road. For **stub switches** these stands should be on the engineman's side ap proaching in a facing direction. For **split switches** they should be on the side of the turnout. Fig. 113 shows a simple form of a **three-throw**, ground-lever **switch stand**.

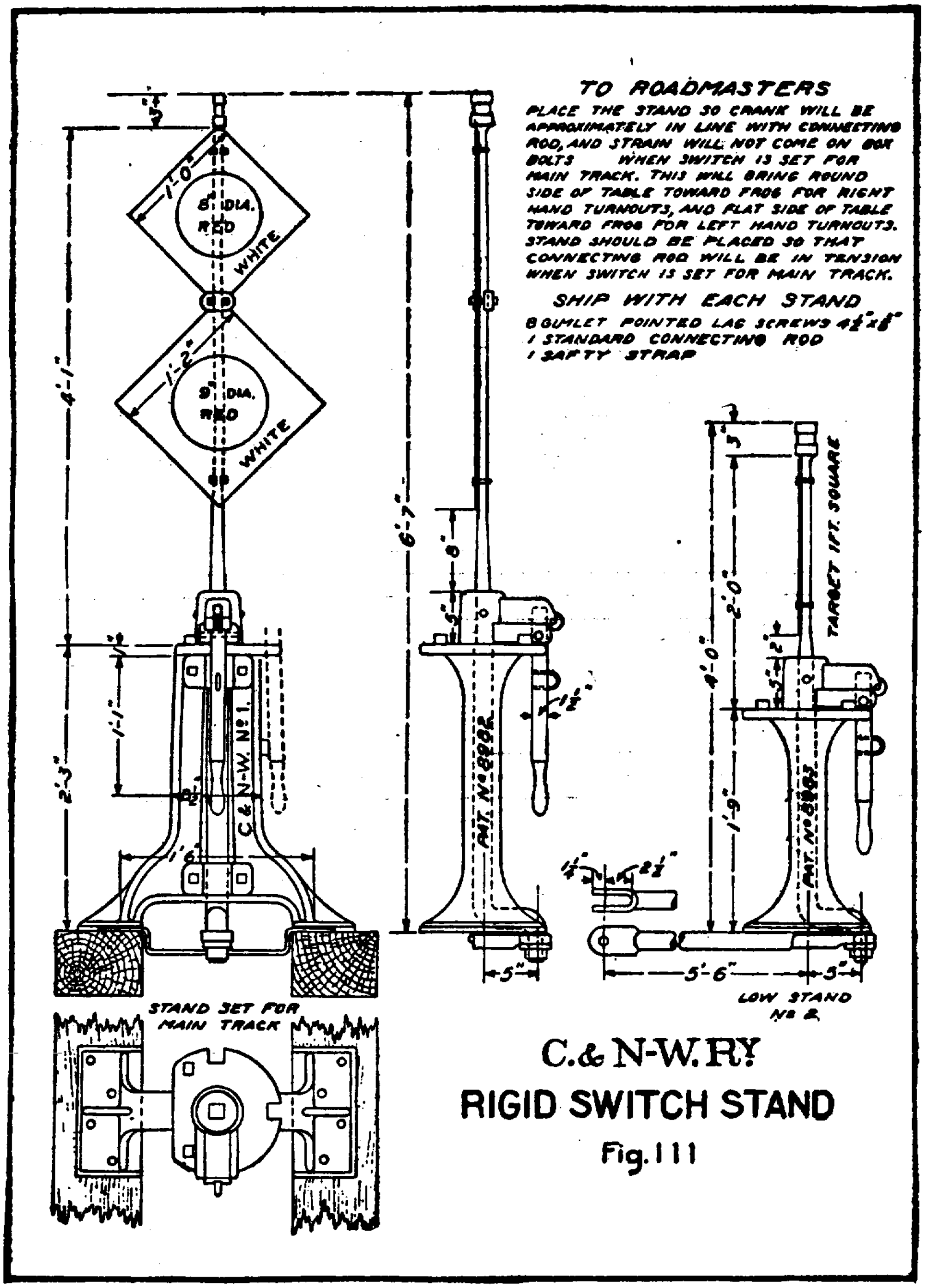


Fig. 111.

157. **Crossings.**—When one track crosses another, a special piece of track construction, called a crossing, is put in. The best results are obtained when both tracks of the crossing and the rails for a foot or so on each side are in one piece,

rigidly fastened together. This lessens the settlement, and what settlement there may be will be the same for the whole crossing. (For methods of measuring the angle of crossing, etc., see par. 25.)

158. When a crossing is very oblique, it is sometimes called a **diamond crossing.** When one or two turnouts connect the tracks at this point and each entire turnout

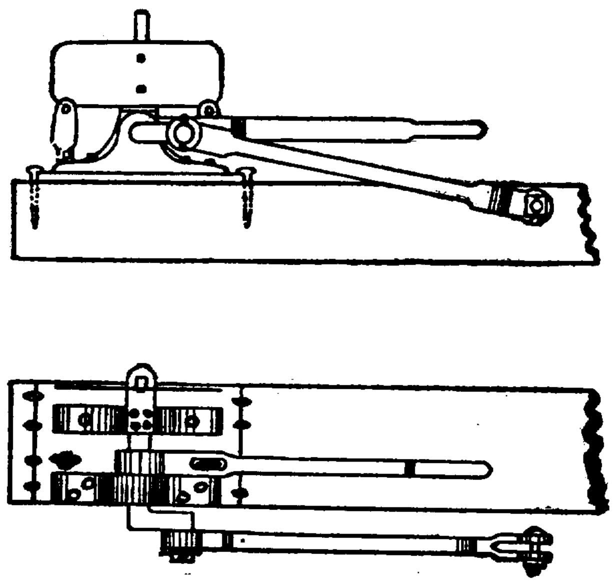


FIG. 112.

lies within the limits of the longer axis of the diamond, it is called a **single, or double, slip switch** (see fig. 114). The latter is sometimes referred to as a puzzle switch. The switch rods for throwing these switch rails are quite complicated and are not shown in the figure.

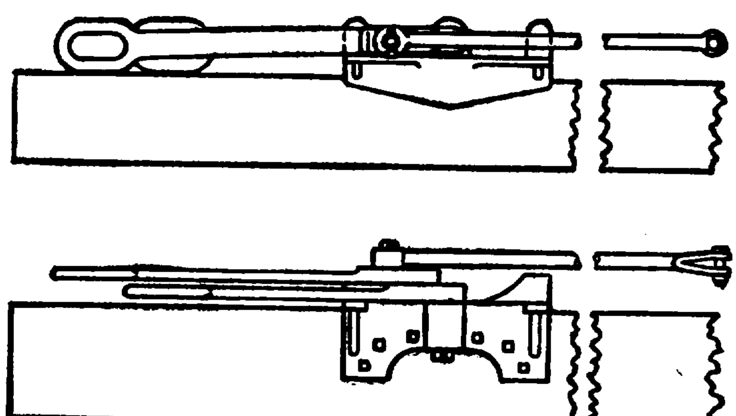


FIG. 113.—GROUND-THROW STAND FOR THREE-THROW STUB SWITCH.

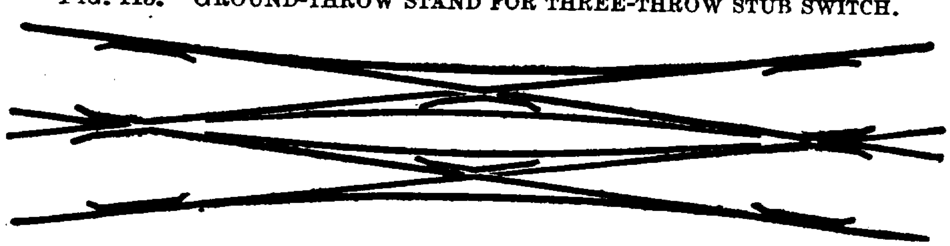


FIG. 114.—DOUBLE SLIP SWITCH.

159. When a turnout from one of two adjacent tracks must cross the other track, the line of the turnout is run until it crosses the center line of the second track. The common point of center is found and the angle of the crossing is determined as heretofore described.

STATIONS AND STRUCTURES.

160. **Mileposts.**—Every mile along the track should be marked with a conspicuous milepost, showing the distance to and from the division terminals or other important points. These are valuable in definitely locating points along the line, in making reports of engagements, accidents, etc. **Telegraph poles** should be similarly numbered, showing mile and pole number.

161. **Stations.** The number of stations, or sidings, that will be necessary depends upon the number of trains that must be run to supply the army and the speed at which such trains can move. This distance between stations will vary according to the grades, but having the profile in hand and knowing the speed of the locomotives in miles per hour for certain grades and loads the distance apart of sidings can be determined, approximately, as follows: N is the total number of trains necessary to pass over the line in a day; T is the time in hours necessary for a train to pass from any station to the next one, and return; if $\frac{24}{T}$ is less than N for any two stations some measure must be taken to decrease this maximum value of T. This can be done by putting in an intermediate siding or by installing a pusher service. On civil railroads, the next alternative is double tracking. Stations should be spaced so that the time required for a train to cover the interval both ways between all adjacent stations will be approximately equal.

Four miles is about the minimum allowable distance between stations, except under rare special conditions.

The amount of construction work that must be done at any station depends upon the location of the station, the number of buildings, and the length of auxiliary track that will be needed at that station to suit the local conditions. The questions of water supply and storage room at a station must be especially considered and are taken up later.

The **location of stations** may be determined by any number of military causes beyond the control of the locating engineer, but where such conditions do not fix the station, and the geography of the ground does not compel the location at any certain point, a study of the grades will be made as indicated in pars. 175, 176, and the stations located as above. The amount of siding, or passing tracks, that will be necessary at a station will have to be figured in each special case, and the minimum amount should be about two and one-half times the maximum train length contemplated on that division. The passing tracks are usually parallel to the main line (see par. 172, **Lap sidings**).

The **station sites** should be as level as practicable, and if possible, located so that the yards can be seen by trains approaching from either direction.

An **open space** should be left near the tracks to facilitate the loading and unloading of troops, by allowing a systematic and orderly arrangement of the troops and their baggage in the immediate neighborhood of the station.

162. **Storage tracks.**—The number and length of these tracks depend upon the importance of the station, the number of troops that will be stationed there, the number of depot storehouses that may be located at that point, etc. A study of these items shows that each must be dealt with as it arises, and as it is impossible to tell how important a station may become at any future time, available track room will be left for additional loading platforms and storage tracks. In locating the storage tracks room should be left between the various tracks so that at least one and preferably two li es of wagons can drive in and receive freight from cars on the storage tracks.

163. **Water supply.**—The question of a good water supply is important for the troops that will be located at the station, as well as for railway purposes. This water supply will be obtained by means of hand pumps, steam pumps, or windmills.

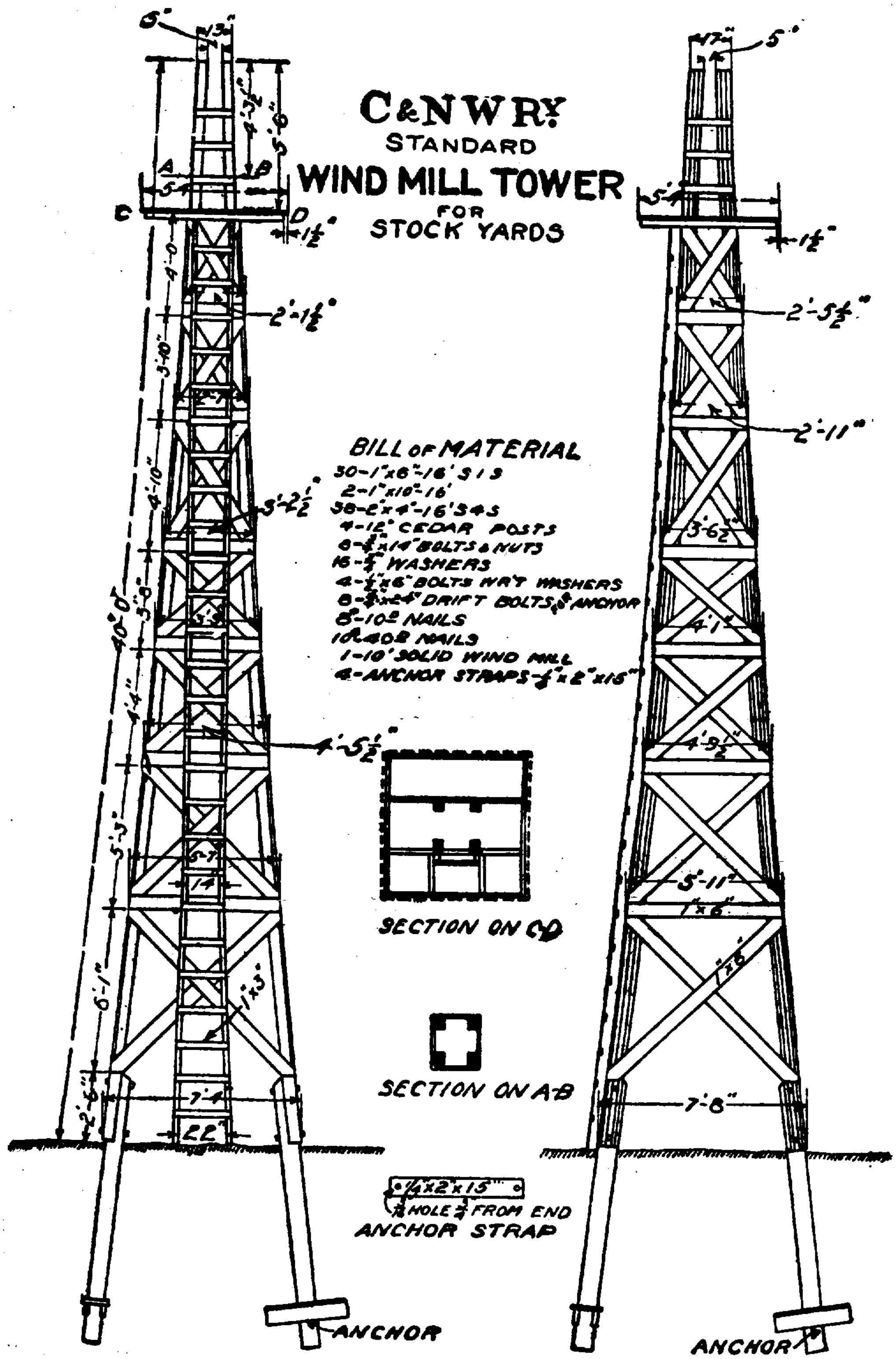
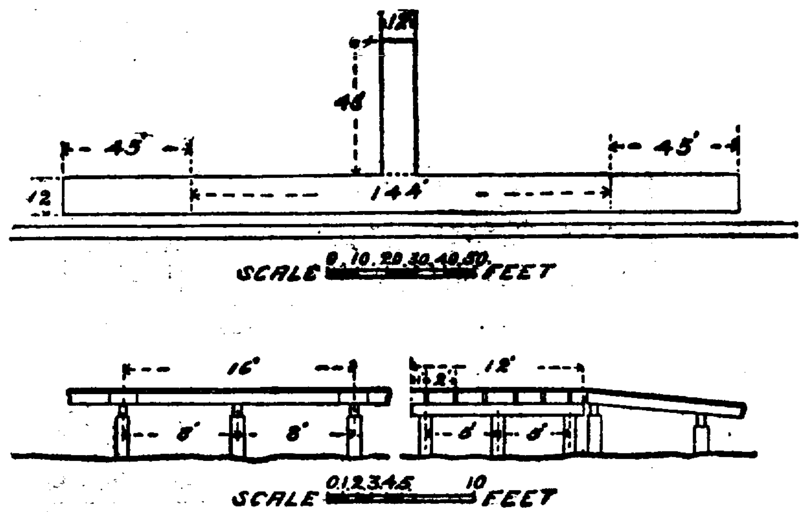

C&NW RY
STANDARD
WIND MILL TOWER
FOR
STOCK YARDS
BILL OF MATERIAL
30-1"x6"-16' S 1 S
2-1"x10"-16'
38-2"x4"-16' S4S
4-12" CEDAR POSTS
8-⅝"x14" BOLTS & NUTS
16-⅝" WASHERS
4-½"x6" BOLTS W'R'T WASHERS
8-⅝"x24" DRIFT BOLTS & ANCHOR
8-10d NAILS
10-40d NAILS
1-10' SOLID WIND MILL
4-ANCHOR STRAPS-¼"x2"x15"
SECTION ON C-D
SECTION ON A-B
¼"x2"x15"
⅝" HOLE ¾" FROM END
ANCHOR STRAP
ANCHOR
ANCHOR
40'-0"
7'-4"
7'-8"
22"

FIG. 115.

These pumps of various kinds are commercial articles, and their pumping capacity can be obtained from the various manufacturers.

A steam pump which apparently has great possibilities for field use is the **pulsometer,** and by means of it the locomotives can water themselves from streams, where the water can be used direct from the stream without having to allow it to settle.

The **amount of water required** for railway purposes varies too widely under different conditions to permit any general rule. Locomotive tanks carry from 3,000 to 7,000 gallons. The amount of water used per mile depends on the loads, grades, and condition of track and rolling stock. On down grades it may be nothing, while on steep ascents it may run as high as 150 gallons per mile, although 75 gallons is a more usual figure. To allow for accidents there should be a water



BILL of MATERIAL

FOR 16' PANEL		TOTAL	
Pieces	Dimen.	Pieces	Dimen.
2	6"x10"x12'	32	6"x10"x12'
2	10"x10"x10'	20	10"x10"x10'
6	2"x10"x18'	108	2"x10"x18'
20	2"x10"x12'	345	2"x10"x12'

FIG. 116.—LOADING PLATFORM.

supply for each 10 miles of track. Wooden and metal tanks are commercial articles readily obtainable. They are shipped knocked down and can quickly be assembled when needed. There should always be one day's supply in the tank if practicable. A very common size tank is 24 ft. in diameter, 16 ft. high, holding 50,000 gallons. The bottom of the tank should be 12 ft. above the rails.

For a movable water supply, **tank cars,** such as are used for the shipment of oil in this country, can be taken with the locomotive. This applies particularly to construction trains.

164. A bill of materials for a **windmill tower** is given in fig. 115. This is made up of small stock material and, on account of the lightness of the material, the tower can be easily built. Such a tower would be useful as a signal tower or observation station.

165. **Platforms.**—On every train length of siding there should be a platform at least 12 ft. wide and long enough to load three or four standard cars at one time. The tops of these platforms should be on a level with the bottoms of the car floors, and the platforms should have ramps leading to the ground at both ends and one

in the middle, if the other tracks permit. These platforms are particularly useful in loading and unloading animals and vehicles and facilitate the handling of freight. Fig. 116 shows the platform and gives bills of materials for the whole platform and for each extra length of 16 ft.

166. **Stockyards.**—At each station a stockyard should be constructed, and this should be connected with the side ramp of one of the loading platforms by a

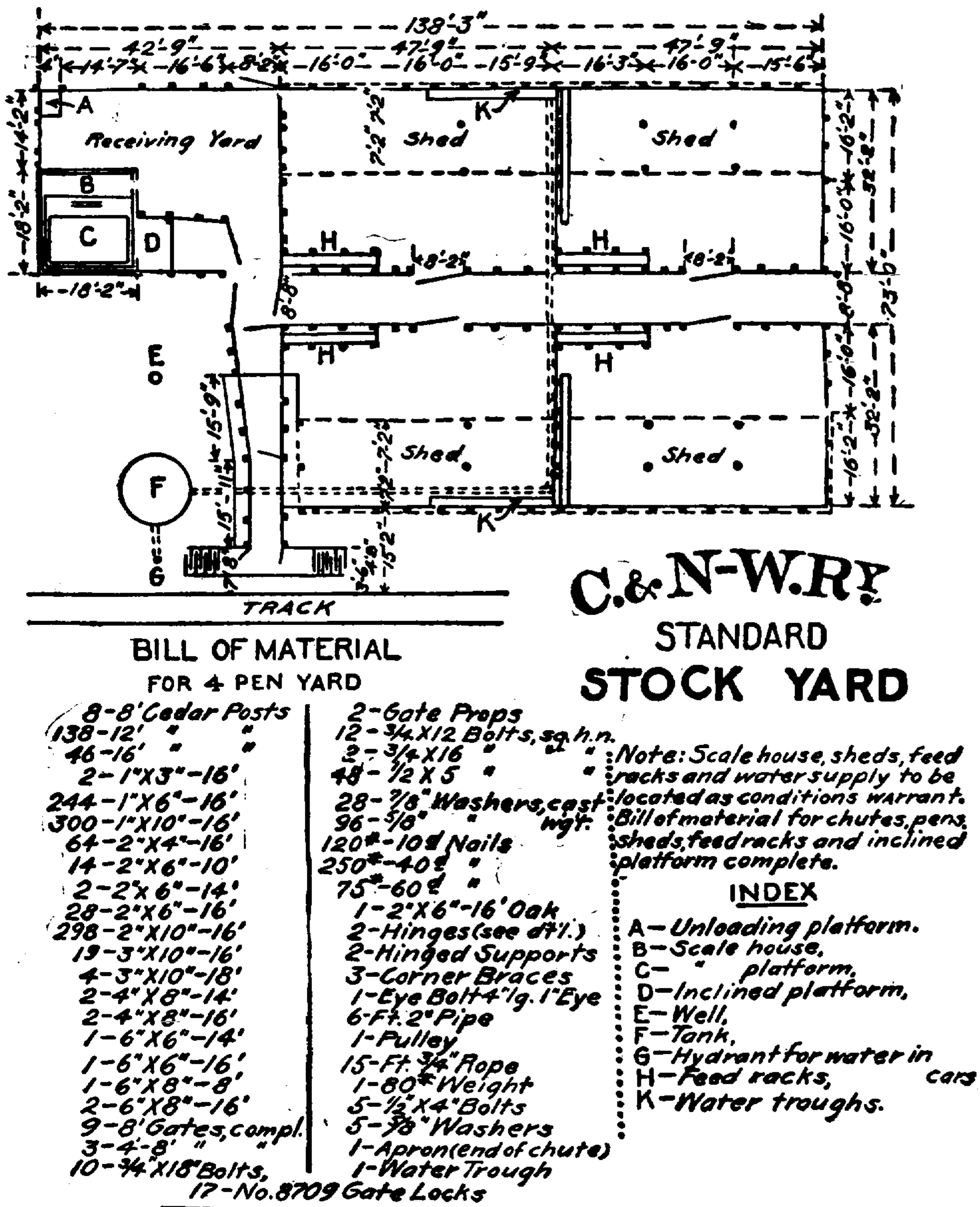


FIG. 117.

movable fence that can be thrown out of the way when the platform is desired for other purposes (fig. 117).

167. **Coal stations.**—The rapid and easy coaling of locomotives requires a gravity supply. This is obtained by raising the coal either by hoisting it into pockets or by running the coal cars up an incline and dumping the coal into bins. One coal station should be located in about each 60 to 70 miles of track and at division terminals.

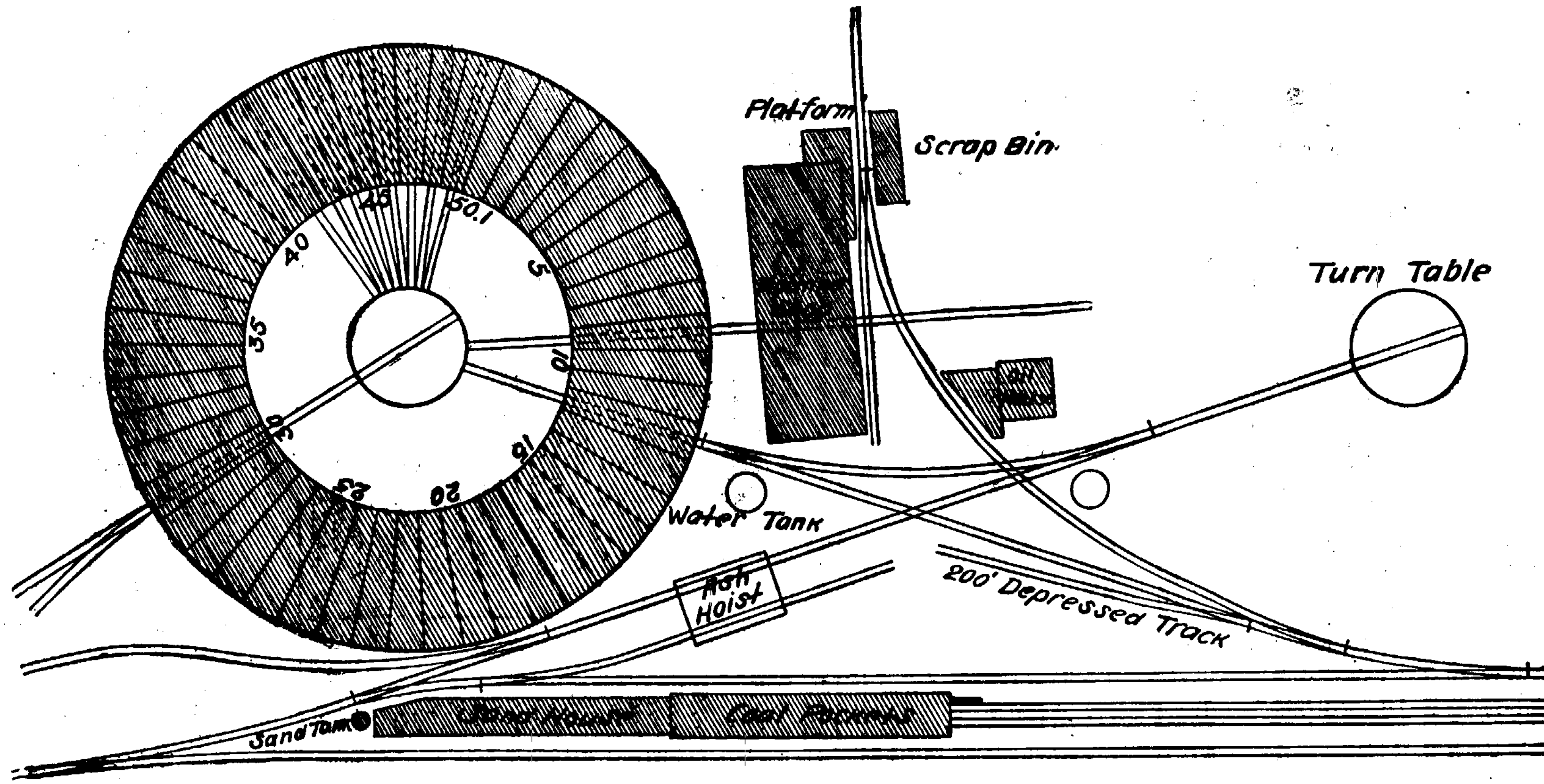
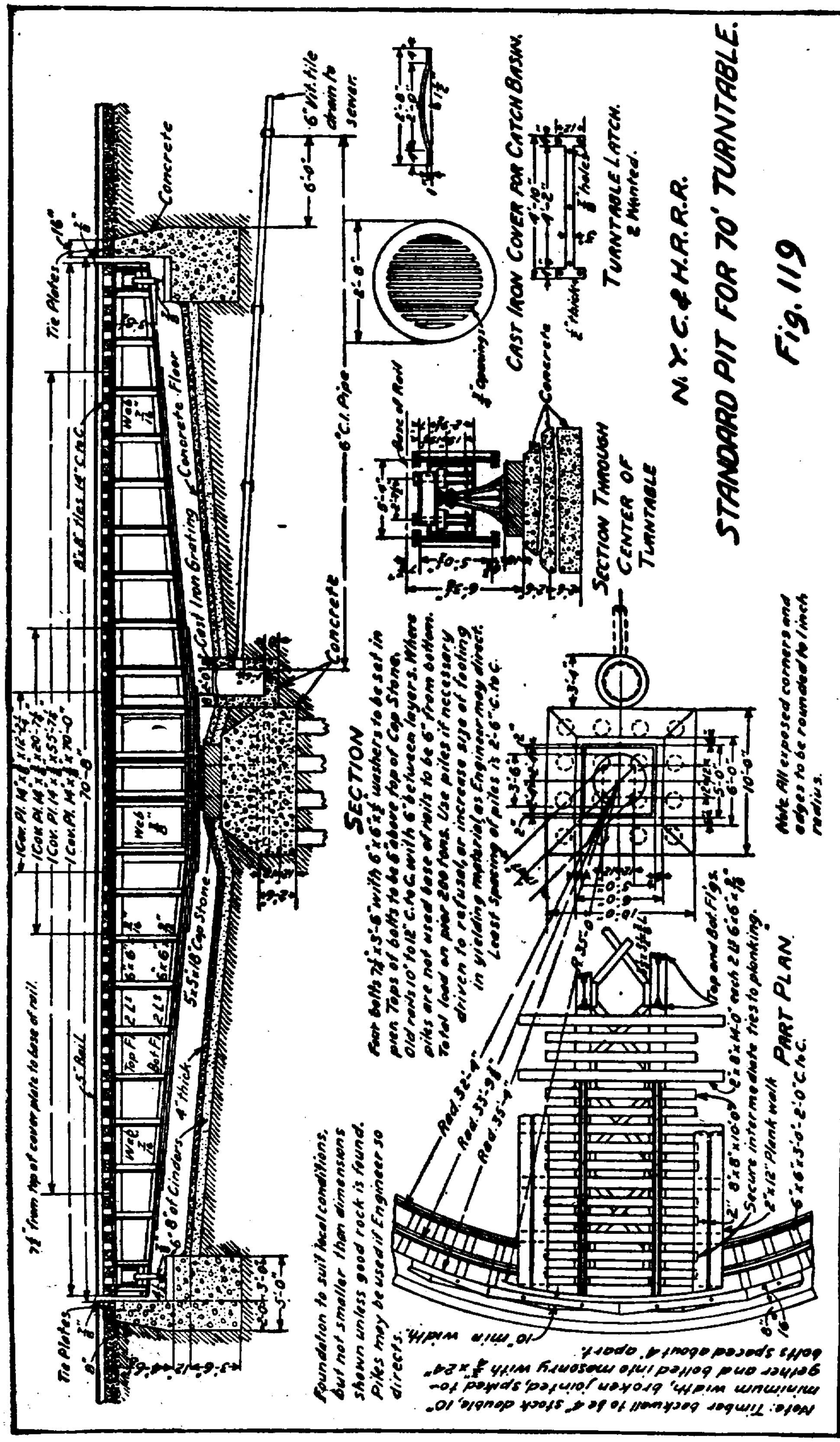


FIG. 118.—ROUNDHOUSE AND TRACKS.

Coal consumption.—The amount of coal required is dependent upon the same factors that determine that of water supply. On the average about 1 lb. of coal is consumed on a locomotive in evaporating 6 to 9 lbs. of water (U. S. gallon, 8.3 lbs.; English gallon, 10 lbs.). Each locomotive carries from 5 to 10 tons of coal.



STANDARD PIT FOR 70' TURNTABLE.

Fig. 119

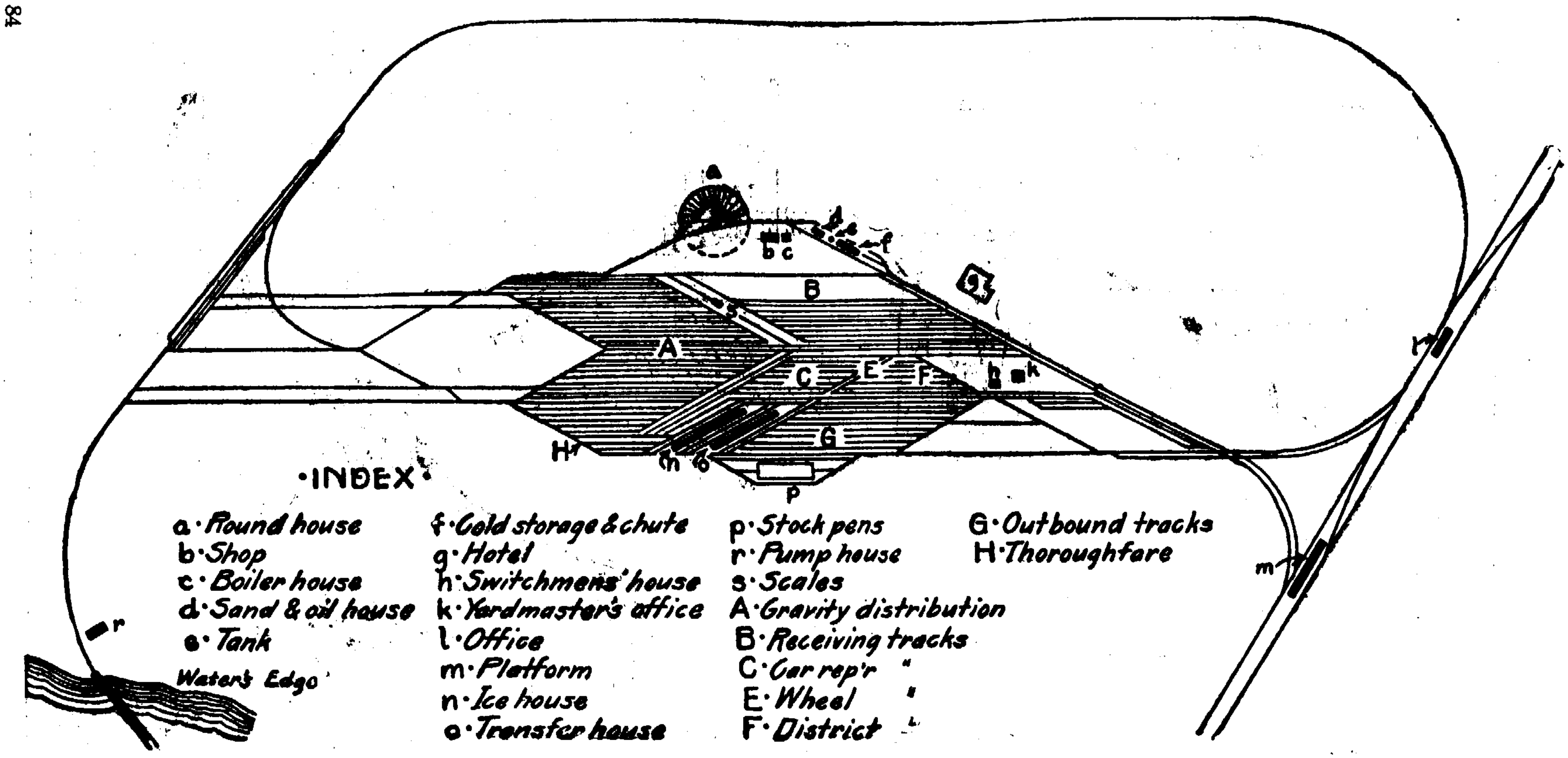


FIG. 120.—TERMINAL YARD.

168. **Buildings.**—The buildings at the stations may be constructed after the line has been finished. Tents can be used temporarily and will answer nearly every purpose.

The railway staff officer in charge of each station must see that there is sufficient storage room for all railway purposes, so that under the most adverse circumstances there will be **no excuse for leaving material stored in cars.** Tents should be supplied for this purpose when buildings are not available or convenient.

FIG. 121.—PLAIN LAP SIDING ON STRAIGHT TRACK.

Roundhouses.—At division terminals temporary roundhouses will be constructed, or storage tracks will be laid, for the proper cleaning and repairing of engines. The plan of such a roundhouse is shown in fig. 118. A **turntable** (fig. 119) is desirable at such points, but if the number of engines is not great, and no roundhouse is available, a few parallel tracks and a Y (fig. 104) for turning engines will answer the purpose of a roundhouse with a turntable. Simplifications of the

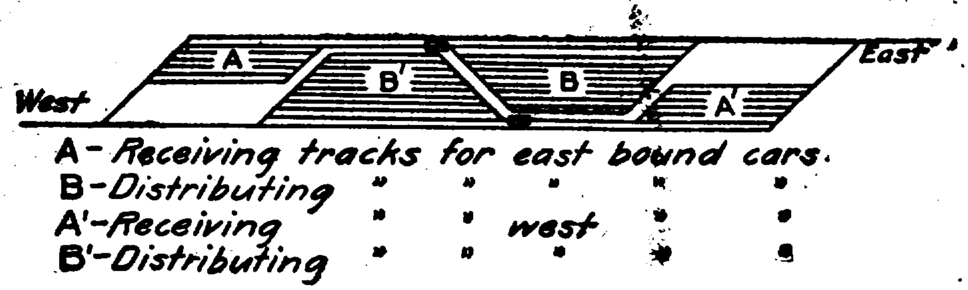


FIG. 122.—DIVISIONAL TERMINAL YARD.

elaborate turntable shown in fig. 119 will suggest themselves to the engineer, but a good turntable for heavy locomotives must be a very permanent structure.

169. **Shops.**—At these same terminals would be located machine shops large enough to keep in repair all the locomotives that would be stabled in the roundhouse, and car repair shops large enough to make all necessary repairs to cars damaged on that division.

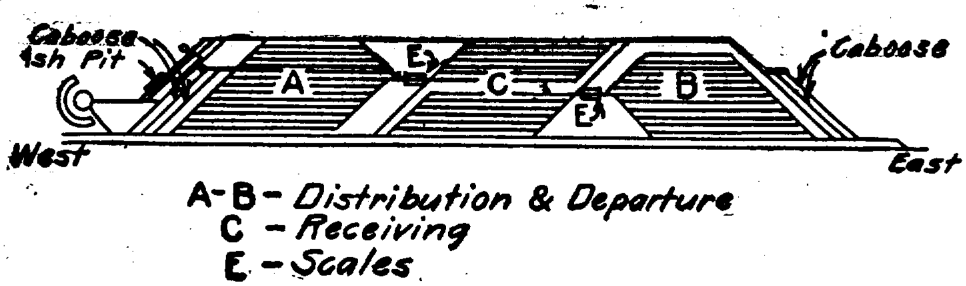


FIG. 123.—DIVISIONAL TERMINAL YARD.

170. **Yards and terminals.**—At division terminals and at other large stations yards must be constructed large enough to receive all the cars entering the station and still allow room for the switching that is necessary in making up trains and in moving cars to and from the storage tracks. In addition, there will be the necessary number of passing tracks.

A yard is a number of sidings and spurs, usually parallel to each other, although often not parallel to the main track. These auxiliary tracks must be sufficient in number to permit the convenient and rapid breaking up of trains, classification of cars by contents, destination, or otherwise, and making them up into new trains in accordance with the new requirements. Yard tracks are divided into groups, according to their purpose. A certain number near the main line at one end of the yard are called **receiving tracks,** and trains arriving pull in on them. In convenient proximity is a **caboose track,** where cabooses are stored when not in trains. A group of **repair tracks** are convenient to the shops, and the **engine track** leads to the engine house, near which should be the coaling and watering stations and the ash pit.

The train on the receiving track is broken up and its cars switched onto the **distribution tracks,** selected so that those on each of these tracks will belong in the same outgoing train. There should be enough distribution tracks to permit the convenient classification of freight cars according to their contents and destination, and of passenger cars according to character, as baggage, express, coaches, tourist and standard sleepers. In most cases, outgoing trains are completed on the distribution tracks and pulled from them onto the main track, when authorized by order to do so. It is better, when possible, to have a third group of tracks at the other end of the yard, which may be called the **departure tracks.** When a train is completed on a distribution track it may be pulled out onto a departure track, where a caboose and engine are added, the designated crew takes charge, and the train is ready, on the receipt of orders, to pull out on the main line without delay, and without crossing or interfering with any of the yard traffic. Departure tracks permit the distributing tracks to be fewer and somewhat shorter. If there are departure tracks, they and the receiving tracks should be divided into two groups designated for traffic in opposite directions. Trains which go through or return without change go direct from the receiving tracks to a distribution or departure track, the returning trains through a loop or Y to turn them around.

All yard tracks, except repair and team tracks, should be open at both ends, so that all traffic over them may be in the same direction. This permits all traffic through the yard to be in one direction, which saves much confusion and delay. The standard method of arranging yard tracks for greatest convenience and compactness is by the use of **ladder tracks,** fig. 103, which are oblique tracks at the proper distance apart to accommodate the other tracks between them. Each receiving, distribution, and departure track connects with a ladder track at each end by the ordinary switch. The dead end of each spur track should be provided with an obstacle, to prevent cars running off.

FIG. 124.—CONVENTIONALIZED TERMINAL LAYOUT.

171. **Gravity or "Hump" yards** will not be considered since there is no chance of having to construct them on a military railway. They are simply yards on a down grade in which the cars are started by a locomotive and then run by force of gravity to their desired position. Theoretically the movement of all cars through a yard should be forward, but this condition would require a layout somewhat like fig. 124. The lead "A" runs into a receiving yard "B." The train is broken up and cars are classified as to destination, etc., on the tracks of the yard, C. The cars are grouped into trains in yard D. The train is sorted and arranged in station order, or as required by regulations in yards E and F and is then run out into yard G ready to proceed. Such a yard layout is not practical, but an understanding of the uses of each part of this layout may assist in planning other yards. Yards at intermediate stations can readily be elaborated from the passing tracks shown in figs. 110 and 121.

172. **Permanent yards** seldom form a part of military construction. For **field terminals,** which are temporary, the arrangement of auxiliary tracks will be much less regular and more open. Sidings will be provided wherever it is necessary to

unload cars. Stores consigned to organizations present will ordinarily not pass through storehouses, but will be unloaded from the trains onto the ground, or, so far as possible, directly into wagons.

Stores consigned to the supply departments will usually go into storehouses or into compact piles at designated points for temporary cover, pending issue. **Platforms** will be used to the degree to which time and materials at hand permit, but the **main reliance for discharging** cars will be **ramps** of suitable form to lead from the car floor to the ground, which should be provided in profusion and so distributed that it will be next to impossible to set out a car at a time or place where a ramp can not be procured within easy carrying distance.

Figs. 141 and 142 show convenient forms of ramps, which may be carried on the car or used otherwise.

Storehouses should be narrow and long enough to permit all the cars of a train to discharge simultaneously. If there are no houses, the ground occupied by the supply departments for storage should be of similar shape for the same purposes.

A very complete type of **terminal yard** is shown in fig. 120. Types of **division terminal yards** are shown in figs. 122, 123.

Local conditions will govern the exact location of yards and special tracks, and only general rules can be made in reference thereto.

A good and convenient form of siding, known as a **"lap siding,"** is shown in fig. 121. When two sidings are necessary and the space is available, this form is an excellent one; whichever train is waiting, or if two are waiting, the locomotives are both within a few steps of the station. Signals are given, and orders are transmitted with more convenience and certainty and less time is lost than if the two sidings were adjacent.

ROLLING STOCK.

173. **Rolling stock.**—The rolling stock of a road consists of the locomotives and cars. Unless notice is given in advance of the proposed construction of a railroad, the rolling stock then on the market or procurable from other railroads will have to be used, and whatever disadvantages are met with will have to be overcome in the best manner possible. If due notice be given, however, of the proposed construction of a road, an equipment can be ordered that will be suited to the local conditions.

If the plans contemplate the use of a railway in a hostile country, plans should be made, well in advance, to obtain a sufficient supplv of rolling stock suited to the road, since it will not be safe to count on capturing rolling stock in usable condition rom the enemy.

A study of the grades and the working time tables will permit an estimate of the necessary amount of rolling stock that will be required. A large allowance for accidents should be made.

174. **Composition and distribution of traffic from bases.**—The amount of traffic originating from the base of an army can be roughly calculated from the following data: From October 1, 1899, to October 31, 1900, there were transported from the three ports, Cape Town, East London, and Port Elizabeth, South Africa, approximatelv 200,000 men; for **each thousand of these men,** during this time, there were also transported 41 officers, 765 animals, 2 guns, 15 vehicles, and 1,406 long tons of stores and supplies.

A compilation for a longer length of time shows that from October, 1899, until June, 1901, from the same three ports, 287,571 men were moved, and that for **each thousand men** there were also transported 44 officers, 672 animals, 1.5 guns, 14.5 wagons, and 1,960 long tons of supplies and stores. From the port of Durban, 89,399 men were transported to the front from September 20, 1899, to June 30, 1901; for **each thousand of these men,** during this time, there were also transported 34.7 officers, 855 animals, 1.9 guns, 7.8 vehicles, and 3,624 long tons of stores and supplies. In addition to this and to the civil traffic that was permitted, from November, 1899, until June, 1901, the railroads moved 941,764 soldiers, 346,965 animals, 10,494 vehicles, and 389,066 long tons of stores and supplies, for which no average length of haul is given. The **percentages of carloads** of the various supplies originating at the bases were as follows: Supplies, 48.5%; ordnance and engineers' stores, 9%; troops, including animals and baggage, 25%; railway stores and labor, 1.5%; remounts, 14.5%; hospital trains and stores, 1.5%.

Based on very scanty data, an estimate of the desired **train tonnage for the supply of an army** seems to be about 35 to 50 lbs per day per man plus the passenger service plus the service to care for the necessary civil traffic. This includes supplies for animals, guns, etc.

175. **Locomotives.**—On supply lines, the sharpest curve allowed would determine, in a measure, the gage to be used, as sharper curves can be used on a narrow-gage road than on a standard or broad-gage road, probably because the rigid wheel base is shorter on the lighter locomotive, since the maximum curvature is theoretically dependent only on the length of the rigid wheel base.

Having decided upon the gage to be used, the first thing to be considered is the **tractive power** desired in the locomotives. A reference to the catalogues of the various firms that build locomotives will give all the data in reference to the ones built by those firms. The tractive power, T, is usually given in pounds and represents the pulling power of the locomotives on a clean, level track. Other conditions being equal, the tractive power of locomotives varies directly with the working steam pressure, the area of the piston, the length of the stroke, and inversely as the circumference of the drivers. It is limited to about ⅓ of the weight on the drivers, under favorable conditions, and to as low as $^1/_7$ of that weight on slippery track.

$$T = \frac{(\text{diam. piston})^2 \times \text{ave. steam pressure} \times \text{stroke}}{\text{diameter of drivers}} \text{ (ins. and lbs.).}$$

Not more than 80% of the theoretical tractive power should be counted upon in working a locomotive, as it has been found in railway practice that this is about the economical percentage to be used. The length of the rigid wheel base and the shape of the wheel should be noted to make sure that the engine can take the maximum curve of the road. The maximum weight on a single axle will determine the lightest rail that can be used for that locomotive (Table IX or X).

The average steam pressure, or mean effective pressure in the formula falls off rapidly with the speed of piston travel. It is about 85% of the boiler pressure up to a piston speed of 250 feet per minute, and falls off, at practically a uniform rate, to 42.5% at a piston speed of 750 ft. per min.; at higher speeds the rate of decrease in mean effective pressure slowly decrease to 30% at 1,075 ft. per min. and 22% at 1,500 ft. per min.

The kind of grate will depend on whether wood or coal is to be used as fuel; only in exceptional circumstances would a wood burner be counted upon at the present day.

All locomotives should be equipped with the modern air brake.

Where the locomotives are to be built to order, the specifications should require that the boiler, water tank, cab, and other vulnerable parts should be **bullet-proof.**

The **speed of the locomotive,** under certain loads and grades, must be computed, and a **freight locomotive** should be required to have an average speed of about 15 miles per hour when hauling 80% of its maximum load. The speed of a locomotive and the hauling capacity should be considered together, for it is evident that a locomotive that will move 500 tons at 15 miles per hour can handle more freight than a locomotive that moves 600 tons at 10 miles per hour on the same grade.

For **passenger service** a locomotive with larger driving wheels and higher speed should be used.

176. With good cars and a good track 1 ton (2,000 lbs.) can be moved by about 6½ lbs. pull. It is probable that on a supply railway the **tractive resistance** per ton, F, would be considerably more than this; probably from 10 to 15 lbs. per ton.

This, however, would depend upon the condition of the track and the condition of the rolling stock, and is given approximately by the following formulæ:

Engineering News formula, $F=2+\frac{V}{4}$,

American Locomotive Co. formula, Baldwin Locomotive Co. formula $\left.\right\} F=3+\frac{V}{6}$,

in which F=tractive resistance in pounds per ton at a speed of V miles per hour on a straight level track.

Up to 40 miles an hour the average of these two formulæ is a conservative estimate.

The hauling capacity of a locomotive is rapidly cut down by grades, and on this account the ruling grade should be kept as small as the conditions of construction will permit.

The **total force,** T, in pounds required to move W tons up a grade where the **grade resistance** is G lbs. per ton, and the force required to move 1 ton on the same track on the level is F lbs. per ton, is given by the formula

$$T=W\ (G+F)\ (G \text{ is not affected by speed}),$$

in which $G=2000 \tan \theta$, when θ=angle of compensated slope (see par. 41). (Practically, G=20 times the percentage of grade.) The weight of locomotive must be included in the train load in above formula. Inertia and wind resistance are not included in T.

Having decided upon the locomotives to be purchased, a table should be made showing their hauling capacity on various grades, and from this table and the division profiles can be determined what is known as the **tonnage rating** of the locomotive; that is, the number of tons that the locomotive will haul over the grades on the division where it is to be used. If different types of locomotives are used on the same division, the tonnage rating of each class should be determined and given to the chief dispatcher, in order that he may know the maximum load that should be required with each locomotive.

177. The tonnage rating depends upon the **train resistance** and the **tractive power** of the locomotive. The train resistance increases with the speed while the tractive power decreases and a consideration of these two factors for each speed fixes the allowable tonnage for that speed. A further consideration of tonnage and speed gives the comparative number of **ton miles** for the different speeds. The maximum seems to correspond to a speed of from 12 to 15 miles per hour.

178. Due to the various other car resistances than those produced by weight alone a locomotive can not haul the same tonnage in empty or half loaded cars that it can in cars loaded to their full capacity.

This gives rise to what is known as **adjusted weight** in trains and **adjusted tonnage rating** in locomotives.

Suppose that it is found that a locomotive will haul, under exactly the same condition except as to train, 20 loaded cars weighing 1,200 tons or 50 empty cars weighing 1,020 tons. The difference is 30 cars and 180 tons. Then the resistances, other than those due to weight, amount for each car to the resistance produced by a weight of 6 tons. Add this adjusted weight to each car of each train and we have 1,320 tons in each case.

$$(50\times6)+1020=1320$$
$$(20\times6)+1200=1320$$

The adjusted weight of the two trains is therefore equal. For any other case for this same rolling stock, use this **adjusted tonnage** as the tonnage rating of the locomotive. Suppose that the yardmaster finds that he has about 35 cars loaded and empty actually weighing 1,050 tons to send in a train using this same locomotive. Then $(35\times6)+1{,}050=1{,}260$ is the adjusted tonnage of the train. One more car weighing 54 tons can be added to the train, making the adjusted tonnage 1,320 tons. The adjusted weight for cars can be found by a similar experiment on any line.

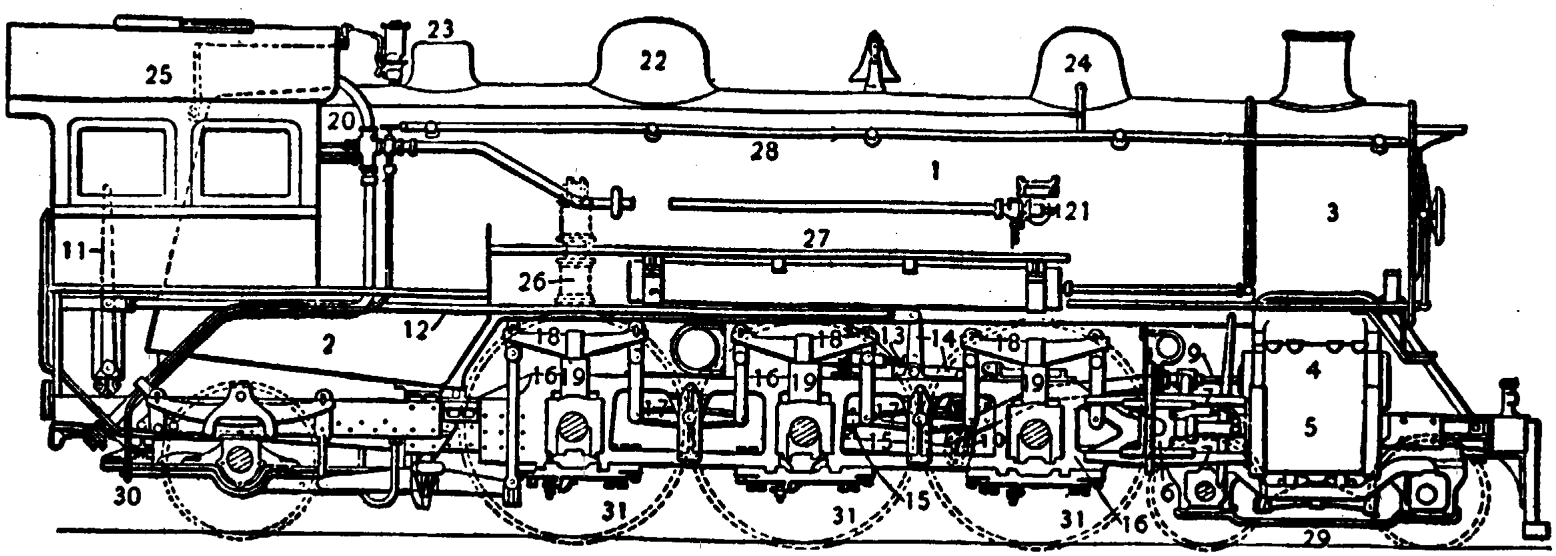


FIG. 125.

NOMENCLATURE OF PARTS OF LOCOMOTIVE.

1. Boiler.
2. Fire box.
3. Smoke box.
4. Steam chest.
5. Cylinder.
6. Crosshead.
7. Guides.
8. Piston rod.
9. Valve stem.
10. Link.
11. Reverse lever.
12. Reach rod.
13. Tumbling shaft.
14. Rocker arm.
15. Eccentric rod.
16. Frame.
17. Equalizing bars.
18. Springs.
19. Pedestals.
20. Injector.
21. Boiler check.
22. Steam drum.
23. Filling funnel.
24. Sand box.
25. Cab.
26. Air pump.
27. Footboard.
28. Handrail.
29. Pilot truck.
30. Trailing truck.
31. Drivers.
32. Main rod.
33. Side rods.