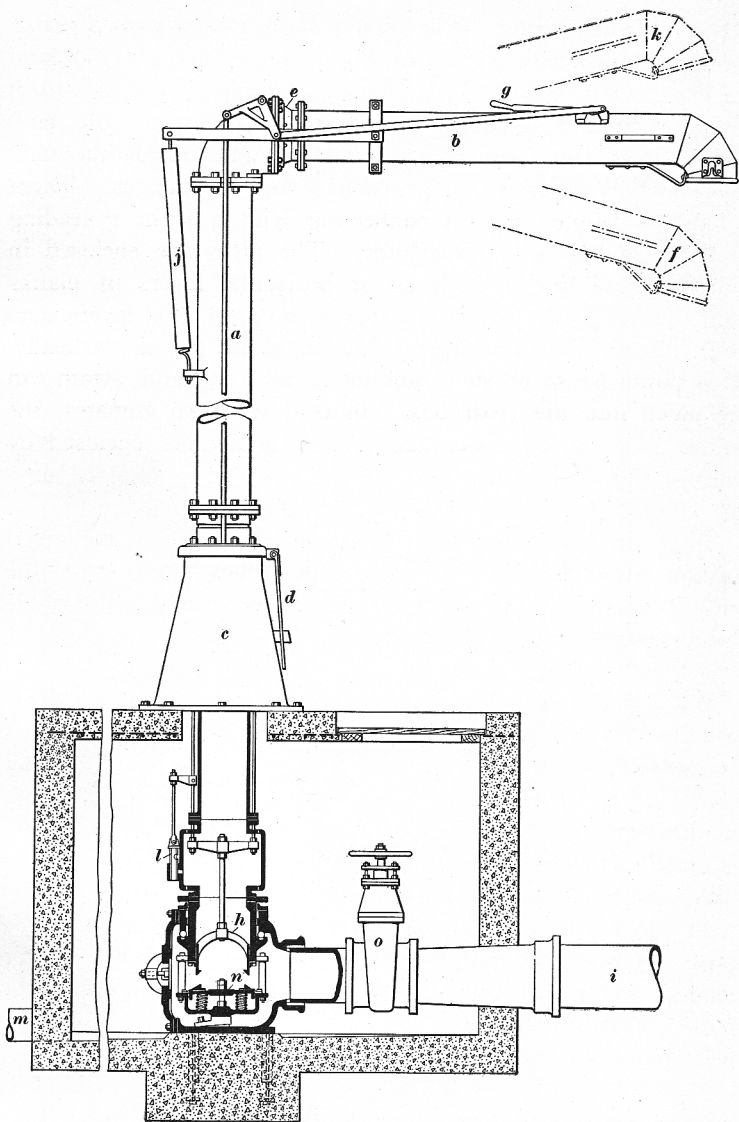


FIG. 34

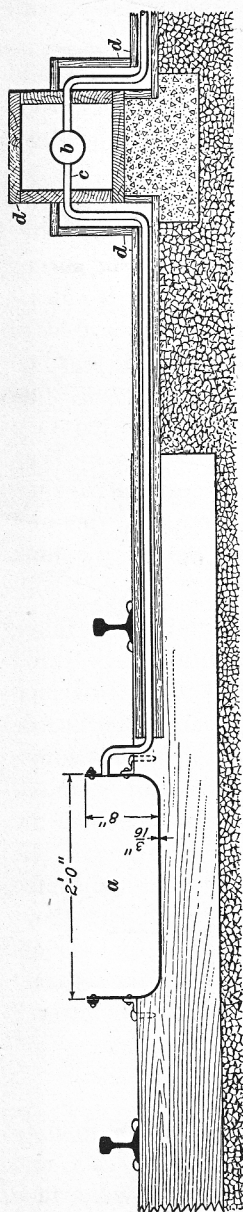


FIG. 35

the valve is closed by means of the lever *g*, and the column is swung around clear of the tracks; the spring *j* then raises the spout a little above the horizontal, to the dotted position *k*, so that the water left in the spout will drain back into the pipe *a*. As the main valve closes, a small valve *l* opens a hole, allowing the water left in *a* to flow out into the pit, which has a drain or sewer connection *m*. Since the main valve is subject to rough treatment, it is made to close against a plate *n*, carried on spiral springs in the bottom of the valve chamber, so that if the valve is slammed down hard the shock is absorbed by the springs. In some designs a screw and hand-wheel are used instead of the lever *g*, so that the valve closes slowly and without shock. The supply main *i* is usually somewhat larger than the column pipe *a*. A gate valve *o* on the supply main provides for shutting off the water to permit repairs to the water column.

64. Track Tanks.—Where the traffic is heavy and fast passenger trains make long runs without stopping, track tanks are provided to enable the locomotives to take water while running 20 to 40 miles an hour. The tank is a steel trough, 6 to 8 inches deep and 20 to 24 inches wide, laid along the middle of the ties on a level stretch of road for a distance of 1,200 to 2,000 feet. It is held in

position by spikes but is free to move longitudinally with expansion and contraction.

A typical track tank with pipe connections is shown in Fig. 35. The tank *a* is 24 inches wide and 8 inches deep, and is made of $\frac{3}{16}$ -inch metal. The track is well ballasted with stone to drain away the water that is splashed out; in some cases, tile drains are laid and the ballast is covered with stone slabs to prevent its being washed out of place. Water is supplied to the track tank from an elevated tank by means of a main pipe *b* laid along the track and small branch pipes *c* entering the trough at intervals. These pipes are encased in plank boxes *d*. In winter, the water in the trough is warmed by steam jets from perforated pipes, placed about 40 feet apart along the entire length of the tank and connected to a boiler at the pumping station. The pumps may also keep the water in circulation as an additional precaution against freezing. Steam pipes are sometimes laid along the ties and near the rails to prevent the water splashed out of the tank from freezing on the rails.

65. Application of Track Tank.—A locomotive that takes water from a track tank must have the tender tank fitted with a vertical pipe projecting through the bottom; this pipe has a double elbow on its upper end, to discharge downwards into the tank, and a flexible spout or scoop hinged to its lower end. The scoop is fitted with a chain so that it can be raised or lowered. When the locomotive passes over the tank, the fireman lowers the scoop about 3 inches into the water. The speed of the locomotive forces the water up through the pipe into the tender tank. With a travel of 1,500 feet, about 5,000 gallons of water may be taken. Signs or signals are placed at the approach end of the tank and within 100 feet of the far end to indicate where the scoop should be lowered and raised.

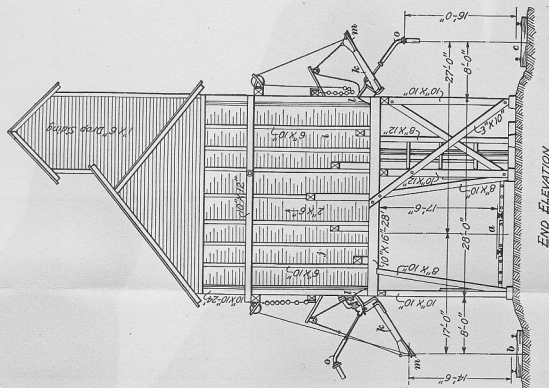
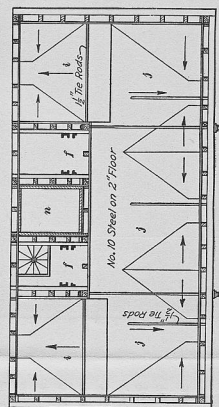
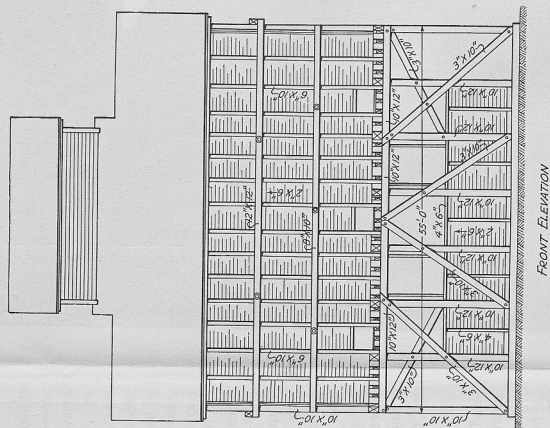
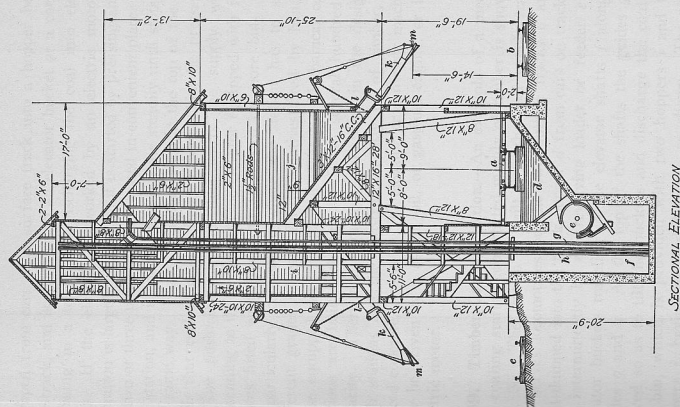
FUEL STATIONS

66. General Discussion.—Facilities for supplying fuel to the locomotives are provided at division points, terminals, and other points along the line, so that locomotives may take

fuel before and during their trips. These stations are usually located at the same points as water stations, enabling the locomotive to take fuel and water at one time. On roads operated by locomotives burning coal, it is the general practice to store the coal in elevated pockets or bins, from which hinged inclined spouts are lowered to deliver it to the locomotive tenders. Usually the coaling station is at the side of, or between, the tracks, but sometimes one or more tracks pass under the bins. If a large number of parallel tracks are to be served, the bins may even be placed on a bridge spanning the tracks. On oil burning roads, the locomotives receive their supply of oil from oil columns, which are similar to the water columns already described. The oil is pumped from a storage tank either directly to the oil column or to an elevated tank, giving a gravity flow through a main leading to the oil column, as explained later. A locomotive tender holds from 10 to 20 tons of coal or from 3,000 to 5,000 gallons of fuel oil. In freight service, a locomotive consumes from 4,000 to 5,000 pounds of coal per hour, and in passenger service from 6,000 to 7,000 pounds per hour.

67. Car-Incline Coaling Station.—A car-incline coaling station is used in open country, where there is plenty of room. The coal bins are filled by dumping or shoveling coal from cars on a track above them, and the locomotive tender is served from these bins. An inclined track supported by a timber or steel trestle usually leads from the ground level to the top of the bins, and the coal cars are hauled up this incline by a cable and steam or gasoline hoist. They may be pushed up by a locomotive, empty cars being placed between the coal cars and the locomotive so that the locomotive does not have to ascend the incline. The grade of the incline should not exceed 5 per cent. if locomotives are to work on it, but if a haulage cable is used this grade may be as great as 20 per cent.

68. Mechanical Coaling Stations.—Mechanically operated coaling stations are extensively used and represent modern practice. In this type of coaling station, the coal is



PLAN
FIG. 36

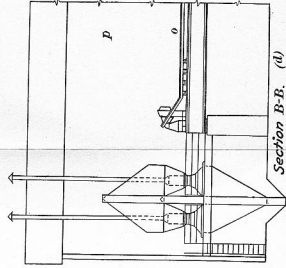
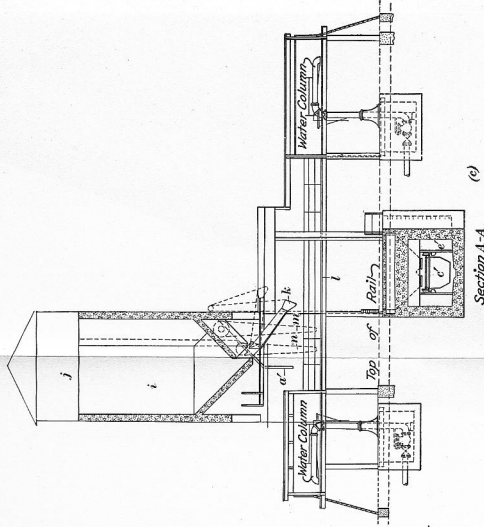
dumped from cars on a surface track into a hopper beneath the track, and is then fed to an elevator bucket or a conveyor working in a tower and discharging the coal into elevated bins. If the elevator is worked by an electric motor, its operation is largely automatic; it is started by pressing any one of two or three push buttons, located in convenient places about the station, and it continues to operate steadily until stopped in the same way. If the operator, when at the top of the plant, finds that coal is needed in an elevated bin, he presses one of the push buttons and thus starts the supply without descending to the ground. One elevator equipped with forked chutes fitted with gates can serve two or more bins. This is particularly convenient where the station has to supply different grades of coal for locomotives fired by hand and those equipped with mechanical stokers. Mechanical coaling stations are built with bins of 50 to several hundred tons capacity. There are numerous variations in the design of such stations and the construction may be of timber, reinforced concrete, or steel. The elevator or conveyor machinery may be driven by a steam, oil, or gasoline engine, or by an electric motor.

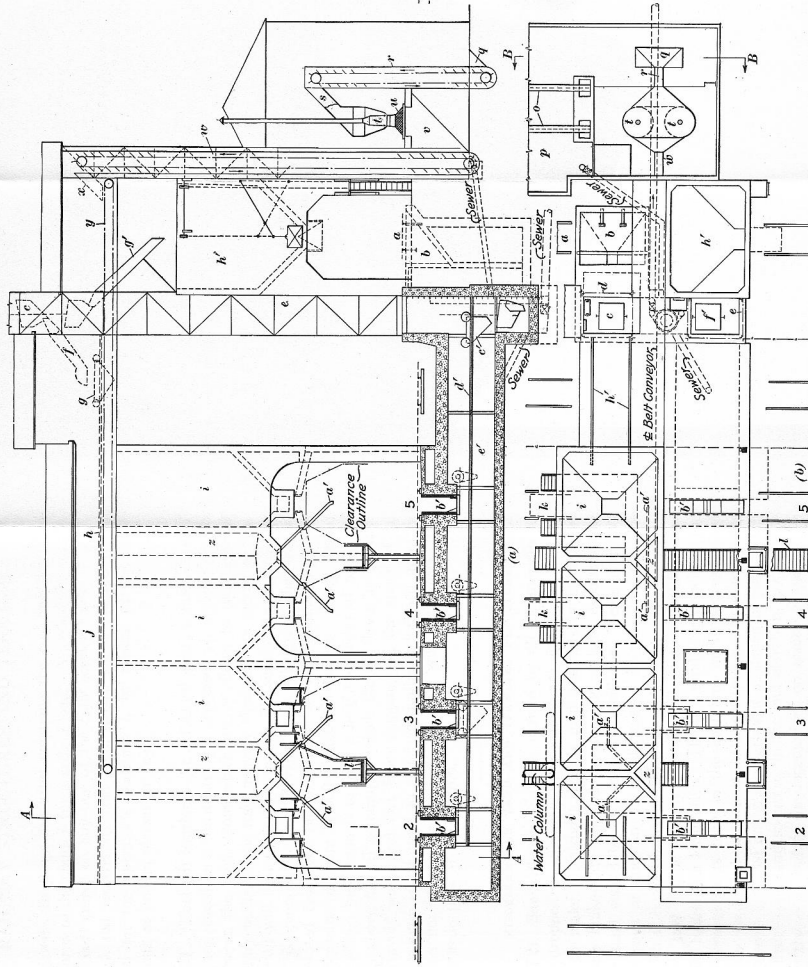
69. Timber Coaling Station.—An example of a mechanical coaling station constructed mainly of timber is shown in Fig. 36. The station is built over the coal supply track *a* and serves locomotives on the two outside tracks *b* and *c*. Coal dumped into the track hopper *d* from cars on track *a* is fed intermittently by the revolving loader or feeder *e* into elevator buckets traveling in the elevator shafts *f* along the guides *g* and *h*. At the top of the shafts the guides *g* are curved so as to tilt the buckets and discharge the coal into the bin, which is provided with two hoppers *i* and three hoppers *j*, having inclined bottoms, as shown. The arrows in the plan indicate the directions in which the bottoms of the hoppers slope downwards. The bin has a capacity of 600 tons and is equipped with five spouts *k* for delivering the coal to the locomotives. These spouts are rectangular in cross-section and are hinged and counterweighted so that they

can be raised to a vertical position out of the way when not in use. When a spout is pulled down to the locomotive tender, a gate *l* is raised, allowing the coal to run through the spout and into the tender. When the spout is raised, the gate descends and cuts off the flow of coal. The discharge end of each spout is fitted with a head *m*, which is open only at the bottom so that the coal drops vertically into the tender and spilling is avoided. To prevent a confusion of lines in Fig. 32 all spouts have been omitted in the plan and front elevation.

The coal supply track is usually constructed with a slight slope upwards from the main track level; loaded cars can thus be set at the upper end of the track and moved by gravity down to the track hopper as required. A bar screen covers the hopper and retains any large lumps of coal, which must then be broken into smaller pieces so that they will fall through.

70. Reinforced-Concrete Coaling Station.—A coaling station constructed mainly of reinforced concrete is shown in Fig. 37, in elevation in (*a*), plan in (*b*), and sections in (*c*) and (*d*). In this design the coal car enters on the coal-supply track *a*, the coal is dumped into the track hopper *b* and served to a 2½-ton elevator bucket *c*, operating in the elevator tower *d*. As shown in (*b*), there are two elevator towers, *d* for coal and *e* for ashes. The one shown in elevation in (*a*) is the elevator tower *e*, which will be discussed later. The bucket of coal is automatically lifted to the top of the tower *d*, to the position shown dotted in (*a*), and is emptied through a coal chute *f* into a tram car *g*. This tram car runs back and forth on a track *h* over the coal bins *i*, which it serves. The tram-car track is located in the head house *j* built over the coal bins and extending to the towers. Each bin has a capacity of 150 tons and is equipped with the usual coal spouts *k* in (*b*) and (*c*) for serving locomotives. As soon as the elevator bucket delivers its load to the tram car, it is automatically released and descends to the bottom of the tower for a second load, the operations continuing intermittently as long as there is coal in the track hopper.





Likewise, the tram car after emptying the coal into the bins returns to the chute *f* for a second load. A locomotive requiring coal enters on any one of the four service tracks 2, 3, 4, or 5 and receives its coal from a coal spout operated by a man on the operator's platform *l*, by means of the hand chains *m* and *n*, shown in (*c*).

71. Fuel-Oil Station.—At a fuel-oil station, tank cars of oil are placed on a track having a depressed pit or long trough between the rails, from which the oil flows to underground storage tanks, or the track may be elevated on a trestle so that the oil will flow to surface tanks. To supply the engines the oil is pumped to an elevated tank alongside the tracks. Elevated tanks for oil are similar to water tanks and have a capacity of from 20,000 to 100,000 gallons. They should be placed high enough to give a height or head of about 12 feet above the oil column, to which the oil flows by gravity. To avoid waste and dirt from dripping oil, the spout of an oil column is arranged to stand vertically or inclined upwards when not in use, so that any oil in it will drain back into the main pipe of the column.

MISCELLANEOUS YARD AND TERMINAL STRUCTURES

72. Sand Plants.—Sand is carried by all locomotives to be dropped on the rails when they are greasy or wet, so as to make the driving wheels grip the rails in starting or when brakes are applied in stopping. It is essential that the sand should be dry so that it will flow freely and will not pack or stick in the sandboxes or in the pipes through which it is distributed to the rails.

A fuel station usually has facilities for replenishing the sand boxes of a locomotive. The dry sand is generally stored in compartments built in the coal bins or in separate sand boxes supported on towers between tracks. In Fig. 36 the dry sand is stored in the compartment *n*, shown in plan, which is fitted with sand spouts *o*, in the end elevation, for delivering the dry sand to the locomotives on tracks *b* and *c*.

In the coaling station illustrated in Fig. 37, the wet or fresh sand enters on the sand-supply track *o* and is stored in the sand house *p*. As shown in (*d*), the track *o* is supported by steel girders resting on concrete piers. At one end of the sand house are located the devices for drying the sand. The wet sand is shoveled from the storage pile into hopper *q* and is raised by the elevator *r* to the chute *s*; from there it flows down over and around the drying stoves *t*, and when dry it drops on the screen *u* that excludes stones, pebbles, or lumps. After passing through the screen, the dry sand drops into the hopper *v* and is taken by the elevator *w* to the top of the elevator tower where it passes through a chute *x* and is delivered to a belt conveyer *y* that carries it to the sand bins *z*. Each of these sand bins has a capacity of 465 cubic feet and is fitted with sand spouts *a'* for delivering the sand to the locomotives.

73. Ash-Pits.—The numerous kinds of ash-pits in use may be divided into two classes; namely, depressed-track pits, and mechanically operated pits. In the former class, the locomotive track is over a pit the floor of which slopes slightly toward a depressed track on which ash cars are operated. This depressed track is approached by an incline and is at such an elevation that the tops of the ash cars are about level with the edge of the pit floor on each side. To clear a locomotive of its ashes, the locomotive is run over the ash-pit and the ashes are dropped and raked from the grates and ash-pans into the pit. The ashes are then cooled with water, are shoveled by hand into the ash cars, and hauled away. The floor and walls of the ash-pit should be faced with firebrick or vitrified brick so as not to be damaged by the hot ashes.

74. Mechanical handling of ashes is desirable where more than twenty locomotives have to be cleaned in 24 hours. A few of the many types of mechanically operated ash-pits are as follows:

1. Water pits, illustrated in Fig. 38, are much like the depressed-track pits, but they have sloping sides and have

closed ends to hold the water. The hot ashes fall into the water in the ash-pits *a*, are cooled, and then removed to the ash cars *b* by the grab bucket *c*. This bucket is handled by a hoist *d* operating back and forth on the traveling bridge *e* spanning the locomotive tracks *f*, ash-pit *a* and ash-car track *g*. In many cases the grab bucket is handled by a locomotive crane traveling on a track alongside the ash-pit. The rails of track *g* and the inner rails of track *f* are carried on girders supported by piers along the middle and sides of the ash-pit *a*.

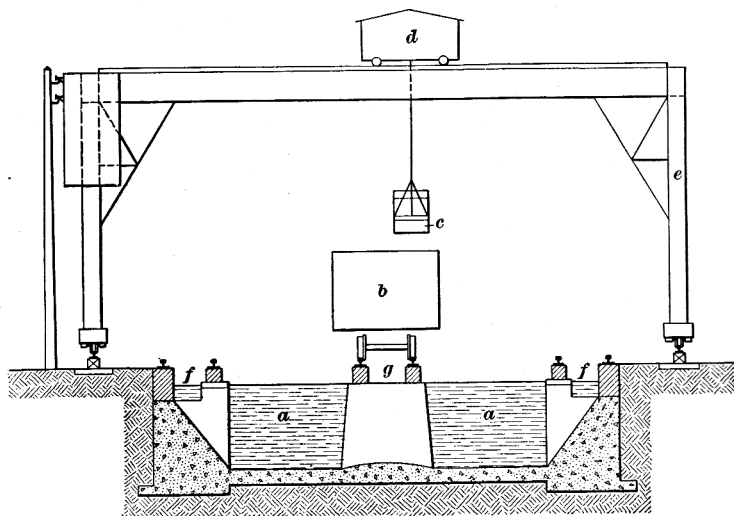


FIG. 38

2. Pits with small iron cars that are hauled out by cable on an incline at right angles to the locomotive track, and dumped into railway cars standing on an adjacent ash track.

3. Pits fitted with stationary buckets that are removed by a locomotive crane or gantry crane and dumped into ash cars or an ash bin.

4. Pits with iron cars that receive the ashes and then travel along a track in the pit to discharge into a hoist or conveyor at the end.

5. Pits in the form of a hopper in the track and serving a tram car or conveyor operating on rails in a tunnel cross-

ing under the locomotive tracks, and discharging into an elevator bucket at the end.

An illustration of the last mentioned type of ash handling plant is shown in connection with the coaling station of Fig. 37. This plant has four ash-pits *b'*, lined with firebrick and each having a capacity of 225 cubic feet. A tram car *c'* receives ashes from any pit, runs along the overhead rails *d'* in the tunnel *e'* and dumps its load into the elevator bucket *f'*. This bucket is then elevated to the top of the ash tower *e* and the ashes are emptied through the spout *g'* into the ash bin *h'*. From the ash bin the ashes are dumped into empty coal cars, standing on track *a*, and are hauled away.

75. Track Scales.—The weight of freight shipped in car-load lots is determined by deducting the weight of the empty car, which is marked on the car, from the weight of the loaded car. To weigh the loaded car, it is passed over a track scale of 100 to 150 tons capacity. The track scale usually consists of a platform supported on weighing beams that are connected to graduated scale beams. The weighing beams are located in a pit between the rails. This pit has concrete, brick or stone walls and a concrete floor, and is covered by a platform, which is 50 to 60 feet long. The graduated scale beams are usually in a building adjacent to the platform. The weights are read in this building and may be recorded automatically.

Where cars are to be weighed in motion, as in passing over a track scale on the descending side of a switching hump, the grade on the scale should not exceed 1 per cent. The accelerating grade above the scale should be such that the speed of cars will not exceed 4 miles per hour so that each car will be alone on the scale for at least 3 seconds. In a yard arranged for flat switching, the track scale may be on a special track. Cars to be weighed may then be pushed slowly along this track and over the scale by a locomotive.

76. Cranes.—Every freight yard should be equipped with some sort of crane for transferring bulky or heavy pieces of freight to and from vehicles and cars. At small

stations a simple jib crane may be used. A convenient form of crane for large stations is one mounted on a traveler operating back and forth along a fixed runway at right angles to the tracks. In operating, the crane picks up its load, moves along the runway and places the load in either the freight car or the vehicles. This type of crane can also be arranged to travel on rails located adjacent to the tracks, thus permitting the crane to move not only laterally to the tracks, but also parallel with them.

77. Oil Houses.—The various kinds of oil used on railroads, such as cylinder oil, signal oil, valve oil, etc., should be stored in tanks located in a pit or basement under the

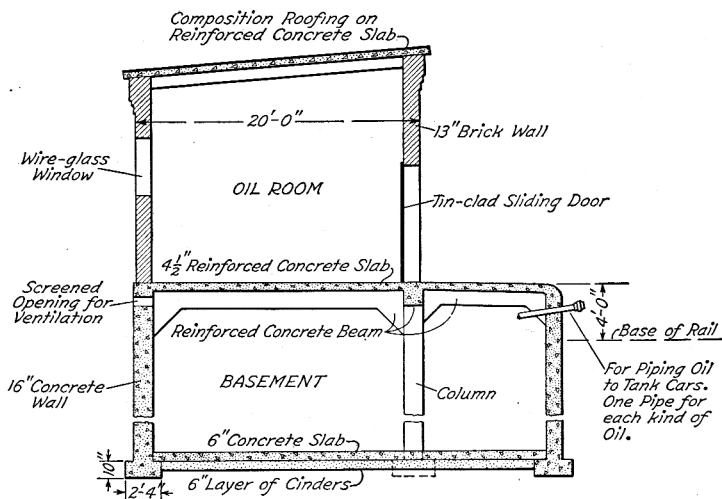
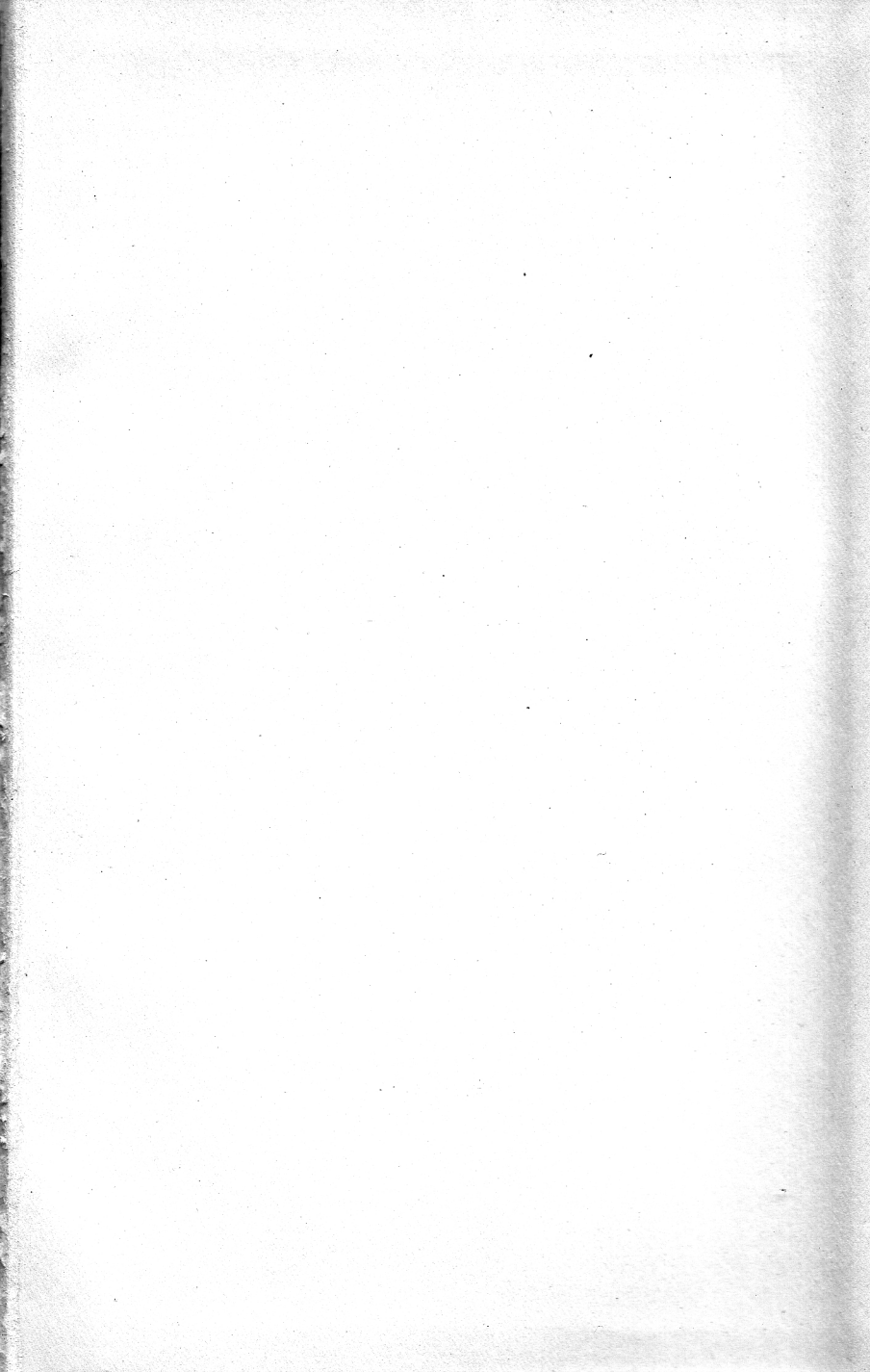


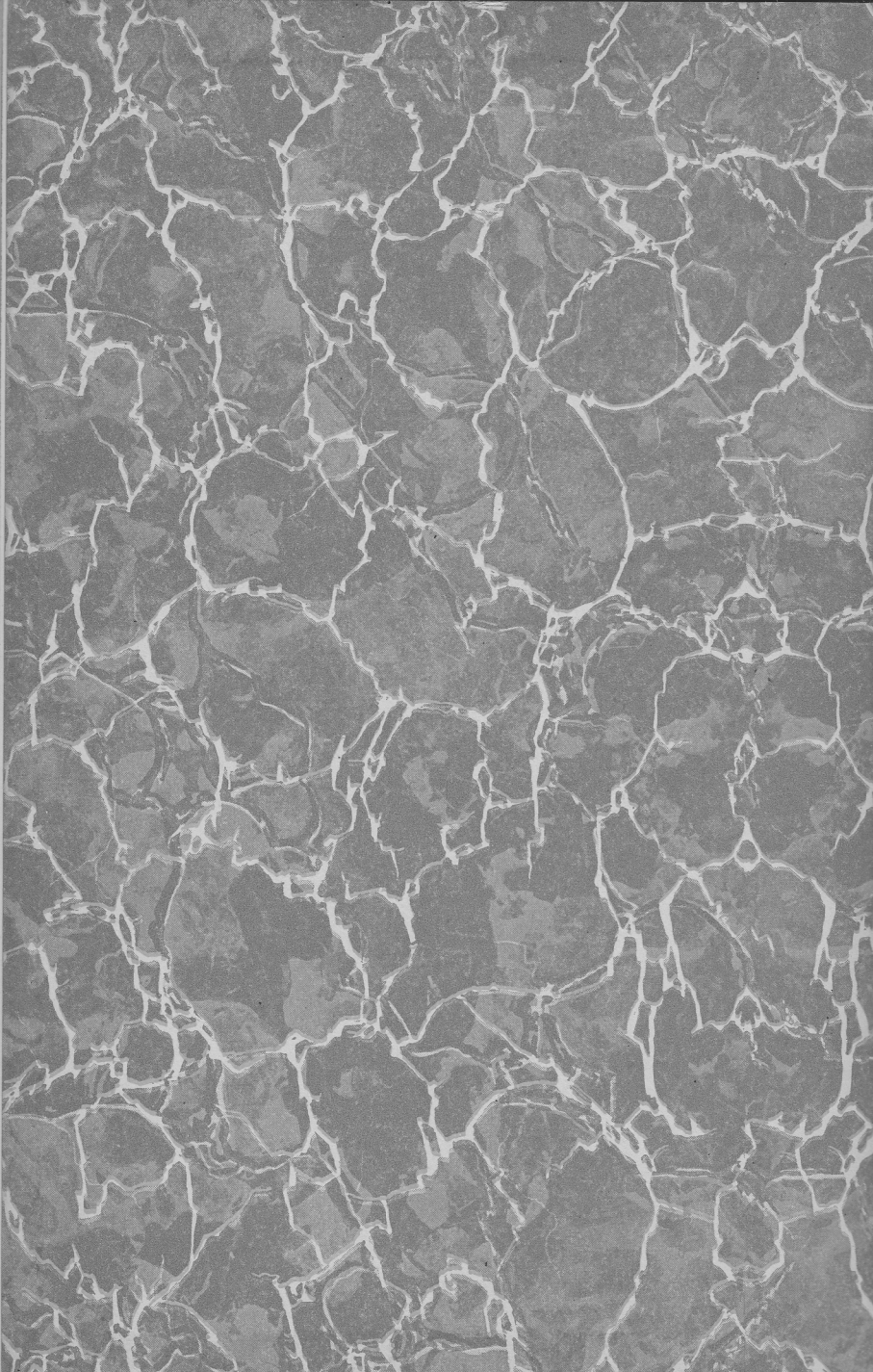
FIG. 39

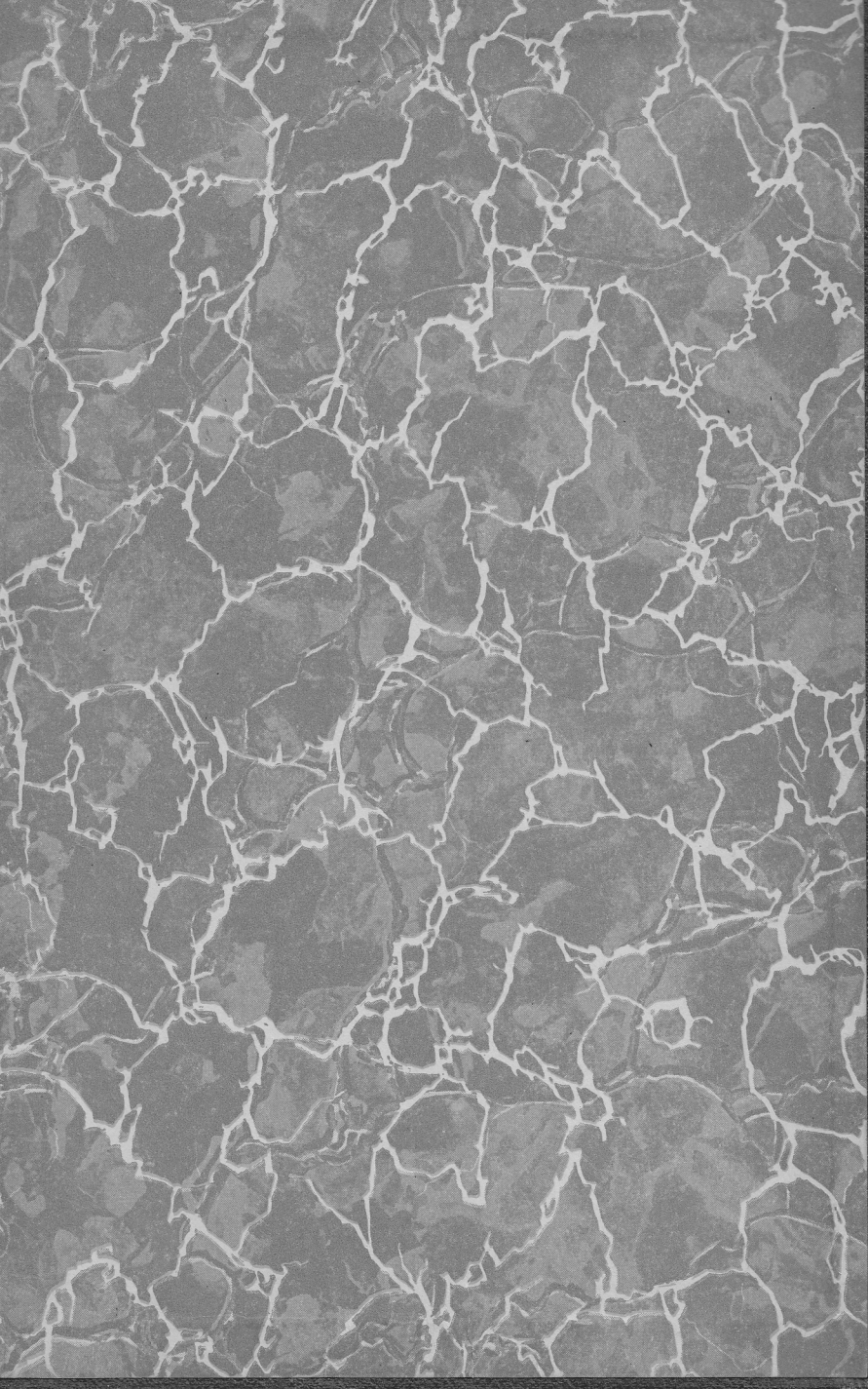
oil house. If a sufficient quantity of any one kind of oil is used, it is delivered to the storage tanks directly from the tank cars. Oils that are stored only in small quantities are delivered to the oil house in barrels and are run into tanks through pipes in the floor.

In Fig. 39 is shown a cross-section of a typical oil house recommended by the American Railway Engineering Association. This building is 20 feet wide, 40 feet long, and

is constructed of reinforced concrete and brick. The necessary openings are protected by tin-clad doors and wire-glass windows to make the structure fireproof. The height of the basement is governed by the number and size of storage tanks used. In the oil room are located the pumps and automatic measuring faucets for delivering the various kinds of oil. Such a building should be heated by steam and lighted by electricity. A fireproof trap door should be the only opening into the basement besides the necessary opening for pipes.







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