7. **Alignment and grade.**—Within the field of observation and fire of a besieged place practically all movements must be made under artificial cover. The location of these lines of approach will be dictated by military principles, and the line of the combat railway will therefore be determined not by questions of economy or ease of construction, but by the location of the siege approaches and parallels.

For the same reason, the grade of the line is practically thrown out of the consideration, although a slight change in the direction of the approach might be made to keep the grade of the line below the limiting grade, if by such a change no military advantage were lost. This limiting grade should be kept as low as practicable, for the difficulties of moving cars under such adverse conditions are great at best, and for any slope greater than 6 or 8 ft. in a hundred the difficulties of ascent with loaded cars will be very great, even for animal traction; and above that, the cars would probably have to be moved by cable.

## TRACK.

8. **Gage.**—The word gage is used with various meanings in railroading, but its most frequent and most important use is to indicate the distance between the inner edges of the heads of the rails when newly laid. **Standard gage** is 4 ft. 8½ ins. to 4 ft. 9 ins., being adapted to running standard-gage equipment. The actual gage of any track exceeds the nominal gage by the amount of wear on the inner faces of the two rails since they were laid, and by any outward movement of either rail due to traffic. The gage of a combat railway may be determined by any of several conditions, such as the amount of portable track available, the weight of the equipment necessary, the amount of materials that must be handled on the railway, etc. The amount of narrow-gage railway stock and equipment that is kept on hand by the commercial firms of this country is very limited and for a sudden call the choice of gages would not be very great. This condition will probably be the controlling one, as at present there is no military railway equipment for our army. **A 2 ft. 6 in. gage railroad** would answer the purpose as well as, or better than, any other, and if notice can be had long enough in advance, the entire equipment for field railways might well be of this gage. Considerations of weight may require a narrower gage, and a **2-ft. gage** will give a very efficient railway. This gives lighter track sections, lighter rolling stock, and in actual siege-work requires less width of trench. Subject to these considerations, the wider the gage the better, although on the offensive a narrow-gage line will doubtless have to be used.

On the **defensive side** of a siege there is greater opportunity to use a standard gage track, and such track will be used whenever practicable, supplemented when necessary by narrow-gage lines.

9. **Roadbed.**—There will probably be no time for ballasting the roadbed, and for this reason the ties used should extend well beyond the rails and, in order to form the least possible obstruction to movements on foot in the approaches and trenches, should be as thin as practicable.

10. **Rails and connections.**—The rails may either be bought already fastened to metal ties, or the rails and ties may be ordered separately. In the former case, the sections are known as **portable track,** and usually come in 15-ft. sections (fig. 2).

FIG. 2.—Section of Portable Track

The weight of the rail of such portable track is usually about 12 to 20 lbs. per yard, and the most common gages are 20 and 30 ins. Portable track of wider gage and heavier rails can be had by special order. The ties used are usually of the cross

section shown in fig. 3, and standard sizes weigh 7 and 12 lbs. per yard. The rail is the standard T rail. The **connections** between the rails are usually the ordinary fish plates and bolts, as shown in fig. 3. **Angle bars** may be used if obtainable, though for so light a rail the **fish plate** answers every purpose.

The rails are fastened to **metal ties** with clips and bolts as shown in fig. 4.

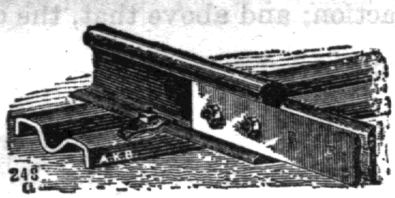

FIG. 3.—METAL TIE AND RAIL CONNECTIONS.

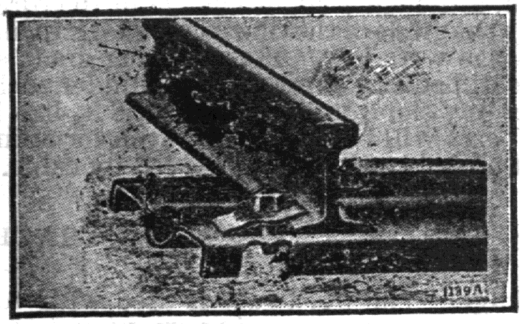

FIG. 4.—RAIL FASTENING TO METAL TIE.

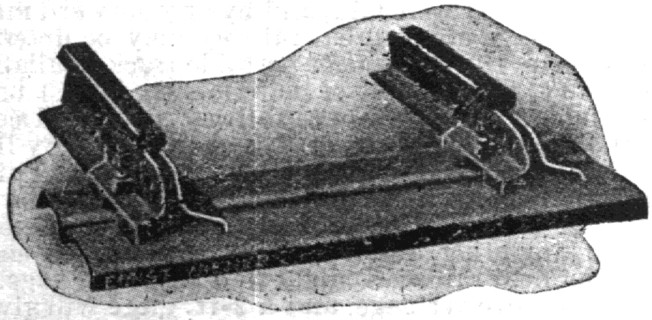

FIG. 5.—ANGLE PLATE CONNECTION WITHOUT BOLTING.

A type of connection for rapid laying, requiring no bolting, is shown in fig. 5. This is only a temporary expedient and the rails should be bolted as soon as practicable. In ordinary commercial portable track the weight of the ties is about equal to that of one rail. Hence the weight of portable track per linear foot is about equal to the weight of 1 yard of rail. Portable track can be estimated to cost about 5 cents per pound, made up at the factory.

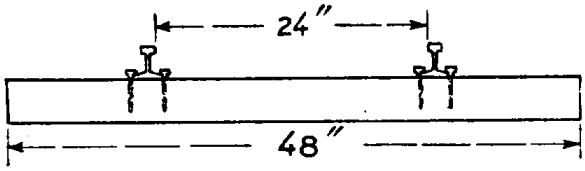


FIG. 6.

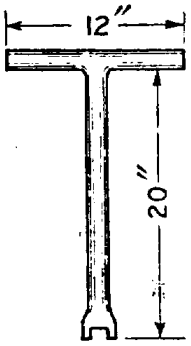


FIG. 7.

11. If the track is laid on **wooden ties,** railroad spikes will ordinarily be used to fasten the rail. However, circumstances may demand that the railroad be laid without noise, in which case **lag bolts** can be used instead of spikes (fig. 6). A wrench for lag bolts is shown in fig. 7.

12. On tracks of this sort, with a poor roadbed, it is advisable to have the rail joints opposite each other (**square**), except on curves, where they can not be so laid without cutting the rails. The joints of the rails should lie midway between two ties which are so placed that they rest under the opposite ends of the fishplates connecting the rails. This **suspended joint** has been found very satisfactory (see fig. 37).

13. **Ties.**—In case **metal ties** can be obtained, and the necessary punch for punching the bolt holes is at hand, these ties are preferable to wooden ones on account of the smaller space they occupy. Metal ties of portable track are but little longer than the gage of the track. Ties longer than those used commercially would require a special order.

In case **wooden ties** are used, 3 by 6 in. or 3 by 9 in. ties are probably the best. If ties of this size are not at hand, thicker ones may be used. If 3-in. or thicker lumber is not available, ties may be made by using inch or half-inch boards nailed and clinched to provide the necessary thickness. The distance between the ties depends upon the load and the weight of the rail. Wooden ties should be at least 2ft. longer than the gage of the track to give good bearing.

14. **Switches.**—For a portable railway, **switch sections** are made that include the main track and turnout from the point of switch to beyond the frog. These switches are usually split switches, as illustrated in fig. 8, and can be purchased

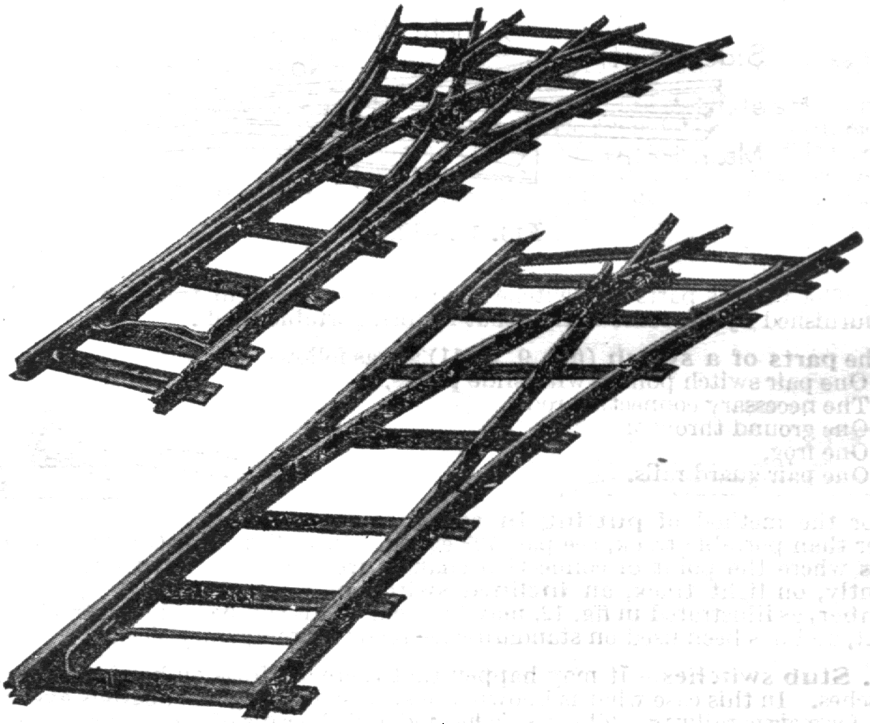

FIG. 8.—THREE-WAY AND RIGHT-HAND SINGLE SWITCHES.

for either right or left hand single switches, two-way or symmetrical switches, or three-way switches. If purchased in this shape, they can be laid down in the track at any point by taking up a section of the same length and substituting the switch section. The radius of the standard curve of departure for these switches is 30 ft.

The switch sections usually correspond in length to the sections of straight track made by the same manufacturer. **Guard rails** should be called for on all switches. (See fig. 107.)

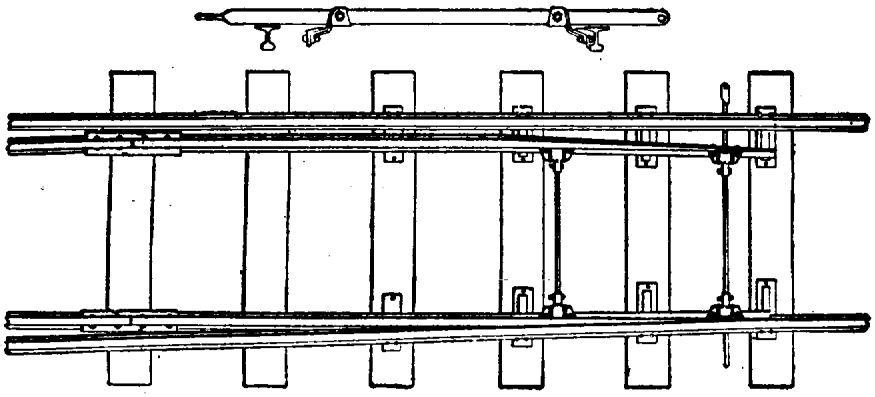

FIG. 9.—SPLIT SWITCH FOR LIGHT RAILS.

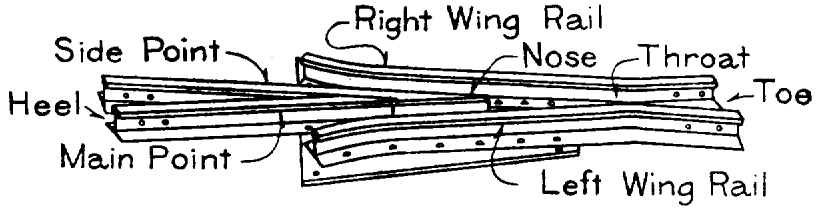


FIG. 10.—FROG.

15. The various parts for switches and turnouts for light track on wooden ties are furnished by the same dealers that furnish portable track.

The **parts of a switch** (figs. 9, 10, 11) are as follows:
One pair switch points, with slide plates.
The necessary connecting rods.
One ground throw or stand.
One frog.
One pair guard rails.

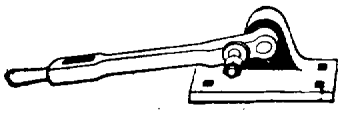

FIG. 11.—GROUND THROW SWITCH.

For the method of **putting in switches** for other than portable track, see par. 127 et seq. In cases where the point of connection changes frequently, on light track, an **inclined switch or climber,** as illustrated in fig. 12, may be used. This can be laid on a track at any point, and has been used on standard-gage roads for temporary sidings.

16. **Stub switches.**—It may happen that there are frogs on hand, but no split switches. In this case what is known as a stub switch (fig. 96) answers every purpose for a siege railway. The frog is located and the rails of the turnout and main track are laid on their regular curves until the distance between the heads of the rails is equal to the required clearance for the wheel flanges. These rails are all permanently fastened and the adjacent half of the rail on the main line is left movable, leading either to the turnout or continuing on the main line, according to the way it is set. The movable parts of these rails are connected by switch rods and slide on metal plates. (See par. 134 for fuller description of stub switches.)

17. **Curves.**—The curves used on this kind of line usually have small radii. The radius may be as small as 12 ft., although a radius of less than 30 ft. is not advisable, if avoidable. For curves with radii over 500 ft., see par. 63 et seq. Curves with

radii under 500 ft. can be laid off without the use of surveying instruments about as easily as with the use of instruments. For the portable track mentioned in par. 10, sections will be bent by the manufacturer to any desired radius. For other track, the rails must be bent and the center line of the track located in order to lay out the curve.

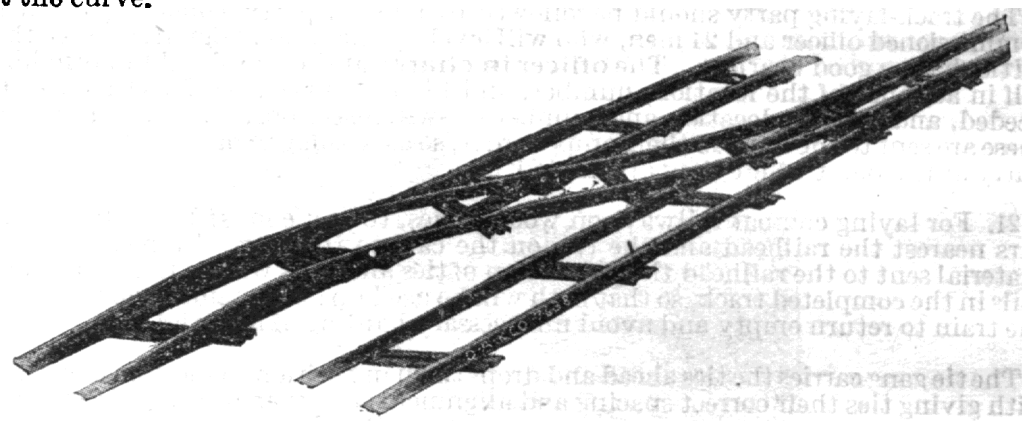

FIG. 12—INCLINED SWITCH OR CLIMBER.

For method of laying out curves when portable track is not used see par. 58.

18. The angles made in the trench lines of siegeworks are so sharp that curves with very short radii will be necessary. Sharp curves, even with low speed, mean derailments and the consequent trouble; and the use of "**switchbacks**" is recommended when the question of speed is a minor one, as it usually is on a siege line. ABC (fig. 13) is the change of direction of an approach; the angle is not exaggerated. A very sharp curve would be necessary to get from A to C by an auxiliary trench, F. A much better method is to extend the trench from B to D and lay the track to D. At B a switch is put in and the line continued to C. BD must be longer than the probable train length and level if possible. The train is moved onto BD, and the animals are put on the other end of the train, or the motor is run backward and the train proceeds, via BC, to the next switchback, when the operation is repeated. E makes an excellent place for storage of tools or materials, or for a dressing station.

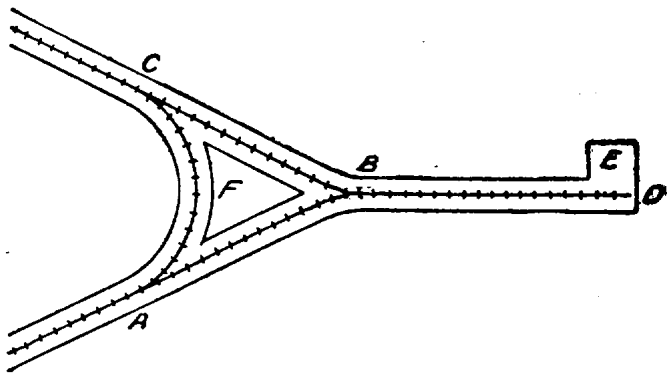


FIG 13.—SWITCHBACK.

19. **Track centers.**—Having decided upon the track to be laid, the **center line** is marked by center stakes about 100 ft. apart, on tangents, and as near together on curves as the radius of curvature requires. For portable track in siegework, very little staking out will be necessary.

20. **Track laying.**—In laying a portable railway, all sections of the track should be inspected before they are sent to the railhead, to make sure that the ties are properly bolted to the track and that the necessary fishplates are attached to one end of each section. The sections are then loaded on the cars with all fishplates pointing toward the head of the track, and the cars are hauled out to the railhead. At this point the **working party,** consisting of 2 noncommissioned officers and 24 men, unload the cars and lay the track. Two men can unload and lay a section of track in about the same time that two men can bolt the fishplates. The party can

be divided into two parts, 12 men carrying the rail sections and 12 men bolting and fastening up the joints. The cars are so light that if there is room in the trench the head cars can be lifted off the track and the remaining loaded cars run past, after which the empties can be put on the track and hauled to the rear. They will either be run singly or in trains, according to the tractive power that is used.

The track-laying party should be followed by another party, consisting of 1 non-commissioned officer and 24 men, who will level up the track, align it, and see that all ties have a good bearing. The officer in charge at the rear should inform himself in advance of the location, number, and kind of curved sections that will be needed, and also the location and number of switch sections, and should see that these are sent to the front in their proper order, so as to come to hand for the working party at the point where they are needed.

21. For laying combat railways on wooden ties, the rails must be loaded on the cars nearest the railhead and the ties on the cars to the rear. In every train of material sent to the railhead the proportion of ties and rails will be that of ties and rails in the completed track, so that both will be used up at the same time and allow the train to return empty and avoid unnecessary hauling of material.

The tie gang carries the ties ahead and drops them in position. One man is charged with giving ties their correct spacing and alignment; two men at the rail car fasten the fishplates to the forward end of the rail, if this has not already been done at the rear, and the rail is carried up and laid with its end between the fishplates at the head of the last preceding rail. The fishplates are bolted temporarily with one bolt, and a clip and rod (**bridle**, fig. 87) fastens the rail bases together temporarily. The construction train is then pushed ahead toward the end of the rail just laid and there halted until the next rail is laid.

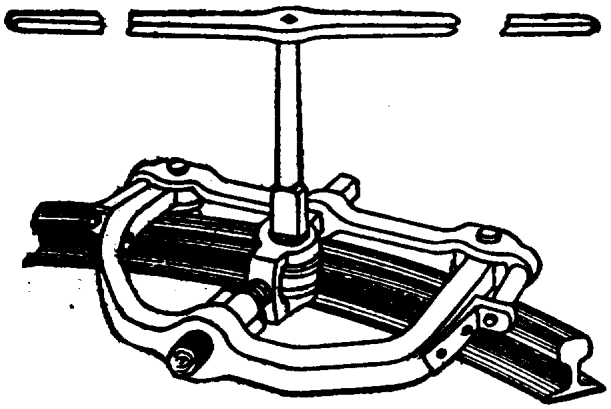

FIG. 14.—RAIL-CURVING MACHINE.

Behind the train is the bolting party that bolts the fishplates permanently to the rail the spiking party that spikes or screws the rail to the ties, and the surfacing, party that aligns and surfaces the track. This is an adaptation of the method described in pars. 118 to 125.

All the **working parties** on this work should be under an officer who has an assistant at the rear charged with getting out and forwarding all material needed. This last officer's instructions should be such that he clearly understands what material is wanted, and when and where it is wanted. As far as practicable, all **rail cutting** should be done at the rear.

It may be feasible to spike the rails to the ties and bolt on the fishplates in the rear, in which case the line is laid as described for portable track. This method would not be economical of space in loading.

22. **Curving rails.**—Before any rail is spiked to its place in a curve it must be evenly bent from end to end, so that it will assume the proper curvature when lying free. This curving may be done by hammers, but that method is slow, and a **rail-curving machine**, shown in fig. 14, is more commonly used. Two forms of **rail bender** are shown in figs. 15 and 16. These are made with either screw or hydraulic power, and are used for bending rails rather than for curving them. For many curves no rail curving is necessary, the friction between the rail and the ties being sufficient to hold the rail in position. The extent of this flexibility depends on the

weight and length of the rail, and can be found by trial; 3° and sharper curves usually require a curving of rails. Rails may be curved by fastening the machine to a tree and drawing the rails through the machine by means of a chain attached to a locomotive.

23. Knowing the radius of the curve and the length of the rail, the **middle ordinate** of the rail can be taken from Table XX. Each half of the rail, from the middle point to the ends, should also be tested for its middle ordinate to insure uniform

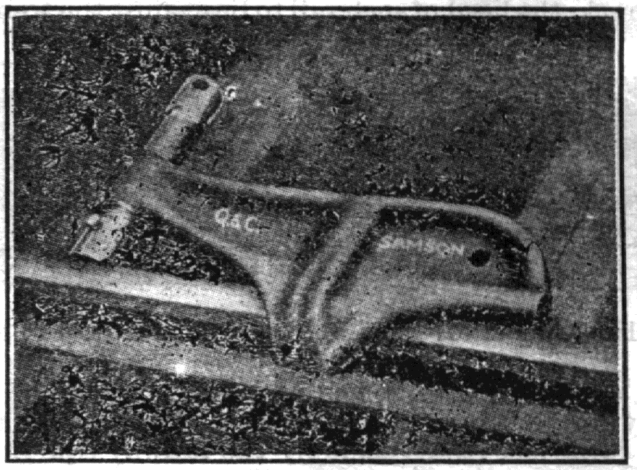


FIG 15.—Q. & C. SAMSON RAIL BENDER.

curvature. The middle ordinate of these half sections is one-fourth of the middle ordinate of the entire rail.

24. **Rail braces.**—The **outer rails** of curves are frequently braced with braces of a kind illustrated in fig. 17. An angle bar nailed to the tie and butting against the web of the rail furnishes a very good brace. (For elevation of outer rails of curves, see pars. 70, 71.) On standard-gage roads the rule seems to be about one rail brace per degree of curvature. On very sharp curves it is a good precaution to have the inner line of track doubled by the use of a guard rail. This will fre-

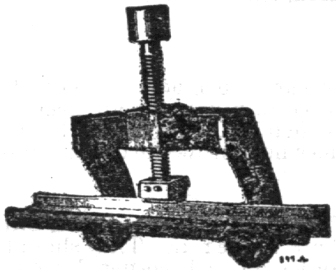

FIG. 16.—JIM CROW BENDER AND WRENCH.

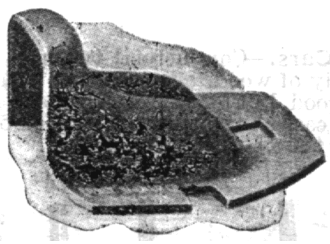

FIG. 17.—PRESSED STEEL RAIL BRACE.

quently prevent derailments and the consequent delay and trouble, and should be the invariable custom on the poorly constructed lines of combat railways.

25. **Crossings.**—For stock gages, right-angle crossings are usually kept in stock by the manufacturers (fig. 18.) Crossings for any angle and weight of rail can be made on short notice. In ordering, state the crossing angle and the degree of curvature, the gage, and weight of rail of each track. The angle of crossing of two curves, or of a curve and a tangent, is measured by the angle between the tangents