

475. Stock.—In moving live stock over a railroad, it is necessary at intervals to unload them for feed and water and then forward them. This plan will necessitate stockyards at such stations. A plan and bill of material for a four-pen stockyard is given in fig. 117. The laws usually require that stock shall not be kept aboard cars longer than 24 consecutive hours, and at the end of that period they shall be unloaded for feeding and watering. Stock should be packed tightly to prevent them from lying down or being thrown down by the movement of the train.

476. Overs and shorts.—If any packages indicated on the waybill are not found when the shipment is received, a list of such "shorts" is taken. If there are any packages in the car not accounted for on the waybill, a similar list of "overs" is made. This list of "overs" and "shorts" must be immediately reported to the division superintendent, giving the number of car that such "overs" or "shorts" occurred in, a list of the transfer stations, the shipping point, consignee, and such other notes from the waybill as will give a history of the journey that the car has made. In the office of the division superintendent there is a clerk who immediately takes the matter up. This clerk looks through his list of overs and shorts received from all other agents on the division, and is frequently able to locate lost packages from such list and to send extra ones to the proper destinations. For all packages that can not be found, or whose destination can not be determined, an investigation is immediately started, beginning with the original shipping agent and following through the various persons who had charge of the shipment en route and at the same time a division list of "overs" and "shorts" is sent to the general superintendent, in whose office a similar investigation is made from the combined reports of "overs" and "shorts" received from the various division superintendents.

477. In investigating for overs and shorts it will be found advantageous to make out a printed list of numbered questions, such as follows:

SUPERINTENDENT'S OFFICE, DIVISION,

Agent, Condr., File , 19..

Please see papers attached and comply with request No.

1. Examine your warehouse, platform, billing, etc., and advise if loaded as billed.
2. If you find not loaded as billed, give full explanation.
3. Was freight checked when loaded and by whom? How long after loaded before car was sealed?
4. For what stations did you load similar freight?
5. Into what car might this freight have been loaded in error and for what points?
6. Who had car out of your station, and on what date?
7. Are you still short the within-mentioned packages?
8. Car into your station Were you over, and was car made empty? If not, give disposition.
9. Car delivered to your division at, date Please trace to an empty and advise if over.
10. Trace through to destination and advise if freight has been received and from what source.
11. Has shortage been filled? If so, give waybill reference on which received.
12. Give your transfer record, disposition of original car if not empty. Did you transfer similar freight, and for what points? How do you account for this shortage?
13. See short report attached. Are you over?
14. You had car in train date Where did you leave it? Are you positive freight was not in car? Can you account for shortage? Did you unload similar freight? If so, at what stations? Give all around seals when taken and when left and say at what stations opened.
15. See over report attached. Are you short, and on what billing?
16. Give record of car passing. Show train, date, conductor, seal record, and advise if you check over.
17. See over report attached. Did you handle similar freight on your train this date? Can you give disposition?
18. Who had car to you and under what seals?

19. Please show delivery to the division.
 20. See over report. Can you furnish billing to cover?
 21. See attached over report. Will this fill your shortage?
 22. First agent note and forward consecutively as shown above, last-named agent forwarding papers to this office.
Please return papers promptly to this office.

....., Division Superintendent.

Make a list of the persons to be questioned, and opposite each name set the numbers of the above questions that it is desired to have each answer. Send this list to first person and direct him to answer his questions and then forward all the papers to No. 2, etc. Thus this list of questions is sent to the original shipping agent with the request that he answer questions 1 to 6, inclusive, and then forward papers to first conductor to answer question 14. This conductor answers his question and forwards the papers to second conductor, etc. If nothing develops from the investigation of conductors, the papers may then be sent back to the receiving freight agent with request that he answer question 7, or to any agent who opened the car en route, for answer to question 8. The various questions suggest the persons to whom the paper should be sent in the investigation. A prompt investigation of all overs and shorts is especially necessary on a military railway.

478. In loading freight, the agent will always check all articles received before giving the waybill; and when such freight is loaded into the cars, some system must be adopted which will make sure that the freight is placed in the proper car and that all the freight on the bill is properly loaded and indicated on the waybills and that all packages are shipped in proper form to insure their safe carriage.

479. At large terminal stations this question of loading becomes a very important factor in the satisfactory operation of the road. A system of loading must be devised so that there will be a cross check on the loading. A suggestion of a scheme is as follows:

Freight is loaded into cars from receiving platforms by truckers, and checked by a loading clerk.

Freight will be received at different doors for different parts of the line.

Each trucker will call out destination and mark of each package as he places it on his truck.

The clerk has blank forms for each trucker, as below; and when the destination is called he writes the number of car and track on the card, records the identification mark, and makes a check after "No." on the blank. No truck will carry packages for more than one car at a time.

Trucker 3.	
Car 6.	Track 4.
Marks A. B. C.	No.....
Marks C. D. E.	No.....
Marks F. G.	No.....

This card is given to the trucker when his truck is loaded, and he leaves the card in a box in the car in which he leaves the packages. These cards are afterwards collected by an inspector and checked back against the waybill. One clerk can

card for about four to six truckers. Large signs will be hung in each car, giving car and track numbers, and points for which that car will be loaded, thus:

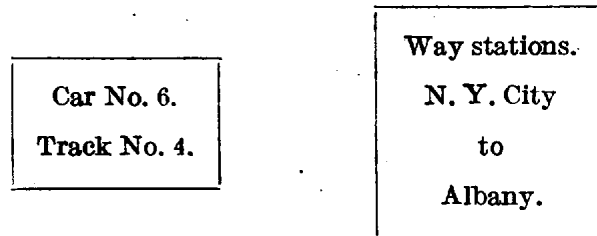


Fig. 140 indicates position of tracks for loading at a large station. The cars are run onto the parallel tracks and so "spotted" that the side doors of cars on all six tracks shall be in line, perpendicular to the loading platform. The platform is con-

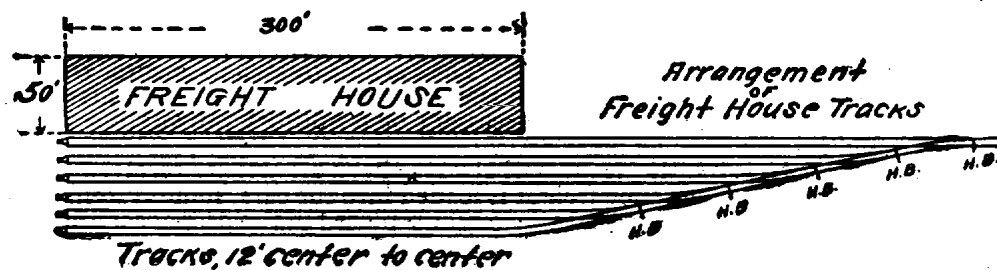


FIG. 140.

nected with the nearest car, and each car thereafter is connected through the side doors with the corresponding car on the next track by a wide plate of steel, over which the trucks run.

TROOP MOVEMENTS.

480. Entraining of troops.—As soon as a railroad is taken under military control, a bulletin for railway use should be published, giving the capacity of cars, and the maximum number of cars, loaded and empty, to be run in trains, where the whole tonnage rating of the engines can not be utilized. The carrying capacity of coaches and other cars should be given for both **normal transportation** and **hurried transportation**; the normal transportation will be used unless the other be specifically stated, in which case trains will be made to carry every available man that safety will permit.

481. Rations for the men on the train will be carried in the baggage cars, or kitchen cars if provided. Where an entire unit can not be carried on one train, battalions can be broken up and certain companies assigned to one train, while the remainder follow in another. The **assignment of troops** to trains will rest with the railway officials. Where regiments carry tentage and camp equipage, these will normally be sent ahead of the troops in one train and will not be divided up amongst the trains carrying the troops. The baggage of the companies traveling on different trains will be kept separate so that the baggage of each company can be shipped in the train with the company. All **company baggage** will be **plainly marked**, indicating the company and regiment. In Infantry regiments, the officers' horses will be shipped ahead in the train with the camp equipage.

482. In mounted regiments, the first trains will carry the horses, with men to look after them. The picket lines and a proper amount of forage will be carried on the horse trains. Guns, caissons, and wagons will follow on trains in the rear of the regiments to which they belong.

483. In loading artillery wagons on trains, they will be loaded on the cars from a platform or from portable ramps (fig. 141). They will be loaded on one car and run by hand or horse power to the car on which they are to be carried. The openings between cars will be covered by plates of iron, or wooden runways, over which the vehicles may run. As soon as a vehicle is on the car, a rope with a hook will be attached to the wagon; a team of horses on the ground, moving parallel to the train, will pull the vehicle while it is guided by men on the tongue. By this means, loading of heavy vehicles will be greatly facilitated.

484. Unloading of troops and animals at or near the railhead must be expedited in every possible way. Platforms and portable ramps must be supplied at all unloading points. A type of platform and bill of material for same is shown in fig. 116. A portable ramp for vehicles is shown in fig. 141. The method of unloading is just the converse of the method of loading, as described in par. 483. A portable ramp for unloading animals is shown in fig. 142. These can easily be lashed on the truss rods of the cars.

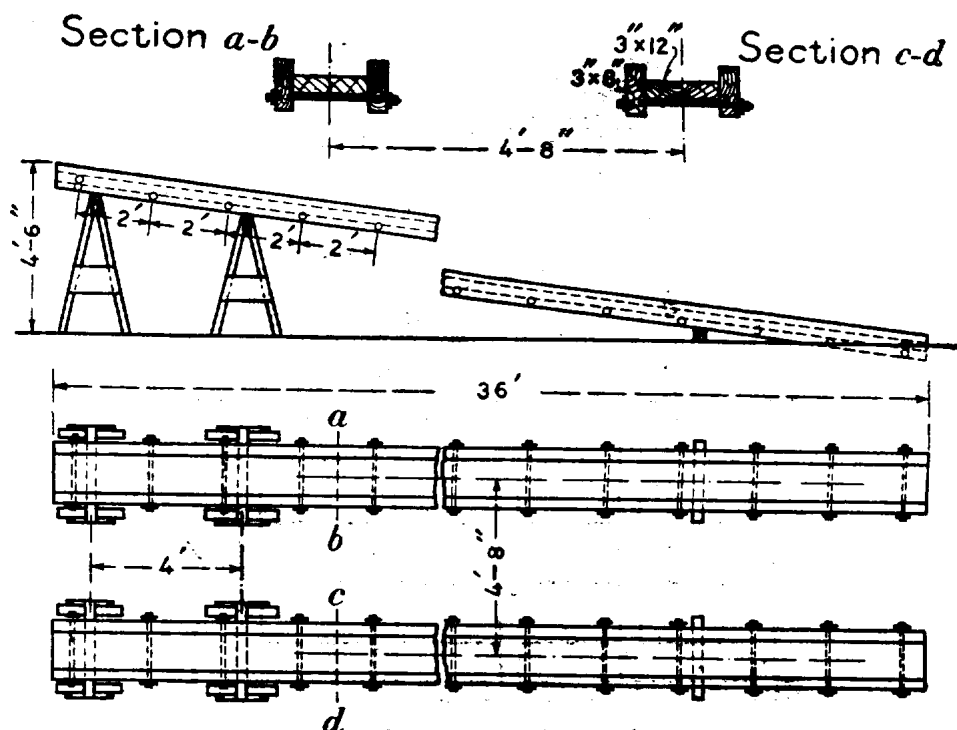


FIG. 141.—PORTABLE RAMPS FOR VEHICLES.

For troop movements on a military railway, each stock car should be supplied with one such ramp. It can be carried on the truss rods or otherwise fastened to the car.

485. No officer, soldier, or civilian can travel on the military railway except he be provided with the proper transportation. Such transportation will not be issued except upon the presentation of an order authorizing the journey, or granting a leave; and in the case of a civilian, an order from headquarters authorizing him to travel on the military railway.

486. When trains are running through a district infested by the enemy, all officers and men traveling by such trains must go properly armed. The senior officer on the train is responsible that order is kept on the train and that the regulations are obeyed; and in case of attack, he assumes command during the attack. In case of disorder on the train he can call any other officer or soldier to his assistance in maintaining discipline.

WRECKING OUTFITS.

487. The organization and equipment of the **wrecking outfits** on a military road must be complete in every particular. These wrecking outfits will be assigned to certain sections of the line and will be stationed at or near the center of the territory to which they belong. The wrecking outfit proper is composed of a crane car equipped with a 50-ton derrick and engine, the number of flat cars necessary to carry the heavy equipment, such as extra trucks, rails, ties, etc., a certain number of box cars that are arranged inside as storerooms for the lighter material, and one or two cars fitted up as living quarters for the wrecking crew, and as a hospital car to take care of the injured that may be found in the wrecks.

One locomotive will be kept under steam at all times so that the wrecking outfit can be started to the scene of wreck on a few minutes' notice.

The wrecking train is equipped with medicines, instruments, bedding, etc., and the commissary is always ready to care for the crew for at least two days. The crew must always be where they can be rapidly collected on notification of a wreck.

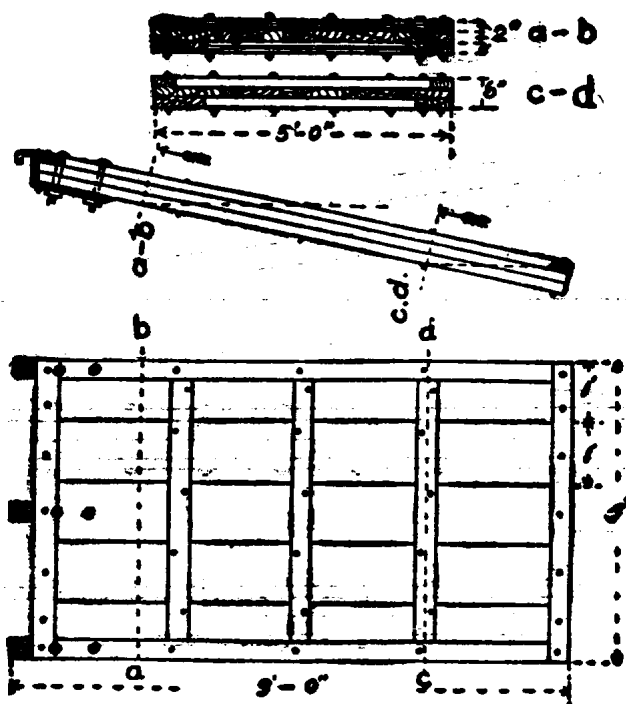


FIG. 142.—PORTABLE ANIMAL RAMP.

The crew will consist of one wrecking master and an assistant, one cranesman and an assistant, and five men, one of whom shall be a cook, and the other four expert car or locomotive repairers. This crew will be employed in the shops when not on wrecking work. Laborers will be obtained from maintenance, or section, crews near scene of wreck.

488. On receipt of information of a wreck, the wrecking crew, together with the necessary train crew, will be immediately notified, and the wrecking train should ordinarily be under way, with good management, within 15 minutes, in daytime, and within from 20 to 25 minutes at nighttime, after the receipt of call for the wrecking train.

489. The **wrecking master** is responsible that the train is at all times fully equipped as to tools, supplies, and commissary stores. The surgeon who accompanies the wrecking outfit is responsible that the proper hospital supplies, instruments, medicines, etc., are in the hospital car. The surgeon is notified at the same time the train crew is.

490. A list of the railway tools and equipment for a wrecking outfit on a standard-gage road is given below:

- 2 pairs Tilden rerailing frogs for proper rail.
- 2 pairs Fewings rerailing frogs.
- 2 35-ton 31-in. Norton jacks, with hooks.
- 2 30-ton hydraulic wrecking jacks, with claw (Watson & Stillman 18-in. runout).
- 2 20-ton hydraulic wrecking jacks, with claws (Watson & Stillman 18-in. runout).
- 2 track jacks (Barrett).
- 4 16-in. triple blocks. Two of these blocks, together with one rope, constitute block and fall ready for use, the remaining blocks and rope being held separately as a reserve.
- 4 18-in. double blocks and 2 manila ropes, 2 in. in diameter, each 400 ft. long, rove as 2 blocks and falls.
- 4 12-in. triple blocks, and 2 manila ropes, 1½ in. in diameter, each 400 ft. long, rove as 2 blocks and falls.
- 1 2-in. manila rope 200 ft. long.
- 1 1¼-in. manila rope 200 ft. long.
- 2 30-in. snatch blocks.
- 2 18-in. snatch blocks.
- 2 12-in. snatch blocks.
- 1 1-in. crucible cast-steel cable 100 ft. long.
- 1 manila dragrope 6 in. in diameter, 50 ft. long, with hook on one end and link on the other.
- 2 4-in. manila dragrope 50 ft. long, with hook on one end and link on the other.
- 2 3-in. manila dragrope 50 ft. long, with hook on one end and link on the other.
- 2 crucible, cast-steel, 1¾-in. dragrope 40 ft. long, with hook on one end and link on the other. This is intended for special use where large engines have to be handled.
- 10 bumper chains.
- 4 ½-in. chains 22 ft. long, with rings on each end, one ring to pass through the other; tested to 70,000 lbs.
- 6 Crosby cable clamps.
- 2 crab links for 1½-in. chain.
- 2 crab links for 1¼-in. chain.
- 2 crab links for 1-in. chain.
- 2 crab hooks for 1½-in. chain.
- 2 crab hooks for 1¼-in. chain.
- 2 crab hooks for 1-in. chain.
- 4 heavy hooks and links.
- 2 hauling links.
- 4 anchor shackles and pins, 1½-in. iron.
- 2 S hooks.
- 2 splice links.
- 1 singletree cable and L hooks for steam crane only.
- Assortment of oval and round thimbles for ropes.
- 1 16-ft. ladder.
- Signal oil and cans, waste, and car oil.
- 4 gallons alcohol for jacks.
- 6 pairs rail tongs.
- 12 track chisels.
- 6 claw bars.
- 10 lining bars.
- 2 hand hammers.
- 3 18-in. screw wrenches.
- 3 track wrenches.
- 2 hand axes.
- 6 chopping axes.
- 2 handsaws.
- 3 crosscut saws.
- 6 clay picks.
- 2 sledges and handles.

List of the railway tools and equipment for a wrecking outfit.—Continued.

- 12 fire extinguishers.
- 1 pair pole climbers.
- 4 pairs rubber boots.
- 2 pieces medium weight canvas, 20 by 30 ft., for protection of perishable freight removed from cars in stormy weather.
- 2 kegs of track spikes.
- 1 keg of track bolts of the sizes used on the division.
- 1,000 nut locks.
- 50 lbs. 8-in. boat spikes.
- ½ keg assorted nails.
- 200 ft. rail.
- 80 ties.
- 6 picks.
- 1 headlight at base of boom of steam crane.
- 1 crane push pole.
- 220 pieces, wedges, etc., for blocking; assorted sizes specified, but omitted here. It is also required that about twice this amount be kept on hand to replenish car (very important).
- 2 Pierson jacks and 2 Jeremiah truck levers.
- 2 long punches for driving out kingbolts.
- 1 stretcher.
- 12 hand torches.
- 6 wrecking torches.
- 8 white lanterns.
- 3 Dressel station lights.
- 2 Sherry lights.
- 4 cant hooks and handles.
- 6 grappling hooks and handles.
- 10 short-handled, round-pointed shovels.
- 6 scoop shovels.
- 6 spike mauls.
- 4 adzes.
- 1 track gage.
- 4 pairs extra car trucks.
- 1 locomotive truck.
- 1 tank truck.
- 4 extra car knuckles.
- 1 extra switch (in some cases).
- 1 extra frog.
- 2 extra center plates.
- 6 kingbolts.
- An assortment of wedges and brasses.
- 6 extra air hoses.
- 6 coupling links and pins.
- 2 long, crooked pins.
- 4 fire buckets.
- 1 wheel gage.
- 1 complete outfit for cutting in a telegraph station at scene of the wreck.
- Hospital equipment as directed by surgeon in charge.

One such wrecking outfit will be supplied for every 100 to 200 miles of line, depending upon the condition of the roadway and the activity of the enemy.

A track-repair gang will follow the wrecking train to the scene of the accident as soon as they can be collected, and a bridge-building crew will also be sent out in case a bridge was damaged in the accident.

An assistant superintendent or train master immediately repairs to the scene of the wreck and takes charge of operations.

RAILWAY POLICE.

491. In addition to the troops employed to protect the line of railway, there will be need of a force of railway police. Certain of these policemen, or detectives, will be directly under the A. D. R., and others will be under the division superintendents. The number employed will depend upon the necessities. They will be detailed to this service by the head of the police of the line of communications.

The duties of railway police are to detect theft from cars, issuance or sale of bogus transportation, interference with the operation of the railway, or destruction of railway property. They will assist in the detection of spies, of employees who illegally transport liquors, or of mail that may have been forbidden by the censor.

ARMY LABOR BUREAU.

492. This bureau will have entire charge of the employment of all labor used by the different departments of the Army, and the bureau should be organized as soon as the Army takes the field. There must be absolutely no competition between the different departments if satisfactory labor conditions are to prevail.

493. Any officer requiring laborers should **apply direct to the bureau**, stating the number and kind desired. The laborers employed by the bureau will be divided into gangs of from 25 to 30 men each, under a foreman. Employment of labor outside the bureau, except in cases of emergency, will be forbidden, and in no case should the pay or allowances be more than that paid by the bureau.

MAINTENANCE OF WAY.

494. In a theater of war, with an active enemy, the number of breaks in a railway will be very large. The repairs thus necessitated must be rapidly and effectively accomplished. The **maintenance of way department** must be so organized that it is prepared to repair any break of whatever nature that may occur. This department can not be an economical one from a money standpoint. A large maintenance force must be kept on each division at all times, and during intervals between breaks it may not be possible to utilize the services of these men. The maintenance of way department behind Sherman's army was at times larger than all the other departments of the railway combined.

495. This department on each division will be under the **division engineer**, and for a division of from 100 to 200 miles in length the department must be self-sustaining. For this reason, the division engineer on maintenance and repair matters is directly under the supervision of the division superintendent.

Each division should be subdivided into districts about 100 miles in length, and each such district should be in charge of an assistant engineer.

Such a large force must be employed by the engineer department for rapid reconstruction that no provision is made herein for a maintenance department such as, on civil railways, is in charge of a **roadmaster**.

Maintenance work can be divided into water supply, track, and bridge work. Each of these departments on a 100-mile stretch will be in charge of a supervisor.

496. The **supervisor of water supply** has charge of the installation and repair of all pumping stations, including the boilers, pumps, windmills, and other structures.

The machinery that is installed should have interchangeable parts wherever practicable, and there will be a supply of extra parts on hand at all times.

Tanks for watering stations will be kept knocked down in the storehouses. It may be impracticable to erect the tanks with the regulation supply pipe; for watering the locomotives, a hose or pipe can be used as a siphon to take the water out of the tank. The **pulsometer**, referred to in par. 163, may be useful for watering stations, since they have very few parts, no wearing parts, and require no foundations.

The supervisor will have under him one foreman and from 6 to 10 mechanics. He will have a car in which is stored parts of a pumping station likely to be destroyed by an enemy.

497. The **supervisor of track** has charge of the maintenance and repair of all track and roadbed.

A large gang of trackmen will be kept together on each division, equipped with tools and supplies, ready to start on short notice to repair the track or the roadbed. When this gang moves to repair a break, they will move in a train consisting of box cars fitted with bunks, and other cars for tools, supplies, and commissary stores. One car will be fitted up as a kitchen car. A few portable forges will be carried with the outfit.

The supervisor is assisted by 1 clerk, 1 timekeeper, a commissary and quartermaster, and a surgeon. He will have 1 foreman, and 3 subforemen to every 60 men. A gang will have about 1 mechanic to every 6 laborers, and 1 cook to every 30 men, 1 for headquarters, and 1 for the foremen's mess. The above makes a flexible organization; it can be worked as a whole, or be subdivided and still retain its efficiency.

In addition to repairing breaks, the supervisor of track has charge of the normal maintenance of the division that is usually called **section work**. He will attend to this duty with his gangs during the intervals between breaks in the line.

498. Section work.—A section will comprise from 5 to 7 miles of single track, and where practicable, the middle of the section will lie at a station. Such a section will be in charge of a section foreman, who will have a gang of from 6 to 8 men on an old road, or 12 to 16 on a new road. The section foreman is responsible for the condition of his section under normal conditions. He will see that the rail joints are kept up, that the crossings are in repair, that the track is kept in alignment, that bad ties are replaced with good ones, and that a thorough inspection is made of his section as often as the conditions necessitate, and always once a day. He will keep sharp lookout for broken rails, fires on wooden structures, and washouts. During rainstorms he will patrol his section and immediately report any danger that may threaten, and will stop all traffic if necessary until proper repairs have been made. He will inspect for and report any break in the telegraph lines. Such section gangs will be detailed and controlled by the supervisor of track.

499. When replacing broken rails or making other repairs to the track, section foremen will see that the proper signals are put out to warn trains (see pars. 241 and 258). No tools or appliances will be operated or left between the rails except when necessary.

500. Each section will be supplied with the following tools and appliances, for which the section foreman is responsible to the supervisor of track:

Adzes.....	2	Hammer, striking, 10-lb.....	1
Augers, post hole.....	2	Hoes, scuffle or weed.....	4
Ax, chopping.....	1	Hooks, brush.....	2
Ax, hand.....	1	Jacks, track.....	2
Bars, claw.....	4	Keg, water.....	1
Bars, lining.....	6	Key, switch.....	1
Bars, pinch.....	2	Lanterns (white), complete... 4	
Bars, tamping.....	6	Lanterns (red), complete.....	6
Board, spot.....	1	Lanterns (green), complete... 4	
Brace, carpenter's.....	1	Level, track.....	1
Brace bits.....	2	Mauls, spike.....	4
Brooms.....	2	Mattocks.....	2
Car, hand.....	1	Padlocks.....	3
Car, push.....	1	Picks, clay.....	6
Chains, lock.....	2	Pail, water.....	1
Can, oiler.....	1	Punch, rail.....	1
Chisels, track.....	6	Rakes.....	2
Cups, tin.....	2	Saw, hand.....	1
Drill, ratchet.....	1	Scythes, grass and weed.....	6
Drill bits.....	6	Shovels, track.....	6
File, large flat.....	1	Shovels, scoop.....	6
File, hand saw.....	1	Stretcher, wire-fence.....	1
Flags, white.....	2	Sledge.....	1
Flags, green.....	2	Spike puller.....	1
Flags, red.....	4	Square, steel.....	1
Gage, track.....	1	Tapeline.....	1
Grindstone, complete.....	1	Tongs, rail.....	2
Handle, extra ax.....	1	Torpedoes.....	12
Handle, extra adz.....	1	Wheelbarrow.....	1
Handles, extra spike maul.... 2		Whetstones.....	6
Handles, extra pick.....	2	Wrenches, track.....	6
Hammer, claw.....	1	Wrench, monkey.....	1
Hammers, spike.....	4		

501. Each section will keep on hand the following supplies:

Angle bars, prs.....	12	Torpedoes.....	18
Nut locks.....	100	Track bolts, kegs.....	1
Spikes, kegs.....	2		

502. The quickest way to replace a line of rails is to string out the rail along the track, with the necessary angle bars, nuts, and bolts. The rail is replaced on one side at a time. The new rail is bolted together and laid along the outside of the rail to be taken out. The old rails are then removed, a few at a time, and the new rail slid into place and spiked. The old rail is only unspiked a short distance ahead of the new one; and when a train is due the new rail is spiked into position nearly up to the end of the old rail, and at this point a switch rail from a split switch is bolted to the old rail and spiked against the new rail. After the train passes, the switch rail is taken out, and work proceeds as before. This work should usually progress against the current of traffic on double-track work.

503. The supervisor of bridges will have charge of the maintenance and repair of all bridges on the section of line assigned to him. These bridges will be either steel, masonry, or wooden. The work on each class of bridge requires a different class of skilled labor, and each will be under a separate head foreman. There will be about three laborers for each skilled mechanic. The ratio of foremen, subforemen, and cooks will be as in the track gang. The common labor will be allotted to each head foreman as the necessity arises. The requirements of work may demand separate messing and camping arrangements for each class; if so, the necessary arrangements are made by the supervisor. When different gangs work together, the supervisor designates one man as head of the work. The supervisor will thoroughly acquaint himself with all the bridges on his section of line. He will have drawings and complete bills of material for all bridges, so that on notice of a break the proper repair materials can be started without delay.

504. The organization of the bridge parties is similar to that of the track gang. The force of assistants to the supervisor of bridges is similar to that of the supervisor of track. When the parties are working at separate points, he will arrange for separate medical attendants, commissaries, quartermasters, and clerks to suit the circumstances.

The bridge train is similar to the track train, with the addition of timbers, blocking, girders, derrick, and other tools and appliances for rapid bridge work. If conditions justify, one car may be made up as a concrete car and carry a certain amount of concrete materials. The size of the derrick will be determined by the weight of the rolling stock and the weights of the heaviest spans. The wrecking derrick, when not otherwise employed, can be used on bridge work.

RECONSTRUCTION.

505. As the army advances along a line of railway the track and structures will usually be found more or less destroyed and until repairs are effected the line cannot be operated. Owing to the nearness to the front, civilian labor can not be counted upon, and this duty must be performed by railway troops assisted by such civilian labor or details from other troops as may be required by the extent of the damage and the necessity of speedy repair.

This work will be in charge of the A. D. R. of reconstruction, who is responsible to the military head of the line in question.

In special cases, where temporary repairs will involve practically as much time as permanent repairs, it may be advisable to make the permanent repairs at once. Wherever practicable, the maintenance of way gangs in rear will be called upon for assistance.

The reconstruction forces can profitably be organized in the manner described for the maintenance of way gangs of the divisions.

506. The work is carried on at the railhead from a construction train made up as follows from head to rear:

Two flat cars with rails.
 Two flat cars with ties.
 One flat car with timbers, namely, 12 by 12, 16 by 8, and 18 by 9 ins.
 One flat car of tools and supplies.
 One box car for finer tools and stores.
 Three tourist sleepers for engineer troops.
 Three tourist sleepers for laborers.
 One combination car for office and officers.
 One box car for commissary supplies, etc.
 One dynamo car.
 One locomotive.
 One tank car.
 One gondola car for coal.

The office car will be connected by telephone and telegraph with the rear. This train should carry about six to 10 days' rations, and an electric light plant should be carried along to light up the work, especially bridge work, at night.

There will be a derrick car near the railhead at all times. This car will be found of the greatest use in reconstructing bridges and removing débris from wrecked structures.

507. The construction train will be supplied with the following tools and equipment and, in addition to these, with any other tools or appliances that will materially assist in rapid reconstruction:

Adzes, carpenter's.....	10
Anvils and blocks.....	3
Augers, long and short, $\frac{3}{8}$ to $\frac{3}{4}$ in.....	100
Axes, hand and felling.....	30
Axes, pick, helved.....	350
Angle bars to suit rails.....	150
Bags, sand.....	500
Bags, waterproof, for explosives.....	3
Bar claw (bull's foot).....	20
Barrows, wheel, wood.....	12
Bars, boring and tamping, $1\frac{1}{2}$ -in.....	17
Bars, crow.....	60
Bars, hold-up.....	25
Bars, pinch, track.....	25
Bellows, smith's, with frame.....	1
Bellows, tinsmith's.....	2
Billhooks.....	29
Blocks, iron, for $3\frac{1}{2}$ ins. circumference rope, single and double..	3
Blocks, wooden, for $3\frac{1}{2}$ ins. circumference rope, single and double..	8
Boards, pine, 20 ft. by 3 ins. to 16 ft. by 1 in., assorted sizes. pieces.	120
Bolt ends, $\frac{1}{8}$ -in.....	200
Boltheads, $\frac{1}{8}$ -in.....	200
Boltheads, $1\frac{1}{2}$ -in.....	100
Bolts and nuts ($\frac{3}{4}$ -in.), 8, 14, 20, 24, 30, and 36 ins. long.. of each..	100
Bolts and nuts ($\frac{1}{2}$ -in.), 2, 4, and 6 ins. long..... of each..	75
Bolts and nuts ($\frac{1}{2}$ -in.), 3 and 9 ins. long..... of each..	100
Bolts and nuts ($1\frac{1}{2}$ -in.), 30 ins. long.....	24
Bolts, drift ($\frac{3}{4}$ -in.), 19, 22, and 26 ins. long..... of each..	100
Bolts, rail (to suit rail).....	3,000
Bolts, steel, for bridge ties.....	1,000
Brushes, No. 8, and liners, 1 and $1\frac{1}{2}$ in..... of each..	2
Brushes, paint, 6-oz.....	8
Buckets, galvanized iron.....	20
Bunting, red, white, and green..... yards of each..	10
Cans, oil, feeding.....	8
Canvas..... yards..	36
Car, push.....	1
Chests, tool, filled, U. S. Engineer Company, carpenter.....	2

Chests, tool, filled, U. S. Engineer Company, blacksmith.....	4
Chest, tool, filled, U. S. Engineer Company, demolition.....	1
Chisels, brick, 18-in.....	12
Chisels, cold.....	25
Chisels, smith's, round nose and crosscut.....	25
Chocks for wheels.....	6
Clamps for track drills.....	14
Cold sets.....	50
Coupling screws.....	5
Crows, jim.....	5
Dogs, timber, 12, 18, and 24 ins. long.....	75
Drills, $\frac{3}{4}$ and 1 in..... of each..	6
Drills for ratchets, long and short, $\frac{7}{8}$ to 2 in.....	100
Drier, patent..... lbs..	14
Elbows and T pieces, 1-in., galvanized iron..... of each..	12
Files, assorted.....	40
Flags, hand, red, green, and white..... of each..	20
Forges, smith's, round.....	2
Gage, wheel.....	1
Gages, track.....	14
Gimlets, assorted.....	12
Glue..... lbs..	5
Grindstone, general service.....	1
Hammers, hand and claw.....	16
Hammers, sledge, 4-lb. to 14-lb.....	33
Hammers, spiking.....	50
Hammers, stone.....	24
Handles for augers.....	75
Handles for axes and adzes.....	15
Handles for hammers, spike and hand.....	200
Handles for tamping picks and pickaxes.....	150
Hinges, T and butt, assorted..... pairs..	120
Hose for pumps..... lengths..	24
Hot sets.....	20
Iron, bar, round, $\frac{7}{8}$, 1, $1\frac{1}{4}$, and $1\frac{1}{2}$ in..... bars..	20
Iron, bar, round, $\frac{3}{8}$, $\frac{1}{2}$, and $\frac{3}{4}$ in..... bars..	50
Iron, bar, round, 3-in..... pieces..	3
Iron, bar, flat, 6 by 1 to 2 by $\frac{1}{4}$ in., assorted..... bars..	24
Irons, expansion.....	40
Jacks, ratchet pulling.....	2
Jacks, track (Barrett's).....	10
Jacks, Pearson's..... pairs..	2
Jacks, traversing, 10 to 20 ton.....	10
Kegs, water, with faucets.....	2
Ladles, melting.....	2
Lanterns, hand (red 10, green 10, white 20).....	40
Lanterns, tail.....	4
Lead, bar..... lbs..	200
Lead, red and white..... lbs..	168
Levels, field.....	4
Levels, spirit.....	13
Locks for switches, with key..... sets..	6
Machines, boring, with augers.....	10
Nails, wire, 5 and 6 in..... cwt. of each..	3
Nails, wire, 1, $1\frac{1}{2}$, 2, and 4 in..... cwt. of each..	1
Nipples, plugs, and sockets, 1-in., galvanized iron, and bibcocks, brass..... of each..	6
Oil, olive, castor, colza, linseed..... gallons of each..	5
Oil, paraffin..... gallons..	30
Padlocks, galvanized iron.....	6
Pins, split, steel, assorted..... gross..	1
Piping, galvanized iron, 1-in..... running ft..	340
Planes, jack and smoothing.....	3
Plates, fish, special junction (or angle bars)..... pairs..	36
Poles, iron-shod (for lights and wires).....	30

Pumps, lift and force.....	3
Punches, center.....	6
Rail saws (each with extra saws and a saw sharpener), "Bryant".....	2
Rails cut to fit standard turnouts (frogs Nos. 8 and 10) of each..	4
Rails, steel, standard T pattern, 24 and 30 ft..... of each..	80
Ratchets, track drill (Paulus or Q. & C.).....	13
Ratchets, fitters.....	3
Replacers, Fewing's car.....sets..	2
Rivets, iron ($\frac{3}{4}$ -in.), $4\frac{1}{2}$ to $2\frac{1}{2}$ ins., assorted lengths.....	600
Rivets, iron ($\frac{1}{8}$ -in.), 4 to $2\frac{1}{2}$ ins., assorted lengths.....	700
Rods, leveling, 6-ft.....	5
Rope, manila, 3 ins. circumference.....coils..	2
Rope, manila, $2\frac{1}{4}$, $2\frac{1}{2}$, and $4\frac{1}{2}$ in.....coil of each..	1
Rules, carpenter's.....	12
Saw-sets, hand and crosscut..... of each	3
Saws, 26-in., hand, crosscut, and pit.....	42
Screws, wood, $\frac{3}{4}$ to 5 in., assorted.....gross of each..	4 to 10
Screws and washers, galvanized iron, for sheets.....gross..	2
Sheets, galvanized iron, corrugated, 6 and 10 ft. long..... of each..	100
Shovels (square-pointed 300, round-pointed 100).....	400
Slings, chain (see wrecking outfit).....	4
Sockets, reducing, 2 to 1 in. and $1\frac{1}{2}$ to 1 in..... of each..	6
Solder.....lbs..	15
Spikes, hand.....	6
Spikes, iron, 10-in.....cwt..	3
Spikes, iron, 8-in.....cwt..	11½
Spikes, rail.....kegs	30
Spun yarn, tarred.....coils..	2
Squares, carpenter's, 6, 9, 12, and 20 in..... of each..	2 to 4
Steel, blister.....lbs..	28
Steel, tool, octagonal, $\frac{1}{2}$, $\frac{3}{4}$, 1, $1\frac{1}{4}$, and $1\frac{1}{2}$ in. bars..... of each..	2
Stocks and dies, 2 to $1\frac{3}{8}$ in., $1\frac{1}{2}$ to $\frac{3}{8}$ in., and $1\frac{1}{8}$ to $\frac{1}{4}$ in., set of each..	1
Switches and frogs, complete, Nos. 8 and 10.....set of each..	1
Tallow, Russian.....lbs..	200
Tamping picks, helved (stone ballast).....	100
Tank, water, galvanized iron, 200 gallons.....	1
Tanks, water, galvanized iron, 50 gallons.....	3
Tapes, measuring, 100 and 50 ft.....	12
Tarpaulins.....	4
Theodolite, level, pair of rods, and chain..... of each..	1
Ties, crossing.....	23
Ties, standard.....	672
Timbers, 18 by 9 ins., from 36 to 20 ft. lengths.....	10
Timbers, 16 by 8 ins., from 32 to 16 ft. lengths.....	25
Timbers, 12 by 12 ins., from 36 to 30 ft. lengths.....	8
Tongs for cold sets.....pair..	1
Tongs, pipe, 1, $1\frac{1}{2}$, and 2 in..... of each	1
Tongs, rail.....	40
Tools, riveter's:	
Spanners and snaps, $\frac{3}{4}$ and $\frac{7}{8}$ in..... of each..	6
Hammers, with 30-in. handles.....	12
Tongs.....pairs..	4
Drifts, $\frac{3}{4}$ and $\frac{7}{8}$ in..... of each..	24
Hammers, sledge, 8-lb., with 36-in. handles.....	6
Turpentine.....gallons..	5
Twine.....balls..	12
Vise, standing.....	1
Washers, iron, 1 by $\frac{1}{4}$ in.....	224
Waste, cotton.....lbs..	50
Wells lights, No. 3.....	2
Wicks for lamps, hand, tail, and hurricane..... per lamp..	4
Wrenches, assorted.....	22
Wrenches, monkey, 12 and 15 in..... of each..	4
Wrenches, Stillson's, 18-in.....	6
Wrenches, track.....	50

508. **Construction wagon train.**—It will frequently be found that all the construction party can not work to advantage on a bridge or a single break at one time, and if there is a wagon train with the construction party that can go on ahead with a party and supplies, repairs can be made for 5 or 6 miles ahead of the train by the time that the train can advance. This wagon train ought to consist of from 30 to 40 wagons.

509. A suitable amount of tentage and camp equipage must be carried to protect the construction parties from inclement weather, and whenever the parties stop long enough at one point a camp will be formed. This will make the men more comfortable and healthy, both of which tend to make them work better under difficulties.

510. **Night work and lighting.**—Night work, except in bridge construction, is done at a disadvantage. For night work the lighting arrangements should be electric lights if possible. Holophane prismatic globes would be of great advantage, as they do not cast such black shadows as do the lights in ordinary globes. Acetylene lamps have reached a high stage of perfection at the present time, but if used as searchlights they throw a very black shadow. Wells lights (fig. 69) give good satisfaction for field use.

511. A large amount of railway supplies, tools, etc., must be kept in store at the advance depot and moved ahead as the depot advances. The available supply of stores and tools must be such that at no time will the work be laid out for lack of either.

512. **All army stores** arriving at the railhead station must be unloaded *immediately* and cars shipped back. If supplies can not be unloaded immediately, the loaded cars must be sent back to the nearest storehouse and the proper person disciplined for blocking the railhead.

513. **Precedence** in trains and supplies will be given to anything that pertains to the construction party, except possibly during an engagement. The temporary construction party will only be called upon to lay additional sidings under cases of great emergency.

514. The following is a list of the supplies that Colonel Girouard, Director of Railways in South Africa, took with him to South Africa when he assumed charge of the railways:

(a) STORES.

Balks, 14 by 14, and 12 by 12 ins., and timbers from 16 by 8 to 9 by 7 ins.....	cu. ft..	152,000
Bolts, $\frac{3}{4}$ -in., of assorted lengths.....		4,400
Boltheads and ends, with washers.....		5,800
Spikes, timber, $\frac{3}{4}$ -in., 7 to 10 ins. long.....		12,000
Piping, iron, galvanized, 2, 3, and 4 ins. diameter running ft.		29,000
Collars, flanges, bends, sockets, elbows, tubes, connecting cocks, plugs, valves, and bibcocks for pipes as above of each..	20 to 250	
Stocks, taps and dies, pipe tongs, spanners, and vises for pipes as above.....	of each..	4 to 24

(b) TOOLS.

A large number of tools of various kinds was ordered, of which the following were the principal ones:

Axes, pick, 5-lb.....	200
Helves for same.....	500
Shovels, universal, helved.....	100
Spades.....	200
Bars, boring, jumping, and tamping, $1\frac{1}{4}$ and $1\frac{1}{2}$ in.....	300
Dogs, sawyer's, straight and cross-ended.....	5,000
Saws, crosscut, blade 5 ft.....	50
Wire, steel, telegraph, $7\frac{1}{2}$ B. W. G., assorted.....	tons.. 20
Iron, wrought, bars, round and square, assorted sizes.....	tons.. 33

Screws, iron, flat-headed, 2 to 5 in.....	gross..	225
Blocks, wood, with sheaves for rope 3, 4½, and 5 ins. circum- ference, single, double, treble, and snatch.....		165
Rope, manila, 1½ to 5 ins. circumference.....	ft..	30,000
Jacks, screw, traversing, 6 to 20 ton.....		30
Winches, crab, double purchase, to lift from 25 to 60 cwt.....		10
Pile drivers, hand, 15-cwt.....		4
Forges.....		12
Well-boring tools, complete, to bore 50 ft.....	sets..	2
Rope, wire, Bullivant's, 1½ to 4½ ins. circumference, running ft..		11,000
Clamps, shackles, thimbles, turnbuckles, nippers, and chain slings for above wire rope.....	each..	2 to 12
Wells lights, with 3 extra burners.....		10
Cable, interruption, 4-core.....	miles..	2
Pumps, hand and steam.....		42
Tanks, water, 1,500-gallon.....		60
Bridges, 50-ft. span.....		10
Bridges, 30-ft. span.....		30

515. The following is a list of the principal stores and tools used on the rail-
ways in South Africa during the first and second years of the war:

STORES.

Asbestos.....	lbs..	386
Bolts and nuts.....		27,000
Bolts, fish.....		46,500
Bibcocks.....		211
Bridge work.....	bridges..	40
Cement.....	barrels..	335
Crossings and points.....		80
Coal.....	tons..	520
Cocks.....		300
Candles.....	lbs..	525
Copper.....	lbs..	1,000
Carbide of calcium.....	lb.,	1½
Dogs, sawyer's.....		18,000
Detonators.....		700
Dynamite.....	lbs..	150
Ends, bolt.....		864
Flanges, pipe.....		200
Ferrules, tube.....		500
Fuse.....	coils..	52
Grease.....	lbs..	1,150
Glasses, gage.....		250
Heads, bolt.....		6,100
Iron, corrugated, galvanized, sheets.....	ft..	52,000
Iron, bar, peak, etc.....	tons..	94
Links, coupling.....		250
Lead, red, white, and black.....	tons..	2½
Lead.....	lbs..	1,896
Matches.....	boxes..	432
Nails.....	tons..	5
Nipples.....		250
Nuts.....		4,800
Oil.....	gallons..	7,400
Piping.....	running ft..	30,500
Pipes, earthenware, etc.....		750
Pins, coupling, etc.....		5,000
Plates, fish.....		24,250
Pitch.....	lbs..	430
Rope.....	tons..	15
Rails.....	tons..	3,300
Rivets.....	tons..	5

Stays and washers.....	lbs..	3,750
Steel.....	tons..	16
Screws.....	gross..	1,030
Spikes, dog.....		174,000
Sleepers (ties).....		66,000
Sal ammoniac.....	lbs..	60
Tubing.....	running ft..	900
Tees.....		550
Tallow.....	lbs..	1,500
Tin.....	sheets..	110
Timber.....	cu. ft..	52,000
Timber.....	running ft..	833,000
Valves.....		150
Vises.....		27
Waste.....	lbs..	3,800
Washers, of sorts.....		20,000
Zinc.....	sheets..	55

TOOLS.

Axes, felling and hand.....		150
Augers, screw.....		950
Braces, ratchet.....		76
Bars, boring, etc.....		315
Beaters, plate layer's (tamping picks).....		400
Bits for ratchet braces.....		100
Braces, carpenter's.....		48
Bits for carpenter's braces.....		53
Blocks, various.....		280
Buckets, various.....		370
Bullivant's gear, complete.....	set..	1
Belting.....	ft..	600
Cans of oil.....		160
Crowbars.....		200
Chisels.....		1,000
Drills, ratchets, clamps, etc.....		120
Emery cloth.....	sheets..	430
Files, various.....		1,400
Forges.....		16
Hammers, various.....		900
Handles, various.....		5,800
Hose.....	running ft..	3,200
Jackscrews, etc.....		52
Lamps, various.....		270
Levels.....		55
Lines, various.....		620
Lines, log.....	fathoms..	1,200
Mallets, carpenter's, etc.....		132
Needles, sailmaker's, etc.....		380
Pile drivers, hand and steam.....		3
Picks.....		1,900
Pencils, carpenter's.....		800
Pumps and boilers, complete.....		7
Pumps.....		30
Phonophores.....		28
Rules for carpenters, etc.....		340
Ramps, rail.....		24
Shovels.....		3,000
Saws, various.....		400
Spanners (bar wrenches).....		400
Stone, oil and grind.....		100
Set saws, cold, etc.....		110
Stocks and dies.....		40
Tape measures.....		60

Tarpaulins.....	75
Trolleys (small cars).....	50
Tongues.....	140
Tools, chests of, etc.....	50
Wheelbarrows.....	200
Winches.....	16
Wedges, hardwood and iron.....	540
Wrenches.....	150

The two foregoing lists furnish about the only available data to guide an officer in his preparation of railway supplies for a campaign. They are too indefinite in many cases to furnish more than a very general guide, but nevertheless they are extremely valuable.

516. **The issue of stores.**—Tools or supplies urgently needed can be issued on receipt of an officer by any storekeeper, who will report to the chief storekeeper. This informal issue applies principally to the advanced bases and, in cases of emergency, to storekeepers along the line in rear. Normally, a requisition should come through the proper division channels.

Storekeepers in making regulations should exercise a wise discretion between expendable and nonexpendable articles, making the amount of paper work as small as possible, and yet be consistent with the regulations.

517. **The storekeeper** of the base storehouse will be in complete charge of all stores. It is his duty to keep track of issues, receipts, and amount of stock on hand; promptly filling all requisitions and taking charge of and properly storing all articles received. Simplicity and promptness must characterize the method of accounting for stores. **Memorandum receipts** will be taken when practicable. This will make receiving officers more careful in the use of the property and will give a closer line on the disposition of property when the same is lost or expended.

518. When any considerable amount of army stores have been unloaded at the railhead, they will **not be reloaded** for shipment to the front, except under great emergency, until traffic at that point has become normal. It will be found that less delay will be caused by getting up new shipments than by reloading at or near the railhead, unless very favorable conditions exist as regards sidings, cars, etc.

519. **Demolitions.**—The constructing engineer may be called upon to make demolitions in case of retreat. The **lower chords** and **batter posts** of trusses and the abutments and piers of girder bridges are the most open to attack with explosives. **Abutments** are destroyed by sinking a shaft behind the masonry, burying a charge at this point, and exploding same by the electric exploder. **Spans** 20 to 60 ft. in length are best destroyed by placing charges at the ends of the truss. This destroys both masonry and truss.

520. **Arches** are destroyed by exploding a charge in a shaft sunk from above to the crown of the arch or to the haunches. A **tunnel** is best destroyed by sinking shafts from above and exploding charges to blow in the top of the tunnel. Two trains loaded with railroad iron or other heavy material will effectually close a tunnel if these trains are started at a high speed from opposite ends of the tunnel at the same time and allowed to collide in the middle of the same.

521. A method of **track demolition** recommended by Capt. W. D. Waghorn, R. E., is to blow up alternate joints of rails for several miles, which, he says would have been much more effective than any form of demolition used by the Boers.

522. In a report on the railroads of the Civil War, an engineer who had great experience in the repair of demolished railways states that in his opinion the most effective way to **demolish a railroad** is to build a fire every 100 ft. along the track on top of the rails. The heat expands the rails and twists them out of shape. The ends of the ties burn off and the resulting demolition is complete. **To repair it**, the twisted mass of wreckage must first be removed, and then the track laid; whereas, if the rails are taken up and bent, only half as much work must be done by the reconstruction party. See chapter on Demolitions.

DEFENSE OF A LINE OF RAILWAY.

523. The defense of a railway against a brigade or division that may be sent against it for its systematic destruction can only be made by a force of sufficient strength to meet and defeat the raiding forces. Besides these attacks by large bodies there are the continual depredations against the line made by small bodies ranging from a regiment down to the lone individual who tries to burn a bridge or misplace a switch. The greatest difficulties in operating a road come from small bands which can operate against the line, especially in a hostile country, without great danger of apprehension, and these bands must be constantly watched for by a special railway guard.

The defense of the railway may be maintained by the combined use of **block-houses and armored trains.**

524. Blockhouses.—Blockhouses will be placed at points along the line within sight of one another and about 2,000 or 3,000 yds. apart on tangents, and at all important points, such as bridges, viaducts, and tunnels. The interval on curves depends on the radius of the curve and the destructibility of the road in the interval. These blockhouse should be of the type and construction shown elsewhere in the Engineer Field Manual. Each blockhouse will be built for a garrison of 8 or more men; each will be supplied with a good-sized water tank, and will be connected with the other blockhouses by telephone or telegraph. For every three companies of a battalion in the line of blockhouses the fourth company should be stationed at a town in the middle of such line as a support in case of attack; and for every two battalions on the line the third battalion should be held at about the middle point as a reserve. These troops belong to the Service of Defense of the Line of Communications.

The track will be **patrolled continually**, both night and day. The patrols should be doubled at night and in inclement weather.

A system of **rocket signals** will be arranged to indicate the presence of the enemy or of an attack by him during the night.

(Pars. 525 to 552, inclusive, are practically condensed from the History of Railways in the South African war, Royal Engineers' Institute, 1904, altered to suit conditions of the United States service.)

525. Armored trains are made up of an armored locomotive and certain armored and unarmored cars. The locomotives should be considerably stronger than the weight of the trains demand, as they are in constant use under adverse circumstances. The locomotive will be covered over its vital parts with **bullet-proof armor of sheet steel.**

The cab, tender, air pump, injector, and other parts, depending upon the make of the engine, that could be injured by bullets at close range, will be protected in like manner. The rear of the cab will be protected from reverse fire, and in the sides of the cab will be placed small hoods with slits, fore and aft, through which the engine-man can observe the track in his front and watch for train signals without exposing himself. The sides of the cab will be provided with sliding steel-plate windows.

The boiler need not be armored if it is thick enough to resist rifle fire; otherwise it must be armored also.

The locomotive will be habitually in the middle of the train.

The train from front to rear will be as follows: (1) Gondola loaded with sand; (2) No. 1 machine-gun car; (3) dynamo car; (4) officer's car; (5) baggage car; (6) locomotive; (7) R. F. gun car; (8) such other cars as may be needed in the train; (9) dynamo car; (10) No. 2 machine-gun car.

526. Searchlights.—An armored train will be supplied with one, or preferably two, 12-in. searchlights. The dynamo and engine for each of these lights will occupy about half a car. The motive power for the dynamo may be either steam or gasoline. Gasoline engines have many advantages, the greatest of which are their independence from a steam generator and the compactness of the plant.

These **dynamo cars** will be run next to the machine-gun cars. If a gasoline engine be used, the entire lighting plant may be carried in the machine-gun car. Steam from the locomotive can not be used for the motive power, since then the light could only be operated when the locomotive was connected with the dynamo car, and the use of the searchlight when the armored train was disposed as in fig. 146 would be impossible. Steam engines and boilers take up too much space if other motive power is available. **Direct-connected units** give the best satisfaction and take up the least room. The steam turbine is most compact and noiseless, but requires a steam generator. Gasoline motive power is doubtless the best for this purpose, and will be used wherever possible. Direct-connected gasoline sets are now on the market.

527. **Glass mirrors** are commonly used in the projectors, but they are more liable to breakage than metal mirrors. On the other hand, glass mirrors can be more readily purchased, and if set in rubber will stand considerable jarring. The projector itself will be armored on all sides and will have a sliding door in front. The light can be maneuvered from inside the car by means of a hand or rope control mechanism, such as shown in figs. 143 and 144. Electrical-control apparatus is only manufactured for projectors 24 ins. or more in diameter.

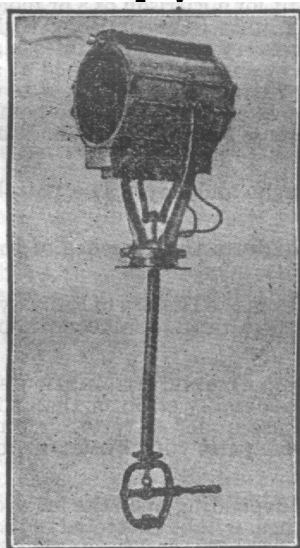


FIG. 143.—PILOT-HOUSE CONTROL PROJECTOR.

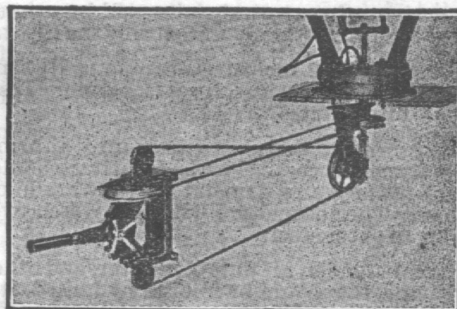


FIG. 144.—ROPE-CONTROL GEAR.

For the 12-in. searchlight a dynamo of about 2 kw. is required. A 12-in. light was found to answer every purpose that was required of it in the South African war.

The searchlights will be located on top of the machine-gun cars, or on the forward machine-gun car if only one light is used. Each searchlight will be provided with a signal shutter similar to the Gibbs shutter used in the Signal Corps. The locomotive should have a searchlight on it for use when the train is disposed as in fig. 146. The turbo-generator sets for this purpose occupy hardly a cubic foot of space, and as an auxiliary light this would be invaluable.

Any extra room in the dynamo cars will be used for bunks for the enlisted men.

The sides of the dynamo car will be plated with $\frac{1}{4}$ -in. steel for a height of 7 ft., and the sides will be slotted for rifle fire.

528. A combination diner and sleeper will be utilized for the **office car**. This car need not be armored unless it is intended to use it as a hospital car. One end of this car will be partitioned off and used as a kitchen for the entire force with the armored train. The telegraph office will also be in this car.

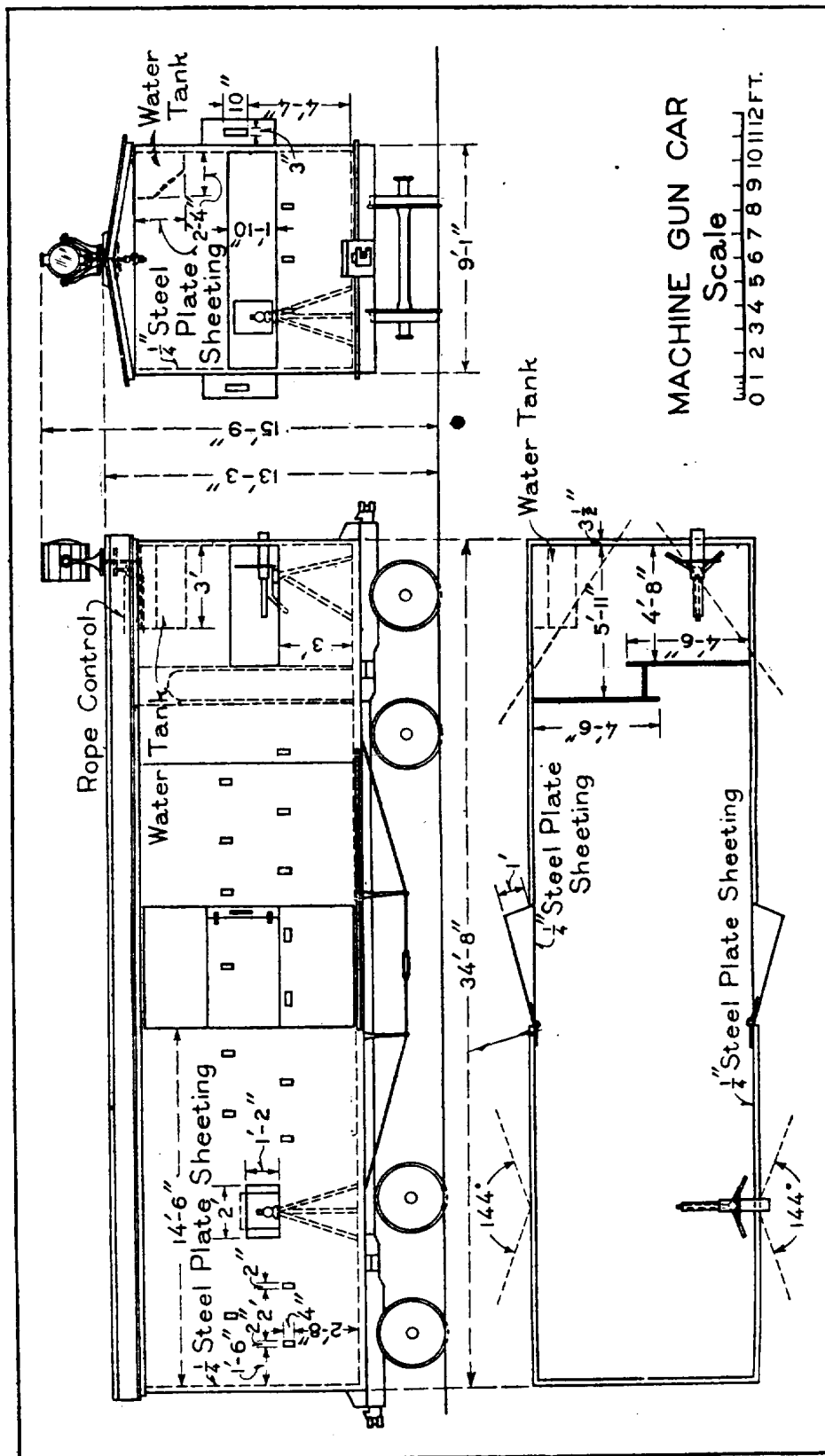


FIG. 145.

529. The **machine-gun cars** will be armored with $1\frac{1}{4}$ -in. sheet steel for a height of 7 ft., and provided with loopholes for infantry fire. The general points of their construction are shown in fig. 145.

530. The front car of the train will be a gondola loaded with sand and rigged with a cowcatcher on its forward end. This car is the defense against contact mines.

531. Immediately behind the engine is the R. F. gun car, and at the rear of the train is machine-gun car No. 2.

532. The details of the R. F. gun car will depend upon the class of mount available and the extra width that the car can have on the line. The car can not be widened very much for fear of "side swiping" other trains. This subject should be investigated before planning the car, and no extra width provided if possible to avoid it. It does not take long to traverse the gun for reloading.

533. It will be necessary to carry a tourist sleeper for the enlisted men and a baggage car for supplies. The position of these cars in the train is shown in fig. 146. A flat car of ties, rails, spikes, etc., for slight repairs will accompany each train.

534. The **side doors** of at least two cars should be so protected that sections can be pushed out about a foot from the car to give a flank fire along the train in both directions (fig. 145).

535. **Armament.**—The main armament of the armored train is a 3-in. R. F. gun, or possibly a 6-pounder, and four machine guns of whatever type may be adopted. The R. F. gun will be placed on a pedestal mount, similar to that used in the Navy, or an adaptation of the pedestal mount with foundation ring and bolts used in our seacoast fortifications. The ammunition for this gun is carried in the car with the gun. The car will carry about 500 rounds of ammunition. This car is also designed for an infantry defense of about 12 men.

The machine guns may be of any of the approved types, on a tripod or fixed mount. Each gun will be supplied with 30,000 rounds of ammunition.

The **garrison of the armored train** should consist of 2 officers and the following enlisted men: Infantry, 8 noncommissioned officers and 42 privates; engineers, 1 sergeant and 8 privates; signal troops, 1 telegraph lineman and 1 operator; artillery, 3 noncommissioned officers and 7 men; hospital corps, 2 noncommissioned officers. Of the officers, one will be an artillery officer. There will be a double crew for the train.

536. **Communications.**—The cars must all open into one another, and must be provided with platforms to lay from one car to the next. There should be telephonic connection from between different parts of the train, and a system of bell signals arranged in case the telephone is broken. All wires should have slip connections between the cars. It is not feasible to protect all the air-brake system of the train, hence some signal should be arranged to order the release of all brakes in case the air line is cut. The engine will thereafter control the train by its own brakes, assisted by such inside hand-brake arrangements as can be made.

537. **Posts of officers when on duty.**—The artillery officer will ride in the R. F. gun car, and the other officer in the forward machine-gun car. The noncommissioned officers in the other cars will be so instructed in their duties that they can handle their men in action and carry out the intention of the commanding officer.

538. **Administration of armored trains.**—The armored trains are under the orders of the commander of the district of the line of communications in which they are stationed. They will be assigned to districts by the commander of the line of communications. They will be moved about within the district by the district commander. The commanding officer of the train being ordered to any point will communicate with the railway authorities and request orders for his train. The trains form part of the line of communications and are only temporarily a part of the district command. The trains must not be used for any other than for railway defense. When it is necessary to proceed to any point immediately, the commanding officer of the armored train is authorized to inform the train dispatcher of his desires, using the signal "21" to give him immediate right of way over the wires. The train dispatcher will, on receipt of this message, immediately issue the necessary train orders to carry out the move.

539. The commanding officer of an armored train will not make use of privileged telegrams, nor shall he interfere with the regular movement of traffic by sudden and unexpected moves except in an emergency; and he must understand that every such case will be passed upon by a higher authority and that he will be held responsible for unnecessary interference with traffic.

Any unnecessary interference with traffic by any armored train will be reported promptly by the division personnel.

540. An armored train will not be used by the commanding officer of the railway guard for **inspection purposes** unless this can be done in the course of its other duties. Unauthorized persons will not be carried on the armored trains.

When any district commander of the line of communication has reason to believe that his section of the line is to be attacked and that the use of an armored train is necessary, he will communicate his information to the Chief of Staff, Line of Communication.

541. **The garrison of an armored train**, after being detailed on this duty, is subject to the orders of the commander of the line of communication, and changes from one district to another, or changes in the garrison, should be made by him only.

542. The commanding officer of an armored train should have had some experience in railway work, so as to appreciate the traffic conditions in addition to the military conditions. He will render a weekly report showing the make-up of the train, the mileage made during the week, the points of the line covered, the condition of the train and its armament, the amount of ammunition spent during the week and the amount on hand, and any repairs that may have been made to the railroad by the engineer detachment of the armored train. After an engagement a report will be submitted showing the amount of ammunition expended, the number of the enemy, the casualties on both sides, and any damage that may have been done to the train or its armament.

543. **Larger guns.**—In case it is desired for any reason to mount larger guns on railway cars, this can be easily done. The 6-in. gun can be mounted and fired from a flat car in a direction 30° on either side of the track without danger of upsetting the car. It can be fired at right angles to the line of the track by the use of two girders or timbers, that can be carried on the car, and which before firing will be shoved under the car and blocked up tight against the floor. It is a slow process to traverse and load for every shot, but with the longer guns this must be done between 50° and 90° from the line of the track to give room for loading. The possibilities for using guns mounted on cars in the **defense of a place** are very great. The guns can be rapidly moved from point to point as needed, or to get under cover when the fire of the enemy gets too hot. It would be impossible for the enemy to locate such a "train battery," for it would have no fixed emplacement. It would also deceive the enemy as to the number of guns opposing him.

In South Africa, 6-in. guns were used on flat cars with a 3 ft. 6 in. gage, and a 9.2-in. gun was mounted and fired on a low metal car of the same gage, with no bad result to the car or track.

Cars can be armored by putting one thickness of rail up the sides and ends, taking precautions to fasten the rails so that they will not be moved by the motion or jar of the train. One rail left out at the proper height makes a continuous loop-hole for rifle fire. By thus utilizing the rails and ties that must be carried along to repair slight breaks in the line, an extra armored car is obtained without increasing the total number of cars in the train.

The commanding officer of the armored train must have **judgment and discretion**, as well as bravery and dash, in the execution of his duty.

TACTICS OF ARMORED TRAINS.

544. **Positions of machine guns and artillery in action.**—The machine-gun cars and the R. F. gun car are self-supporting against a small force of the enemy; any one of them is practically impregnable against infantry fire alone.

The general practice to be adopted against the enemy will be to extend the line by distributing the armored cars along the track such a distance that the rear can not be turned. The cars must be within rifle range of each other, and will be about 1,000 yds. apart. As the train advances, if the enemy is at long range, the train is cut in

two just ahead of the R. F. gun car and the locomotive runs on ahead, with the forward part of the train, until within an easy rifle range; here it cuts off the No. 1 machine-gun and dynamo cars, and the locomotive retires to the R. F. gun car. In case the enemy attempts to cut the railroad in rear, the rear section of the train will be backed down the line where the machine-gun car No. 2 is cut off, and the R. F. gun car and the locomotive return to their former position.

If the locomotive is in rear of the R. F. gun car, or if the train is backing up, the train will push up to within easy rifle range, cut off the machine-gun and dynamo cars at that end, and then back down the line and leave the R. F. gun car and the other machine-gun car where it is desired to use them.

The field of fire and position of the cars in action is shown in fig. 146.

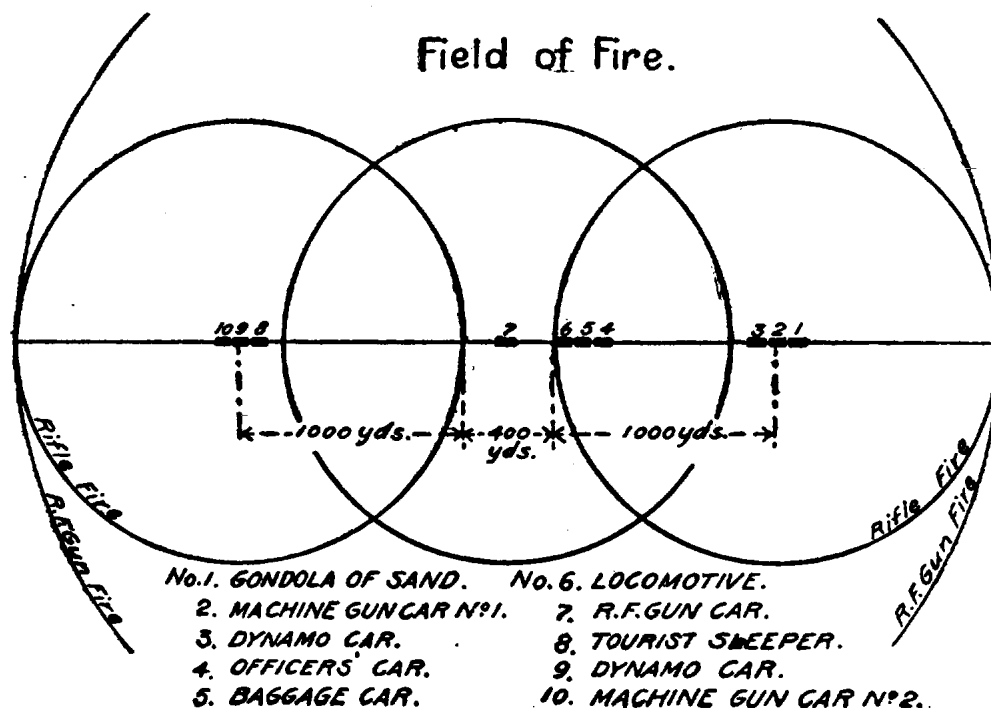


FIG. 146.

In using two or more armored trains together, each train is divided up as described for one train, thus covering a long section of line. The track to the rear is patrolled by the rear locomotive and a machine-gun car, to give notice of any turning movement and prevent the destruction of the track in the rear.

DUTIES OF ARMORED TRAINS.

545. The chief duties of armored trains may be briefly stated as follows:

- (1) To intercept and attack a retreating enemy whom the army is driving onto the railroad line.
- (2) The train being well advanced, to prevent the enemy from moving around the flank of a column or a line of columns.
- (3) To reinforce stations and camps that are threatened by the enemy.
- (4) To escort ordinary trains.
- (5) To reconnoiter.
- (6) To patrol the railroad.

546. In the first two uses above mentioned, the railway must be divided into sections, each train taking care of a section. Each train should keep moving back and forth, especially at night, over its section. Foot patrols, provided with rockets or fuses, should patrol the track.

In the first use mentioned above, searchlights will not be used unless it is desired to harass the enemy by frightening him into cautious movement. In the second case they will be used to a very great extent.

547. The third use permits of **smaller garrisons** along the line, and of rapid and efficient reenforcement of same.

548. The fourth use mentioned is one of the most important duties of armored trains. On this work the ordinary trains are either run in fleets under the protection of the armored trains, or the latter remain on the threatened sections, escorting trains each way. When the threatened section is short, trains can be escorted one by one, but over a long stretch the fleet system must be adopted. Special care must be taken in the use of the fleet system to prevent collisions. This danger together with the difficulty of handling a fleet of trains in different yards and over sections of line with short sidings, makes the running rate of the trains very low. On account of this, the system will only be used when there is reasonable ground for supposing that the trains would be in imminent danger.

549. The **position of an armored train** is, normally, behind the first ordinary train, as in this position it has the ordinary train constantly in view and can protect it correspondingly better. When it is desired to give the enginemen confidence, the armored train may be run ahead. If ordinary trains are provided with escort cars, these escort cars of the whole fleet should be run together in the last train, except possibly one car, which might be run in advance of the leading engine.

550. In using an armored train for **reconnoitering purposes**, the train should under no circumstances be sent so far ahead of the troops that the track in the rear can be broken beyond supporting distance of the troops and the train thus captured. The proper use of the armored train in reconnoitering toward a large force of the enemy is in conjunction with mounted troops, whose principal duty is to assure the safety of the railway behind the train and to scout on the flanks, the armored train keeping well in advance of the horsemen. Deep cuts, however, should be reconnoitered by the cavalry before the train enters them.

551. **Patrolling by day** is not a very important duty, especially if the railway is protected by a line of blockhouses. A certain amount of day patrolling, however, is advantageous. Good work is done and important information can be frequently obtained by dropping scouts from the armored train at one point with instructions to join it later at the same or some other point. No information should be given out relative to the position of an armored train at any future hour.

Patrolling by night is one of the most frequent duties of armored trains, for night is the time when the enemy will most frequently attempt to cross or destroy the railway. In patrolling at night, if ordinary traffic is stopped, information should be sent ahead to the stations, ordering switches to be set so that the train can pass through without whistling. Every precaution should be taken to prevent any more noise and light than is absolutely necessary in running the train at a fair rate of speed.

The searchlights should be ready for work at all times. The train need not be on the move all the time in patrolling, as much information can be obtained by lying in a cut or behind a hill and sending out scouts on foot.

The night work just described presupposes that ordinary traffic is suspended during the hours that the armored trains are patrolling the line.

Where **blockhouses** are used in conjunction with the armored trains, the system of signals will notify the armored trains in that vicinity of the presence of the enemy. Armored trains should halt at certain prearranged hours, not over 2½ hours apart, and establish telegraphic communication with other armored trains, and with neighboring stations, to give information and receive orders for further movements.

552. The use of armored trains on single-track road is of doubtful value when the consequent interference with traffic is considered. If the capacity of the road is fully taxed by the requirements of transportation it will doubtless be best to depend upon the defense by troops and block houses; if it is not fully occupied, armored trains may advantageously supplement the other means of defense. On double-track road the interference is far less marked.