Alternating Current Signals on the Southern

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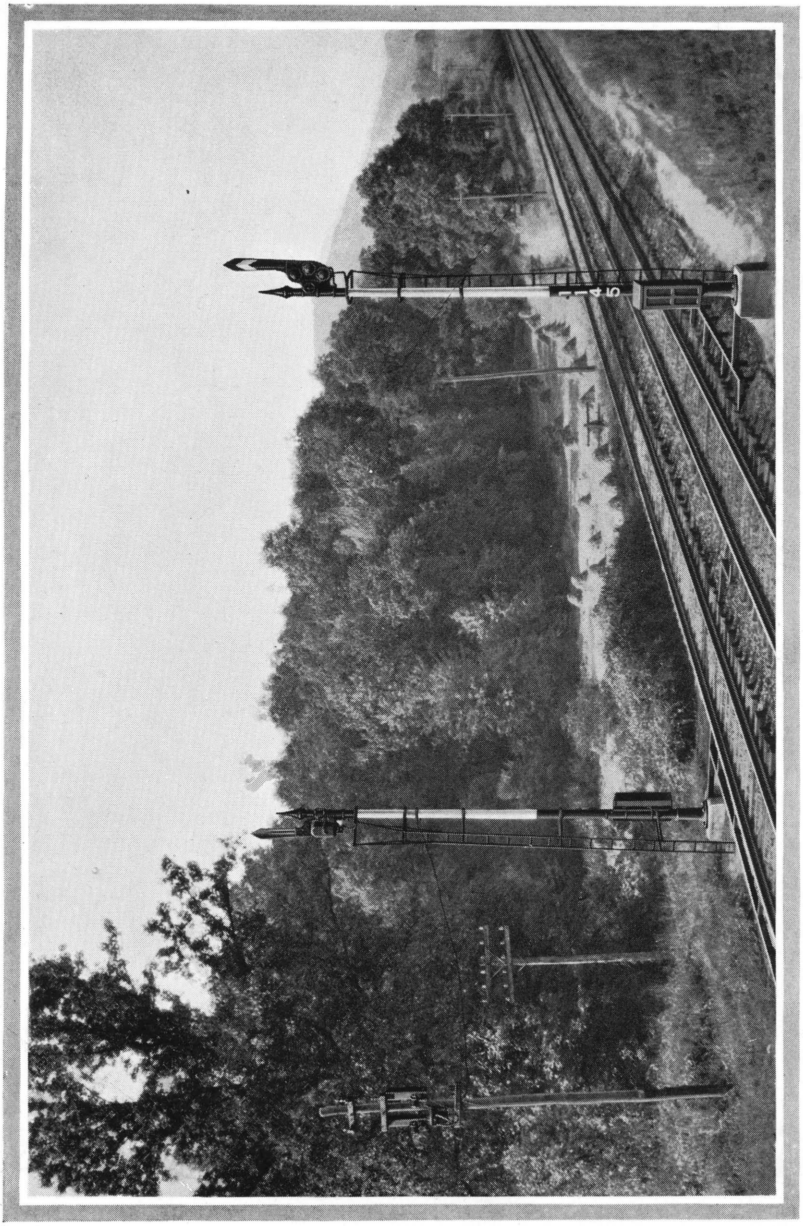

Alternating-Current Block Signals on the Southern Railway System

By
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Southern Railway System

Bulletin Number 146 October, 1925

GENERAL RAILWAY SIGNAL COMPANY
ROCHESTER, N. Y., U. S. A.
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Introduction

The Automatic Block Signal Installation described in the following pages consists of 667 continuous miles of double track Alternating-Current Signaling and presents a good example of the greater utility and economy of this type of system on a steam railroad where average traffic conditions prevail. The first hundred miles of alternating-current signaling were installed on the Southern Railway System over twelve years ago and the results secured have a twofold significance.

1st. The effects of Automatic Signaling on train operation were so thoroughly demonstrated that the Southern Railway began an extensive program of signaling which will no doubt continue until every mile of main line track is signaled.

2nd. The efficiency, reliability and utility of the alternating-current system of signaling have been so satisfactory that the Southern Railway has adopted this type of system as standard.

The use of alternating current from the signal power line to operate coaling and watering stations and to illuminate buildings along the right of way has effected substantial economies.

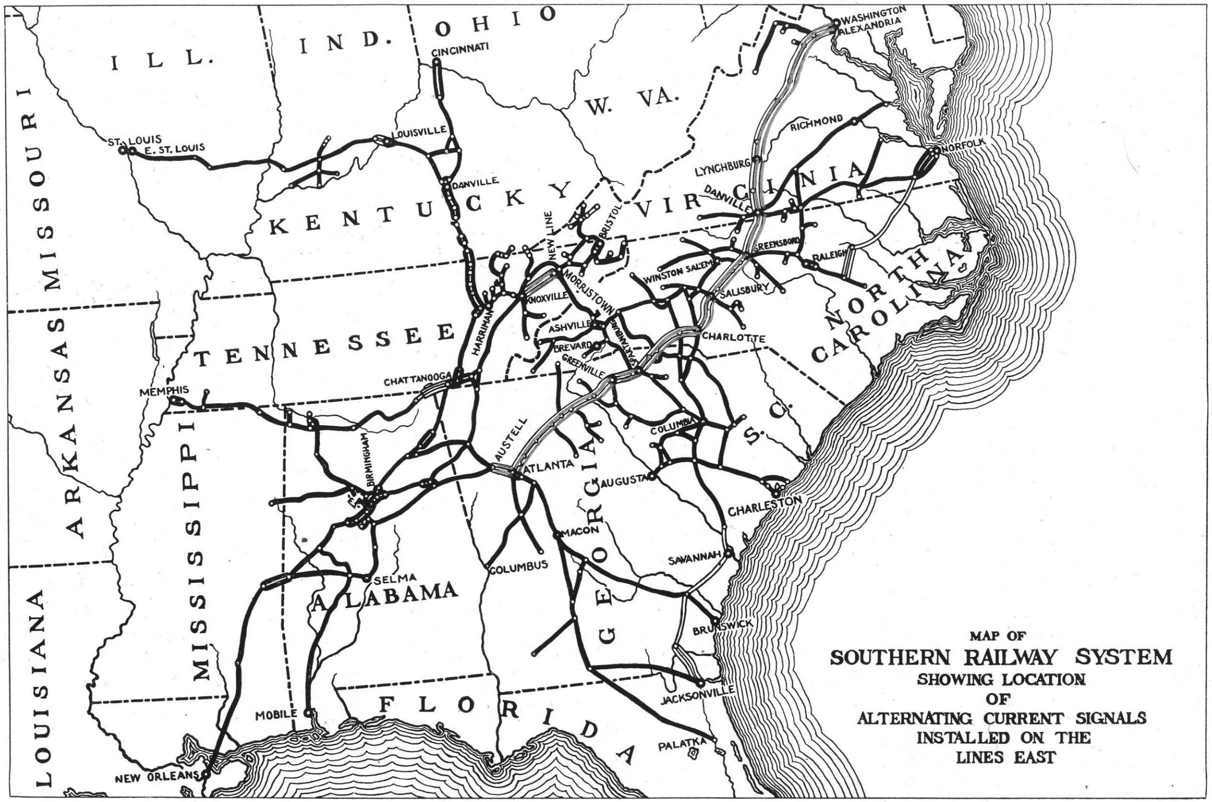
No reason exists why signaling cannot be utilized to a fuller extent in aiding transportation, and we believe the reasons which prompted the Southern Railway to choose a type of system which offers greater opportunities in this connection and the results secured through years of service to be worthy of your most careful study.

Since this is one of the most extensive installations of alternating-current signals on a steam railroad, the engineering information contained in the bulletin should be of interest and value to those who contemplate a similar type of installation.

GENERAL RAILWAY SIGNAL COMPANY

Rochester, New York

October, 1925



MAP OF
SOUTHERN RAILWAY SYSTEM
SHOWING LOCATION
OF
ALTERNATING CURRENT SIGNALS
INSTALLED ON THE
LINES EAST

Alternating-Current Block Signals on Seven Hundred Miles of Double Track

THE Southern Railway System, between Washington, D. C., and Atlanta, Ga., is a part of the main thoroughfare between Washington and New Orleans, Birmingham, Mobile, Atlanta, etc., and traverses an exceedingly fertile and prosperous section of the South.

It passes through the states of Virginia, North Carolina, South Carolina and Georgia, a section which equals in fertility of soil and extent of manufacturing any other of equal length in the country. It is said that from some point on every mile of track between Danville, Va., and Atlanta, Ga., one or more cotton mills can be seen. The city of High Point, N. C., is second only to Grand Rapids, Mich., in the production of furniture.

Other flourishing industries, such as fruit growing, tobacco raising and manufacturing of many kinds, provide a heavy local and through traffic which is constantly growing.

To provide for the present and future needs of the territory served by the Southern Railway System, an extensive program of expansion has been under way for a number of years: Additional main tracks, rock ballast, heavier rail, new and commodious stations, steel and concrete bridges, etc., have been built so that the railway company's slogan "The Southern Serves the South" is not a matter of mere words only.

Recognizing the safety and additional facilities afforded by an Automatic Block Signal System, the management of the Southern has, in addition to the other improvements, authorized automatic signals from time to time until now a large proportion of the main lines are so equipped.

The recent completion of a second track between Charlotte, N. C., and Spartanburg, S. C., permitted the placing in service of the last section of an alternating-current Automatic Block Signal System which gives complete signal protection from Washington, D. C., through Atlanta, Ga., to Austell, Ga., a distance of 667 miles without a break. This with an installation of 42 miles between Morristown and Knoxville, Tenn., makes a total of over 700 miles of double track completely signaled on the Lines East of the Southern.

For many years these lines have been operated under the Manual Block System. The installation of the automatic signals closed most of the block station offices and the operators were transferred to other sections of the road.

The manual block system, while offering a very large measure of safety over the time interval system of handling trains, does not permit the utilization of the full capacity of the tracks provided. The traffic on this section consists of some 42 passenger and freight trains per day, and it is of such a character that, at certain times of the day, there are many trains in the same direction at very close intervals. Several of the passenger trains are run in two or more sections regularly. The handling of large quantities of fruit, vegetables and perishable freight, at certain seasons of the year, add so many additional trains that the manual block system could not handle the traffic without serious delays. After a careful consideration of the entire subject, the management decided that the use of automatic signals would at a less annual cost add much more to the capacity of the existing track facilities than could be obtained by any re-arrangement or addition to the existing manual block system, besides increasing largely the safety of train movement.

When the signal system was authorized a study was made of the traffic to be handled, the local conditions, and the first cost of an installation on the basis of one, two and three-mile blocks.

Three-mile blocks did not provide the facility of train movement desired. One-mile blocks were rejected on account of increased cost and the blocks being shorter than is necessary at the present time. Two-mile blocks were decided upon as permitting a large increase in the capacity of present trackage at a reasonable cost. It was realized that blocks of this length require, in three-position signaling, the giving of the distant indication farther from the home signal than is generally thought desirable, but no practical difficulties have resulted.

When in the future, traffic has increased to the amount that this spacing of signals will not adequately take care of train movements, additional signals may be installed between the present signals without disturbing the installation, thus cutting down the length of the block so that the maximum traffic capacity may be obtained from the present tracks.

Fig. 1 Clear Signals

Location of Signals

A SCALE plan showing switches, grade, and alignment was prepared and a tentative location of the signals made on this plan. Keeping in mind the block length of approximately two miles, the signals were located with reference to the switches, curves and grades in the best apparent location. The locations were then checked by riding over the territory a number of times on trains. Where a good view of the signal in the proposed location could not be obtained, it was shifted to secure the best possible view. A motor car was used when marking the precise locations on the ground, so that a minimum amount of trunking and wire would be required.

The location of the signals was marked for the construction force by nailing a tin disc to the nearest cross tie. This method proved unsatisfactory on account of the disc rusting, and white paint on the rails and joints was later used.

In general, the signals were placed to secure protection for trains standing at stations without greatly delaying following trains; at

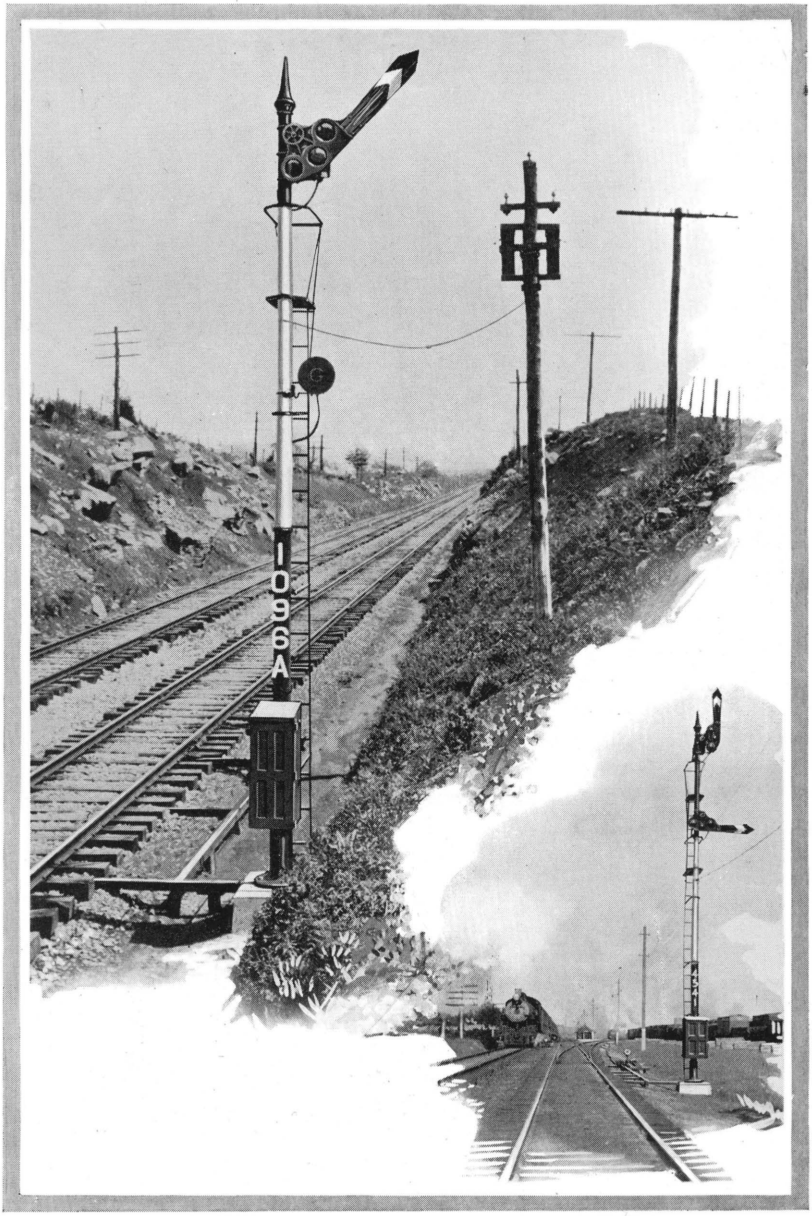


Fig. 2 a Grade Signal
b Two Arm Signal approaching Station

facing point switches from 60 to 500 ft. in the rear; at lap sidings at points where future home signals would be located if the ends of the sidings and crossovers are ever interlocked; on grades, where possible, at points where tonnage trains can start after being stopped by a signal; and at ends of tangents where track is curved.

It was necessary to vary from these general principles in only a very few instances.

Grade or Tonnage Signals

Certain of the grades were so long that it was impossible to avoid locating a signal on each one without breaking up the average train spacing. At these points, where because of switches or other local conditions tonnage trains were liable to be frequently stopped on the grade and have to double to get away, a special aspect was developed, Fig. 2a, which would permit tonnage trains to pass the signal when in the Stop position without stopping. However, only a few of these signals were required.

The standard signal was changed by adding a round yellow disc 15″ in diameter fastened to an electric lamp box, about 7′ below the signal arm. The disc has cut out from its center the letter "G" (for Grade) which is illuminated when the signal arm is in the Stop position, the control of the electric lamp being through the circuit breaker of the signal. The indication for this signal is the same for the 45 degree and 90 degree position of the arm as other signals, for the 0 degree position it is:

Indication: (For tonnage freight trains only)

Proceed at slow speed prepared to stop short of train or obstruction.

Name: Grade-Signal.

Indication: (For trains other than tonnage trains)

Stop: then Proceed.

Name: Stop and Proceed Signal.

Choice of System

AFTER the average length of block had been fixed, a comparison of the various methods of supplying power for signals was made, and alternating current was adopted as it was found to possess numerous advantages over direct current for this installation. Briefly, these advantages are:

1. It is free from the adverse influence of foreign current.
2. The track circuits can be made equal to the length of the block.
3. Much less apparatus is required, not only for the installation but also to be maintained.
4. The signals and the railway company's buildings along the right-of-way can be lighted from the signal line.
5. More reliable working in all kinds of weather on account of the amount of power available to operate the signals.
6. Cost of operation and maintenance is less.
7. The number of maintainers required could be reduced.
8. Power from the transmission line could be used for coaling and water stations.

The disadvantages were:

1. That a separate pole line would be required.
2. The breaking of the transmission line would cause delay.
3. The cost of the a.-c. system was about 30 per cent greater than a d.-c. system with wires on the telegraph poles.

The advantages, however, so greatly outweighed the disadvantages that the alternating-current system was decided upon.

Transmission Line

ALTERNATING current having been chosen, it became necessary to determine the proper frequency, phase and voltage for the transmission, the materials to be used and the details of the pole line construction.

Alternating-current signal apparatus is built for two frequencies; viz., 25 and 60 cycles. The 25-cycle apparatus is somewhat more economical in current consumption but it is higher in first cost, and as this frequency would probably be used in the future electrification of the railway, it was desirable to select some other frequency to avoid interference at that time. A 60-cycle current is available from many commercial sources throughout the South and its use in the operation of the signal system would not require rotary transforming devices. For the above reasons, it was decided to use 60-cycle signal apparatus.

Three-phase current was selected in preference to single phase due to the long distance that it was anticipated the signal system would eventually cover and the relatively heavy power load due to lighting stations, operating coal and water stations, etc.

These same considerations led to the choice of 4400 volts as the most desirable transmission-line voltage. This voltage permits the amount of power required to be transmitted without undue loss with a small line conductor and is still not so high as to require expensive protective devices and insulations.

This voltage required that the wires have a conductivity approximately that of No. 6 B & S gauge hard-drawn copper. The comparative ease with which hard-drawn copper breaks when it has been injured in the work of erecting led to an investigation of the properties of steel reinforced aluminum cable which is used largely for high voltage transmission lines.

The excellence of this material resulted in its being adopted as standard for the signal transmission line on the Southern. The service obtained has been very satisfactory and it has met all of our expectations as to reliability and economy.

The conductor selected was a No. 4 aluminum cable, steel reinforced, which is composed of six strands of aluminum about a steel core which is very high in ultimate strength, elastic limit and ultimate elongation. The steel core is double galvanized and it is further protected against corrosion due to the fact that the stress resulting

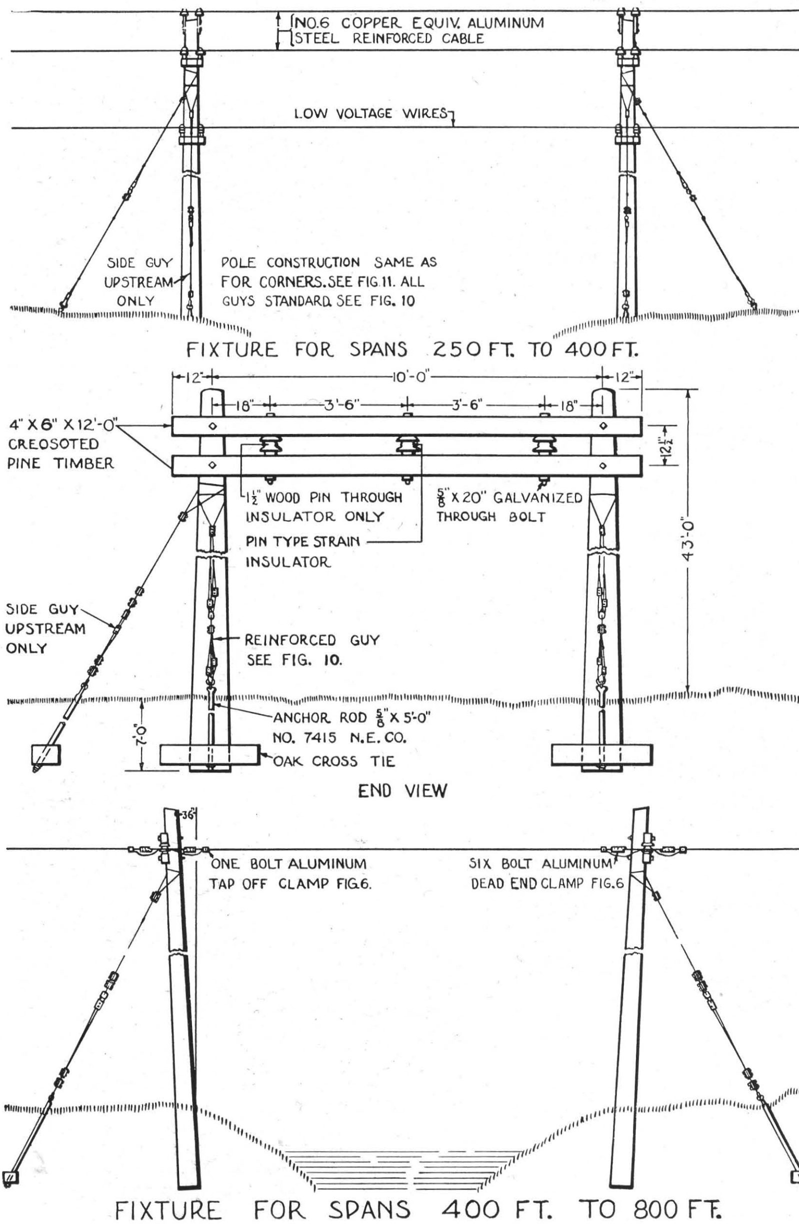
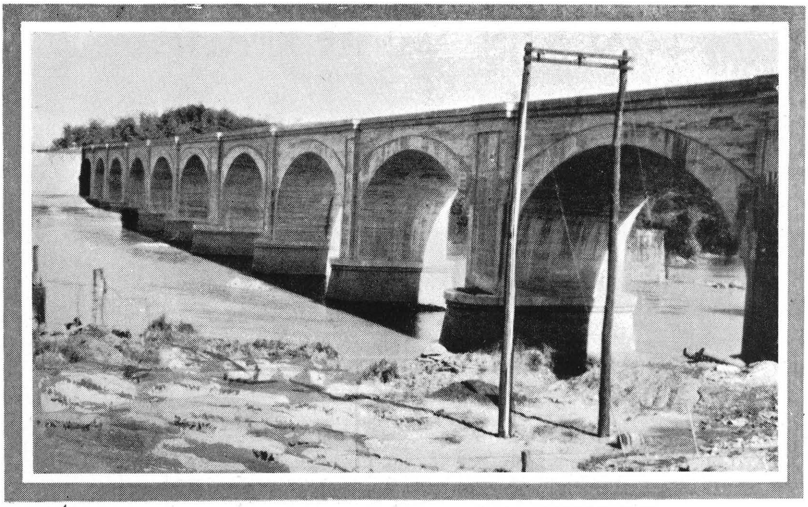


Fig. 3 Special Fixtures for Long Spans



4a

4b

4c

Fig. 4 a "H" Fixture at Dan River
b Tower Fixture at Dan River
c Tower Fixture at Broad River

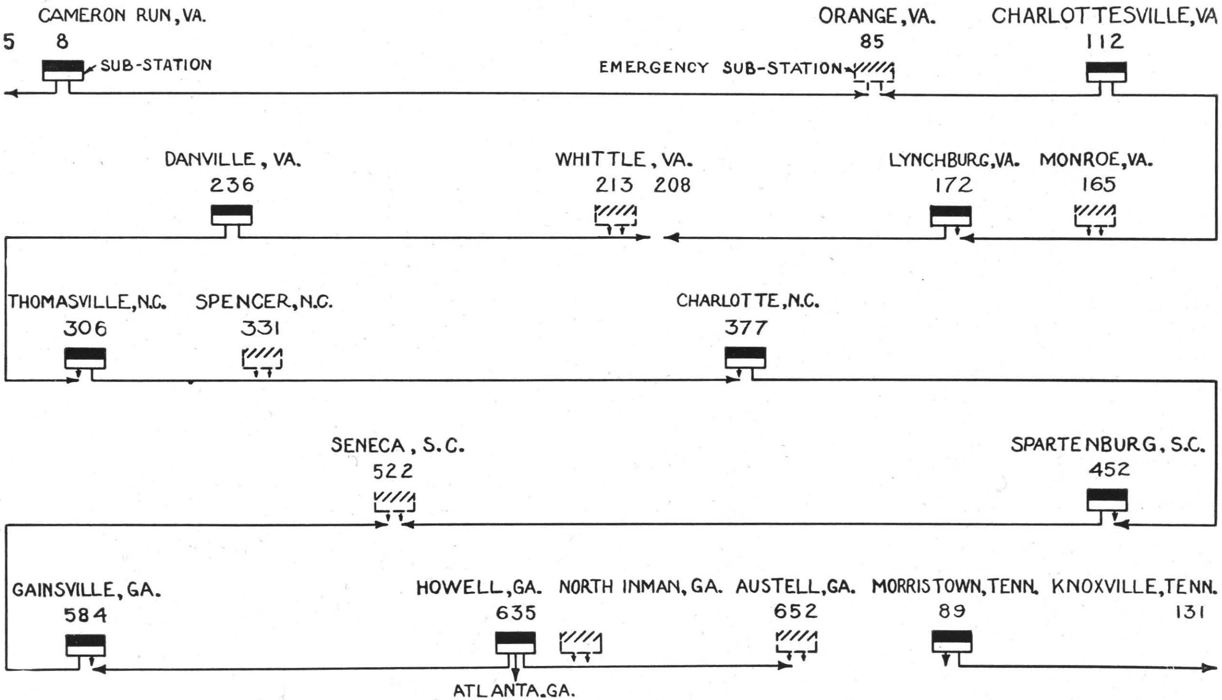


Fig. 5 Normal Feed for Transmission Line

from the load on the cable causes the aluminum strands to fit tightly around the core. The assembled cable has approximately the same conductivity as a No. 6 hard-drawn copper wire. It is manufactured by the Aluminum Company of America.

Comparison of the Properties of Aluminum and Copper

	Copper	Aluminum
Size (B & S Gauge)	6 (solid)	4 (stranded)
Resistance, ohms per 1000 ft.	.4073	.4073
Resistance, ohms per mile	2.1505	2.1505
Total area (c.m)	26,250	48,699
Area aluminum (c.m)		41,742
Area steel core (c.m.)		6,956
Weight, pounds per 1000 ft.	79	58
Weight, pounds per mile	417	306
Ultimate strength, pounds	1,239	1,665
Elastic limit, pounds	619	1,170

It will be noted that the steel-reinforced aluminum cable has the following advantages: (1) greater strength; (2) much less weight; (3) greater ease in erection; and (4) economy in first cost and maintenance. In considering greater strength, account was also taken of the fact that in the aluminum steel-reinforced cable, the high strength core is at the center of the cable and is not easily injured in erecting. Abrasions are of minor importance since they affect only a portion of the aluminum strands. In the case of erecting hard-drawn copper wire, however, nicks and abrasions which ultimately result in line breaks are difficult to avoid. The peculiar property of aluminum to withstand the corrosive action of sulphur fumes and flue-gases from locomotives was also a factor from the stand-point of maintenance. The greater strength of aluminum cable permitted a standard span length of 200 feet, which is greater than could have been used with equivalent copper wire. This construction resulted in lower first cost and less maintenance. Several spans of 600 feet and over have given entire satisfaction at river and stream crossings. At one point over the Dan River at Danville, Va., a span of 1200 feet has been in service for a number of years without failure, an H fixture, Fig. 4a, being used on the north shore and a tower (Fig. 4b) on the other side, the wire spanning the river being dead-ended at each fixture. A similar fixture at the crossing of the Broad River in South Carolina is shown in Fig. 4c.

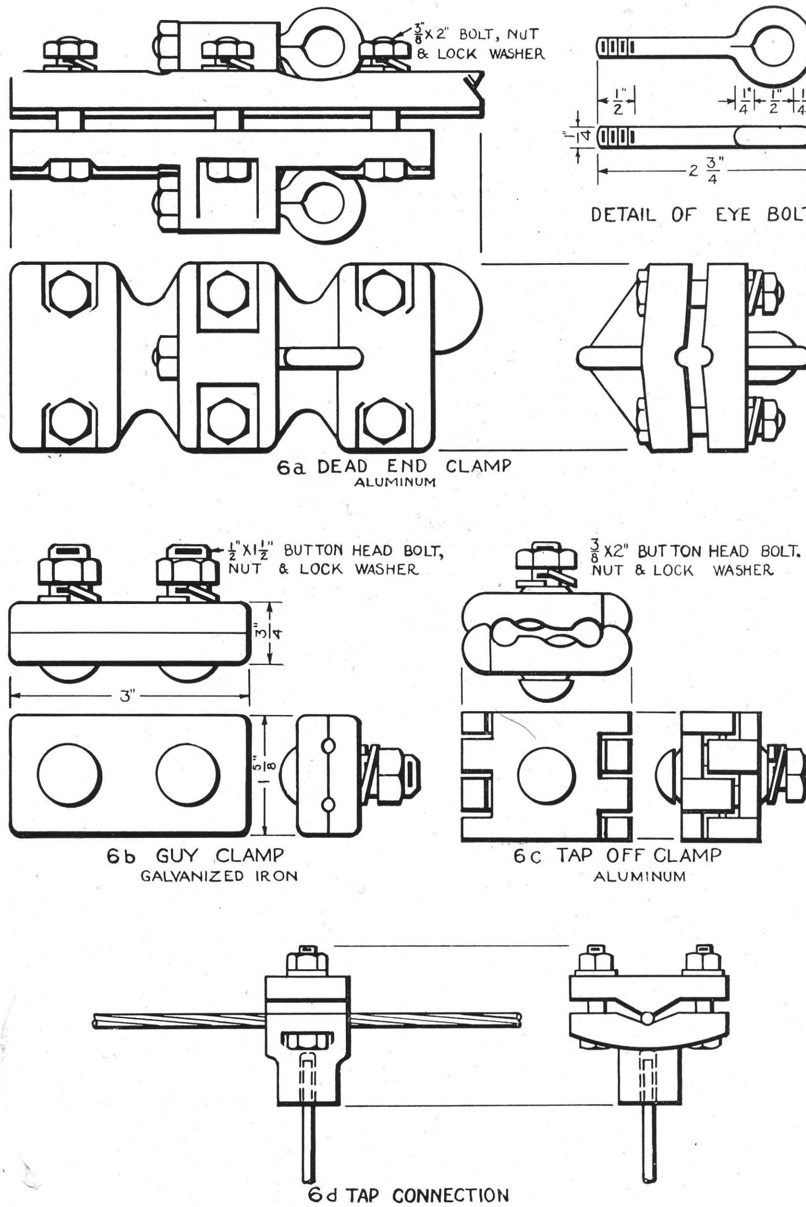
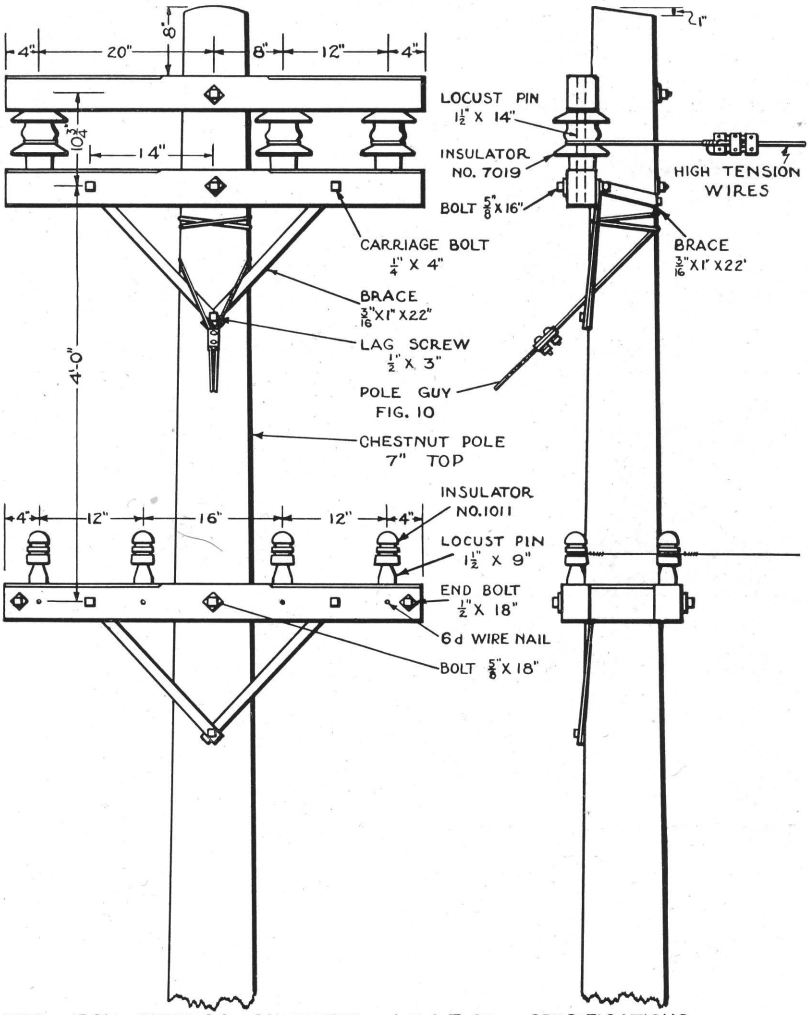


Fig. 6 Clamps for Signal Transmission Line



NOTE - IRON FITTINGS GALVANIZED A.T. & T. CO. SPECIFICATIONS
CROSS ARM 2 PIN STANDARD CYPRESS $3\frac{1}{4}$" X $4\frac{1}{4}$" X 3'-0" BORED FOR $1\frac{1}{2}$" PIN
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GAINS TO BE $4\frac{1}{2}$" WIDE AND $\frac{1}{2}$" DEEP
POLES TO BE TREATED WITH WOOD PRESERVATIVE ON CUT SURFACES AND 18" BOTH WAYS FROM GROUND LINE

Fig. 7 Dead-end Construction

Joints

OWING to the difficulty of soldering aluminum, some other method of joining the line wire and taps had to be used. The joint used in the transmission line is shown in Fig. 12. It consists of two 10″ aluminum sleeves. It will be noted in the figure that one sleeve is twisted in a direction opposite to that of the other. This construction was adopted in order that the strength of the joint would be equal to the full strength of the steel core of the wire. The wire will break before the joint will give away.

Tap-offs from the high-tension line on the original installation for the transformer and lightning arrester connections were made with the special cast aluminum clamp shown in Fig. 6d. The lug part of the clamp was drilled in the factory for the tap-off wires and filled with a special solder and flux. The clamps were attached to transformer leads, lightning arresters and other apparatus before the apparatus was distributed by merely applying heat to each lug and inserting the lead. The tap-off connections were readily made in the field by simply placing the clamp on the transmission wire and tightening the bolts. Spring lock washers were provided to prevent the bolts from coming loose. A very reliable, easily applied and good contact was thus obtained. A type that could be applied in the field without heat and requiring the tightening of only one bolt to attach it to the high tension lead was later developed and is now used. This is shown in Fig. 6c. All of the connections with this clamp are made at the time the apparatus is connected up.

At dead ends on the transmission line, Fig. 7, special aluminum clamps, Fig. 6a, were used to prevent injury to the aluminum strands and to retain the entire strength of the wire.

In the vicinity of the interlocking plants where it was necessary to string low-tension lines, No. 12, 40 per cent copper clad steel wire furnished by the Duplex Metals Company was used. Joints and branches in the low-tension circuits were made with ordinary copper sleeves in the usual manner.

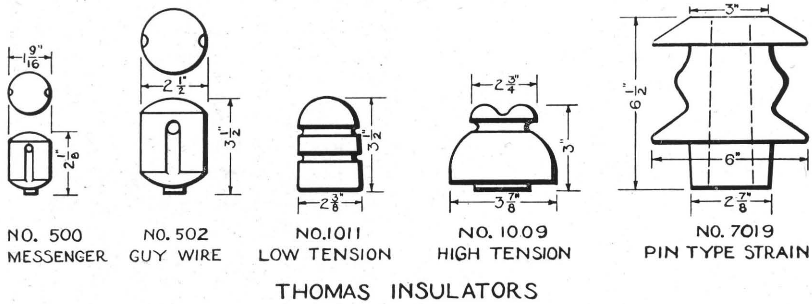
Poles

CHESTNUT wood poles were used, as they could be obtained along the railway company's lines and are relatively long lived. (7 to 12 years.) The poles have a 7-inch top and vary, by 5 ft. in length, from 25 to 60 feet. Very few of the higher poles are used, the average height being 30 ft., with 25 ft. above the ground. The tops of the poles were graded for height so that the wire line is approximately level, though no additional expense was incurred to make it exactly so. On highways, a height of poles was chosen so that the wires clear a minimum of 22 ft., and over railways, 30 ft. Crossings over the railway tracks were made at an angle of 45 degrees whenever it was feasible.

The transmission line wires were, wherever possible, carried above all other wires and structures crossing the railway. Considerable expense was incurred in later installations to rebuild crossings of other line wires so that the transmission wires could always be above the telephone and telegraph lines, it having been found that the telephone and telegraph wires gave trouble by breaking where they were over the transmission while the transmission wires never broke. On curves, poles were set on chords of the curve to obtain as much straight line as possible. This made a much stronger line than following the curve of the track and is more sightly, as each pole does not require a guy wire and anchor.

The tops of the poles were sawed off smooth to an angle of 1 in 7 and the top painted with Avenarious Carbolineum; also a 3-ft. band, 18″ above and 18″ below the ground line, all surface cuts, ganes and knots were treated with this preservative. The minimum depth of the hole in the soil was 5 ft. for 25-ft. poles, increasing to 7 ft. 6 in. for 60-ft. poles. In solid rock where it was necessary to use dynamite, the holes were somewhat shallower, but no poles were set less than 4 ft. even in rock. In filling the holes, only one man was allowed to shovel in the dirt to three men tamping. This, with the requirement that the fine earth or sand be used at the bottom of the hole and the coarse soil or gravel at the top, secured a very firm foundation for each pole. In the solid rock, broken fragments of rock were tightly wedged about the pole.

All hardware used was galvanized, and was required to meet the specifications of the American Telephone & Telegraph Company.



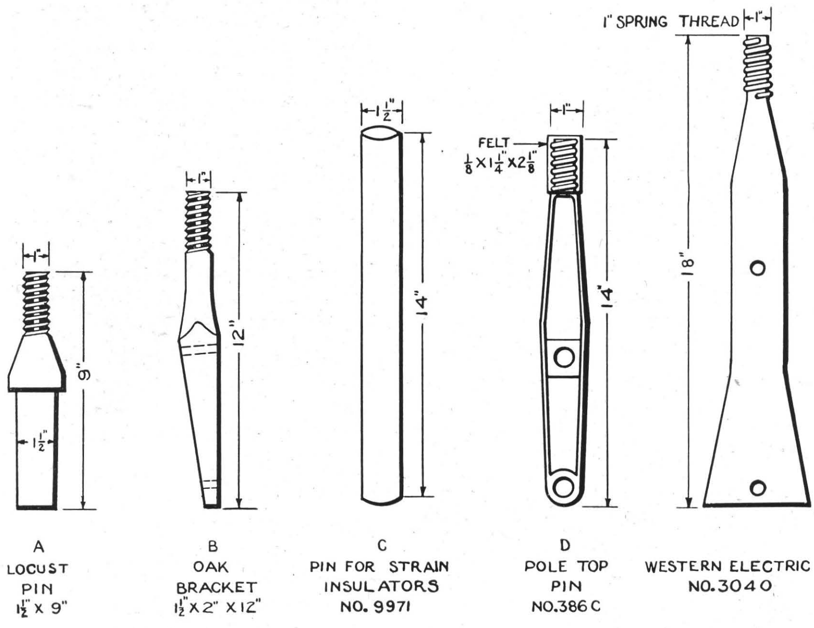


Fig. 8 Pins and Insulators

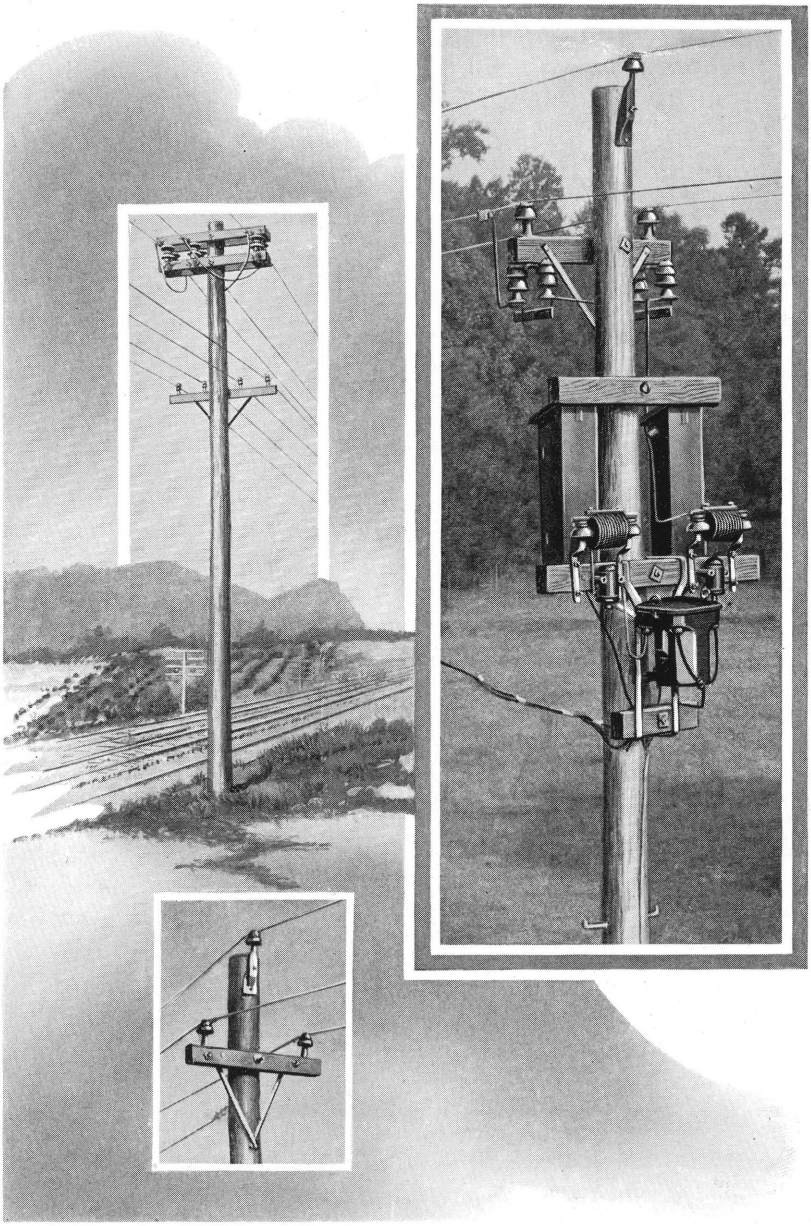


Fig. 9 Pole Line Details

Transformer, lightning arrester, and sectionalizing-switch poles were provided with steps.

All details of the pole line and the methods of construction were selected with a view to obtaining a strong substantial line with a minimum of skilled labor.

Cross-Arms

Except at the interlocking plants, only two sizes of cross-arms were used. One size, 3 1/4 in. by 4 1/2 in. by 36 in., bored for four 1 1/2 in. wood pins, was used for the sectionalizing switches and transformers. The location of the arms on the pole is shown in Figs. 7 and 11. A few 6 and 10 pin arms were required at the interlocking plants.

The cross-arms are unpainted cypress, this wood having been chosen on account of its very long life and availability in southern territory. The use of metal arms was considered but on account of the smaller sized insulators that could be used with wood arms and the increased insulation resistance between the phase wires, the wood arm was deemed most suited for the work.

Guying

All curves, crossings, corners, terminals, transformer poles, and extra long spans were securely guyed with 1/4-in. galvanized guy strand, Fig. 10. Storm and head guys were used where necessary, but in no case more than one mile apart.

Special effort was made to bring transformer poles on the tangent to eliminate the necessity of guy wires on these poles, not only to improve the appearance of the line, but also to make them more accessible for the maintainers and safer by avoiding the danger of broken down guy wire insulators.

When guy wires were liable to be a menace to employees or the public, a guard consisting of about 6 ft. of 2 in. by 2 in. trunking (Fig. 10) was fastened about the guy wire which passed down through the groove in the trunking with the trunking resting on top of the anchor. This forms a neat and effective guard. A very large number of guys were used in proportion to the length of the line as they add greatly to its stability.

Anchors

CROUSE-HINDS, ungalvanized, butterfly pattern, harpoon-drive, anchor rods were used throughout. They were very easily and quickly installed even where the soil contained considerable quantities of rock. A very material saving in labor was effected by their use over what would have been required if parts of poles or "deadmen" had been employed, as there were no large holes to dig. These anchors were inserted, wherever possible, at least one-third of the height of the pole away from the ground line of the pole.

Insulators

All line insulators were of brown glazed porcelain, a brown color having been chosen as being inconspicuous and not liable to be used as a target to shoot at by thoughtless persons. The high and low-tension insulators are shown in Fig. 8. The former is a standard 6,600-volt insulator weighing about 1.75 lbs. and tested to 12,000 volts wet and 20,000 volts dry. A soft-drawn aluminum wire 28 in. long, No. 4 B & S gauge, was used for tying the transmission line to the insulator. See Fig. 12.

Strain insulators were installed in all guy lines to prevent grounding the line and to avoid danger of shock due to touching a guy wire in case of an accidental contact between a phase and a guy wire.

Insulator Pins

The pole-top pin used was of galvanized malleable iron. A detail is shown in Fig. 8. The high-tension insulators were cemented on to the pin with thin Portland cement before being distributed, care being taken to screw the insulator on as firmly as possible and still have the top groove of the insulator perpendicular to the back of the pin. The groove is thus parallel to the line and the wire can be tightly and easily tied in. Later, however, a No. 10 gauge pressed steel pin, Fig. 8, with a 1-inch spring thread was used. The change was made to permit the replacing of a broken insulator without taking the pole top pin off. This could not be done on the original pin on account of the insular being cemented. The pole top pin is attached to the pole by a ½-in. by 9-in. bolt and a ½-in. by 6-in. lag screw. Where double pins are required, two bolts are used. This construction is easily erected and is believed to be much stronger

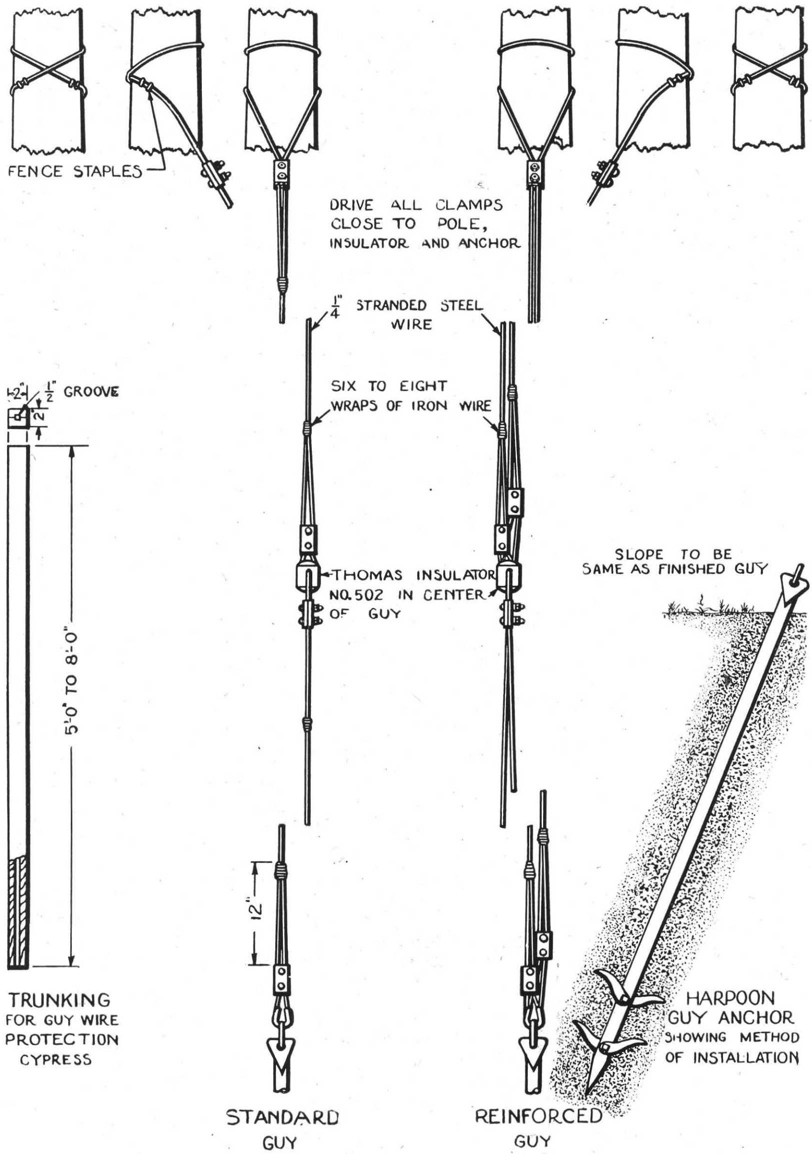
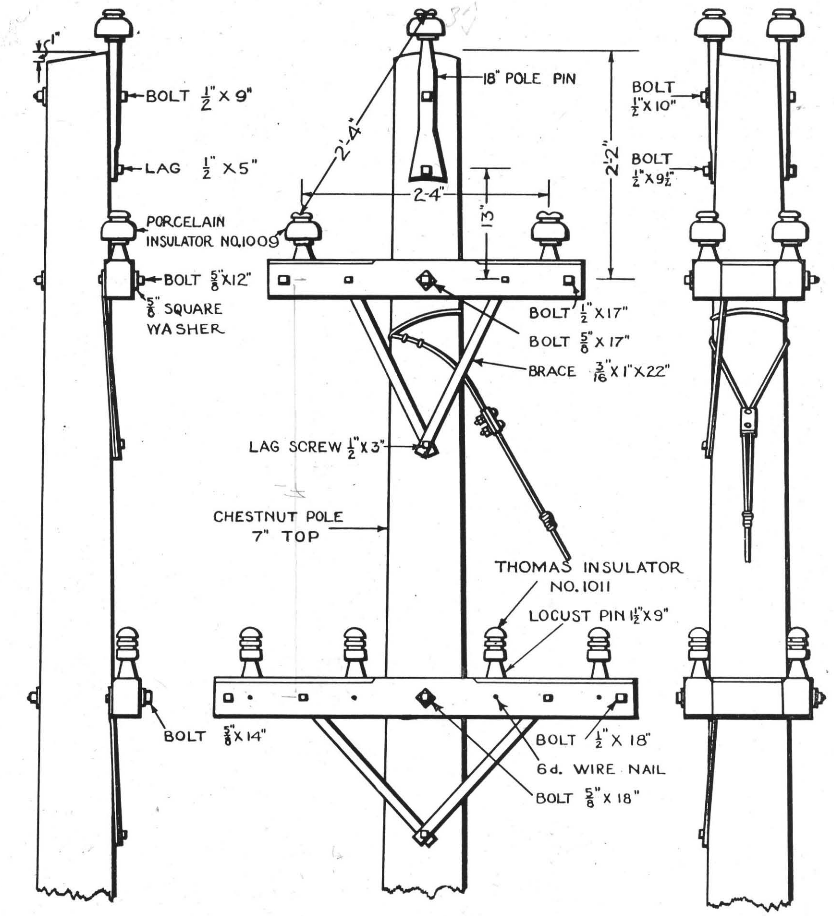


Fig. 10 Pole Guys



CONSTRUCTION FOR STRAIGHT RUNS

CONSTRUCTION FOR CORNERS OF 10' OR MORE

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POLES TO BE TREATED WITH WOOD PRESERVATIVE ON CUT SURFACES AND 18" BOTH WAYS FROM GROUND

Fig. 11 Pole Construction for Signal Transmission Line and cheaper than the method sometimes used where the top of the pole is bored out and the top pin mounted directly on top of the pole. All other pins used are standard 1¼-in. wood locust pins, unpainted, and are practically immune to decay.

Danger Signs

Painted signs bearing the words, "Danger Electric Wires 4400 Volts," in red letters upon a blue background and over a blue Southern Railway seal with white letters, were attached to poles in the vicinity of station and road crossings where it was thought there was any liability of employees or others climbing the poles or coming in contact with the high voltage wires.

These signs are 6 in. by 12 in., made of No. 30 gauge sheet steel lithographed; commercially known as, "decorated tin."

They have faded to some extent but have proved more satisfactory than the enameled steel signs used in the first installation which did not fade but the enamel was chipped badly due to the signs being used as targets for stones, etc., by the maliciously inclined.

Sectionalizing Switches

To provide means whereby repairs could be made to the transmission line without putting the entire signal system out of service, sectionalizing switches, Figs. 13 and 53, were installed at convenient intervals, averaging five miles apart. These switches permit the current to be cut off the transmission line in emergencies at practically any point and yet keep nearly all of the signals working. They have proved very valuable and should not be omitted from a similar installation.

The switches are of the hook type, Fig. 53. A copper bar is mounted on vitrified porcelain attached to a cast iron pedestal which in turn is bolted to the under side of the cross-arms. The porcelain supports are designed to withstand the voltage of the circuit without breaking down or puncturing.

A hook stick, used to operate the switches, is housed in a special casing mounted on each transformer or sectionalizing switch pole directly under the switches, Fig. 13. This shelter is made of 1¼-in.

conduit with a type "A" condulet on the bottom and a plain cap on the top. It is perfectly waterproof and the stick is locked and held in place with a Signal Department padlock put through a hole drilled in the condulet. The switches may be opened or closed when the circuit is alive without danger as the normal current is small and does not form an arc. Hook sticks are also provided in all sub-stations and power houses to entirely disconnect the lines from the stations as necessary, or to feed any combination of the lines entering the station.

Transposition of the Transmission Line

To reduce the possible interference with parallel telegraph and telephone lines to a minimum, a regular system of transposition (Fig. 14) of the transmission line was worked out. The wires were given a one-third turn in their position on the pole line approximately one-third the distance of the normal sub-station feed and, in addition, the load was balanced as nearly as possible on each phase. Except where a broken insulator on the transmission line has allowed a phase wire to come in contact with the cross-arm, there has been no interference with telephone or telegraph circuits, notwithstanding the fact that these circuits closely parallel the transmission line for the entire 700 miles.

Balancing the load on the separate phases was accomplished as follows:

> The signals supplied normally from a given sub-station were connected to the bottom phase wires on the pole and, on account of the transposition, this divided the signal load equally between the phases. The transformers lighting the stations are also connected to the bottom phase except in a number of instances it was necessary, on account of the size of the lighting load, to connect a few of the transformers to the other two phases. It required very little shifting of the transformer leads to secure a very well balanced line.

The normal supply for the line is shown in Fig. 5, the line being transposed and balanced for these conditions. In emergency cases such, for example, as the cutting out of one sub-station, the line is unbalanced to some extent, but since no ill effects have been reported and since these conditions are only temporary, no effort has been made to arrange for an exact balance at such times.

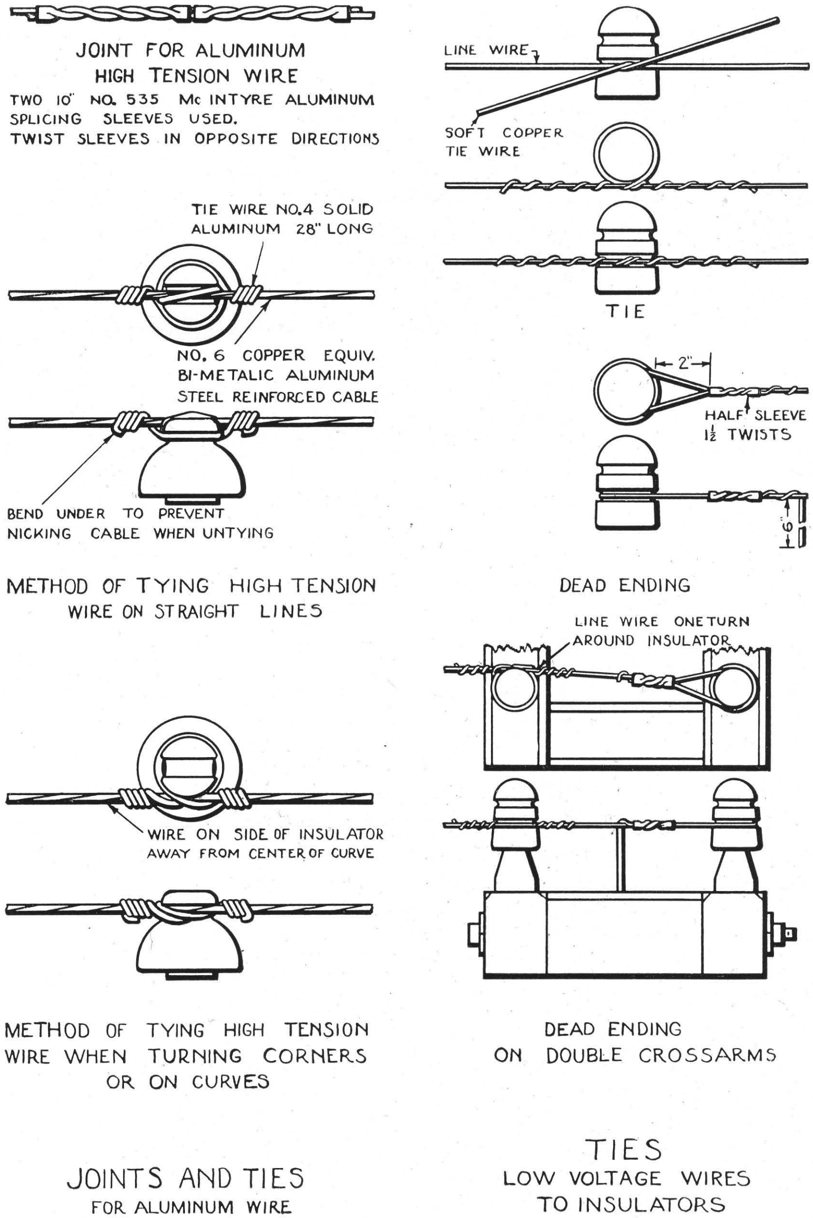


Fig. 12 Joints and Ties, Signal Pole Line

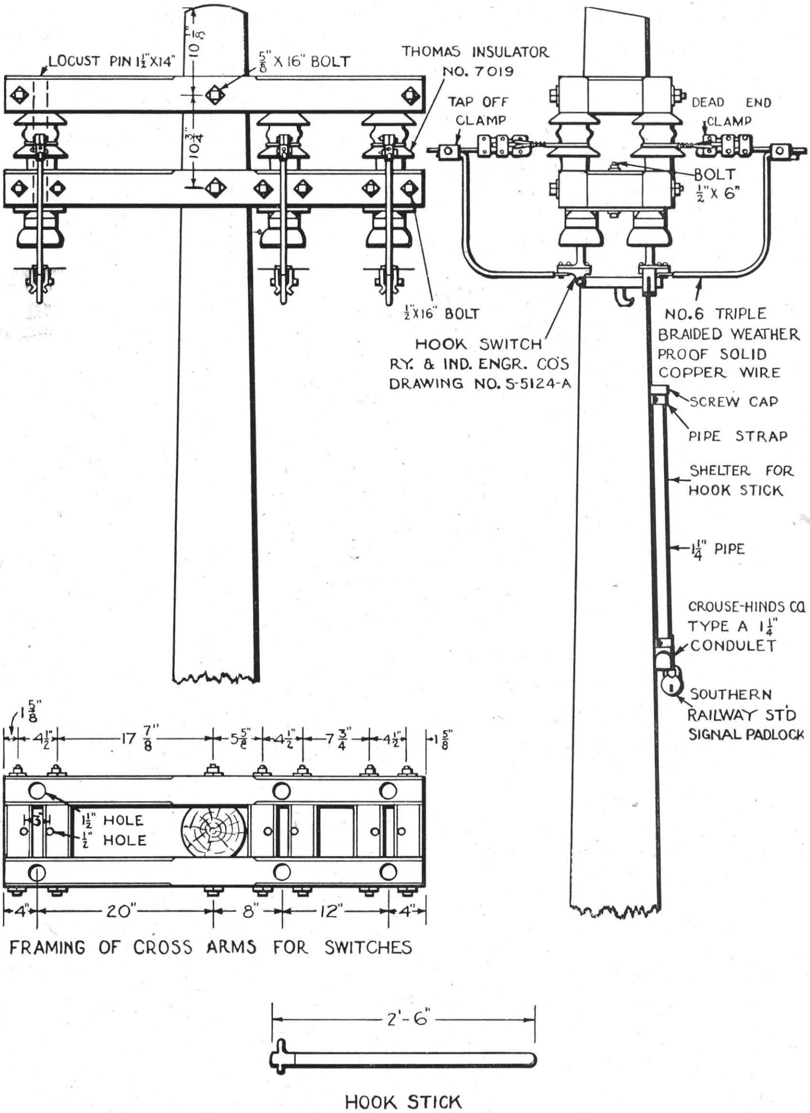
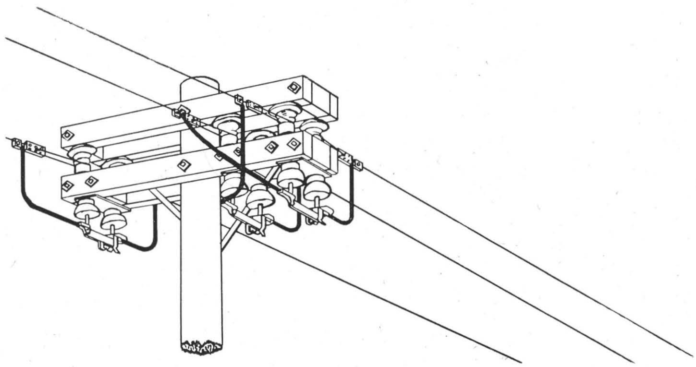


Fig. 13 Sectionalizing Switches, Signal Transmission Line



POLE CONSTRUCTION FIG. 13

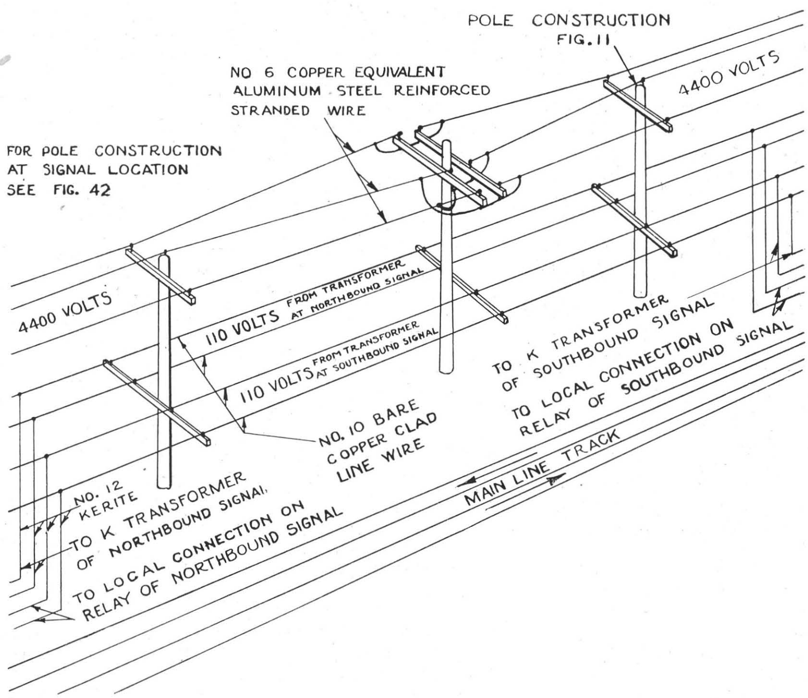


Fig. 14 Transposition of Phases or Division of Power

Lightning Protection

TO protect the apparatus from the effects of atmospheric electrical discharges, three types of lightning arresters were used, namely; General Electric Graded Shunt Resistance Multigap Arrester No. 149755 for transformer protection on the transmission line, G-R-S Model 1B Arrester for low voltage line circuits and G. E. Vacuum Arresters for track circuits.

Transformer Protection

The G. E. Graded Shunt Resistance Multigap Arrester is designed to prevent an excessive rise in potential between the phase wires to ground, to restrain the flow of dynamic current and to extinguish the arc of discharge, as well as to discharge high potentials covering a wide range of frequency. It consists of a number of cylinders mounted upon porcelain and spaced with a small air gap between them. Some of the cylinders are shunted with resistance rods which tend to extinguish any arc formed.

Two arresters, mcunted in wood cases immediately above the transformer, are used at each transformer location, Fig. 16. In the first installation, the lightning arresters were not mounted upon the same pole as the transformer but upon the adjacent pole. It was found that this did not give as good protection as when they were mounted upon the same pole with the transformer and the entire installation now conforms to Fig. 42.

The efficiency of the arrester has been greatly increased by the use of choke coils as described under the subject of choke coils and we believe that they should not be omitted in a similar system.

Choke Coils

To prevent high potential discharges due to lightning or other causes from reaching the transformers at the sub-stations and power-houses, choke coils were inserted on each wire entering from the transmission line. These coils do not act as lightning arresters but they offer such reaction as to force the discharge through the arrester. The coils are circular in shape, heavily insulated, and are mounted on brackets on the wall of sub-stations.

The choke coils proved so successful that now all line transformers at the signal locations have been provided with choke coils inserted between the lightning arresters and transformer fuse-blocks. They

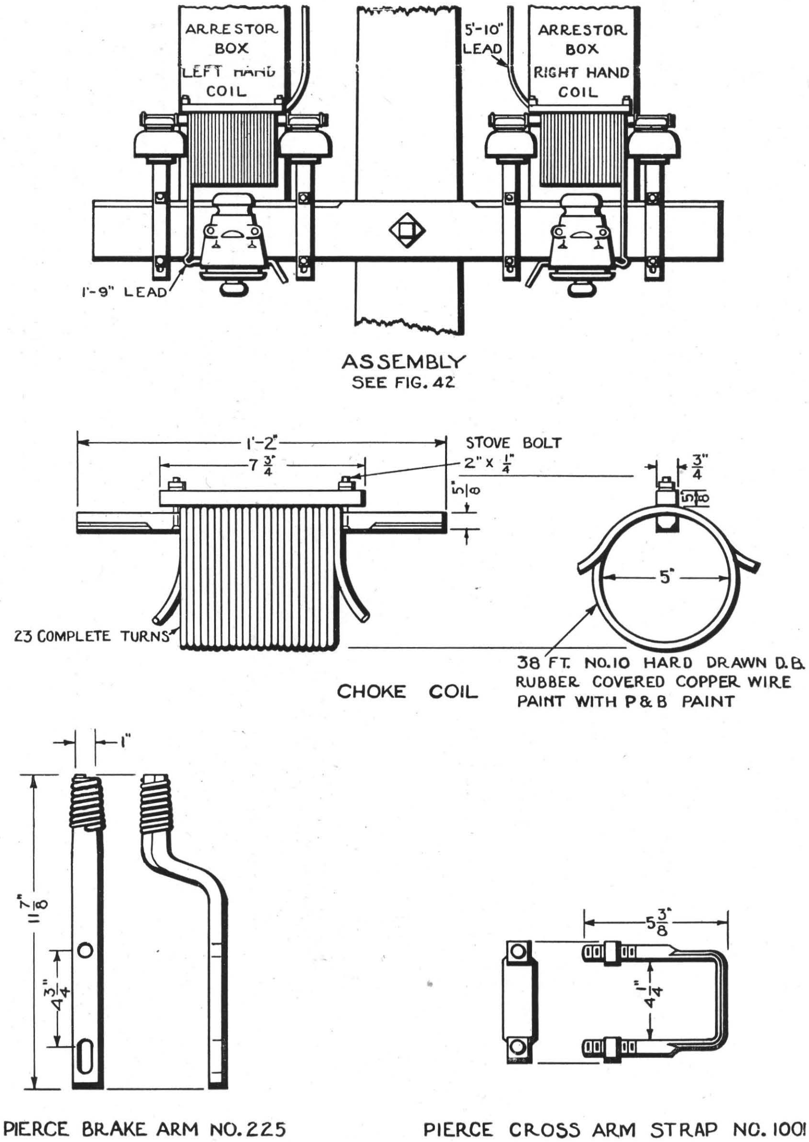


Fig. 15 Choke Coils and Supports for Transformer Pole

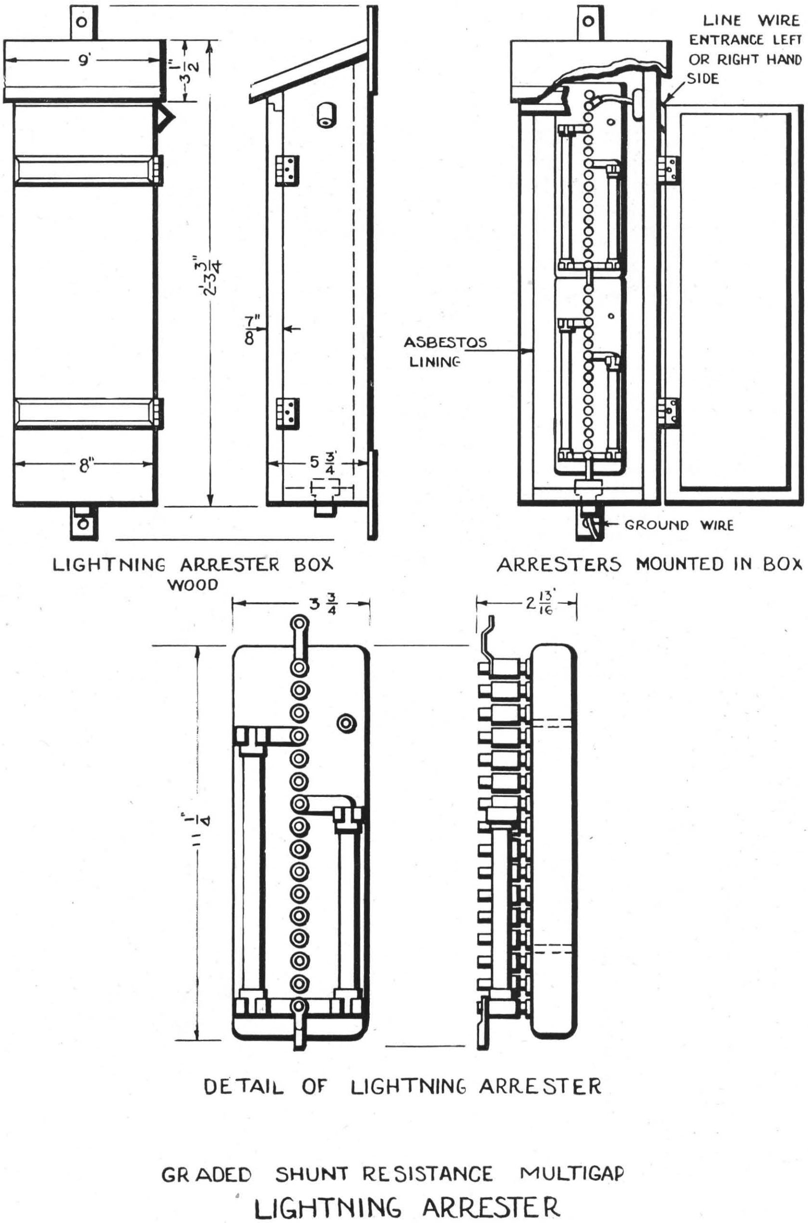


Fig. 16 Lightning Arrester, Signal Transmission Line

are made of 38-ft. of No. 10 hard-drawn, double braid, rubber covered, copper wire shaped into a coil, 5 inches in diameter, and held in place by a wooden clamp as shown in Fig. 15. After the coil is made up, it is painted with P & B Compound. All choke coils are made up by the Signal Department.

Grounds

Grounds for lightning arresters are obtained by driving 1-inch galvanized iron rods 8 feet into the ground. At the sub-stations and power-houses, four of these rods are connected together in multiple. At transformer locations, two are used. This type of ground is very quickly installed, is cheap, and, it is believed, is as efficient as more elaborate grounds consisting of copper plates.

Fig. 17 shows the method used for grounding at power-houses, sub-stations and at signal locations. Each season two handfuls of coarse salt are placed around the rod about 6 inches from the top of the ground which materially decreases the ground resistance.

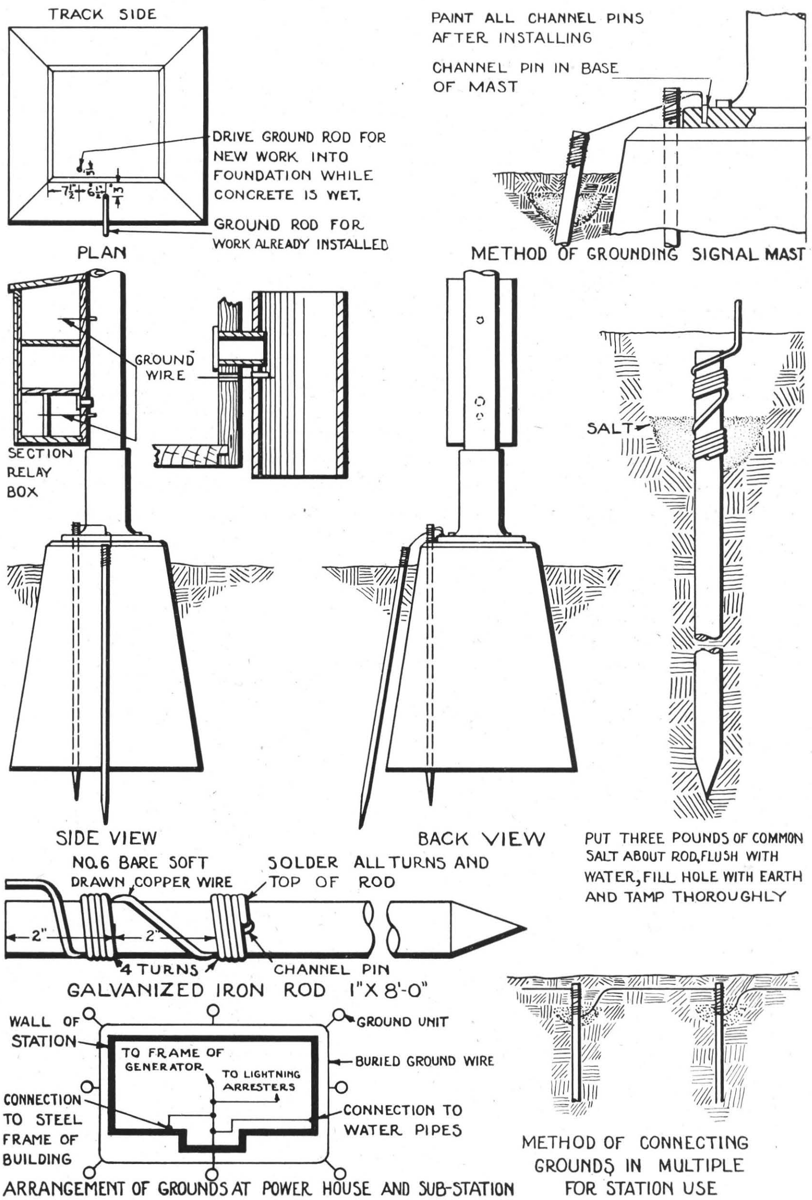


Fig. 17 Ground Connections

Power Supply

Sub-Stations

TEN sub-stations, fed from a commercial power source, are provided to normally feed the 700-mile transmission line and, in addition, one sub-station and five power-houses are maintained for emergency use.

The sub-stations which normally feed the line are located at Cameron Run, Charlottesville, Lynchburg and Danville, Va., Thomasville, and Charlotte, N. C., Spartanburg, S. C., Gainesville and Howell, Ga., and at Morristown, Tenn., Fig. 5.

In equipment, these sub-stations are practically alike although the arrangement of switches, bus bars, etc., varies slightly to suit local conditions. At Charlottesville and Danville, the Southern Railway apparatus is located in the Power Company's power-house, while at each of the other eight locations, a special building was erected. These buildings are substantially constructed of pressed brick to match the architecture of adjacent station buildings, Fig. 21.

The equipment consists of a switchboard, lightning arresters, measuring instruments, transformers and disconnecting hook switches. The transformers vary in size from 10 to 30 k.w. each and they step the Power Company's circuit up from 2300 volts to 4400 volts.

Four transformers are provided at each station, three of which are connected in delta to bus bars which feed the line and the fourth, which is a spare, is mounted directly below the bus bars with terminals so arranged as to quickly substitute it for any of the other three in case of transformer trouble.

An alarm bell which sounds when the current is off the line is mounted in each telegraph office adjacent to a sub-station. In some cases, the operator attends to restoring the current, while in others, he immediately notifies the maintainer who restores the current.

An emergency sub-station of the outdoor type, mounted on a four-pole fixture as shown in Fig. 20, was used at Inman, Georgia. The transformers are mounted on a platform located half way up the poles and the switches are attached to a framework at the top of the poles. On the ground directly under the platform is a steel box containing the switch board, circuit breaker and measuring instruments.

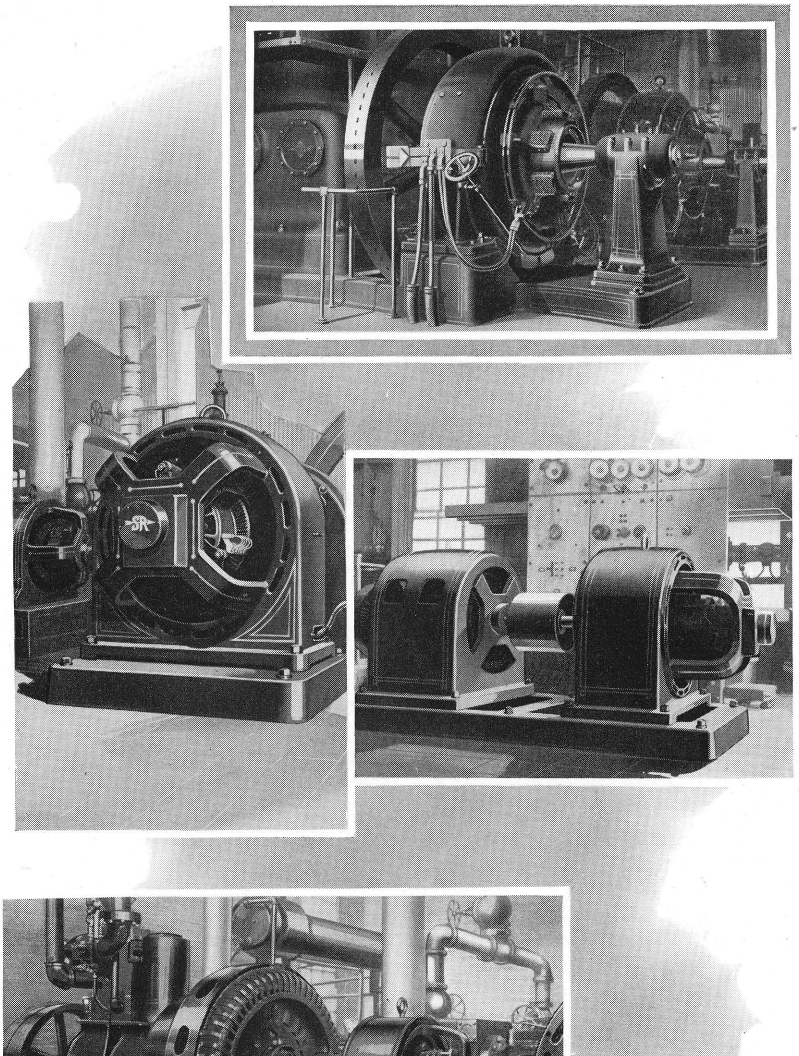


Fig. 18 Typical Power Equipment

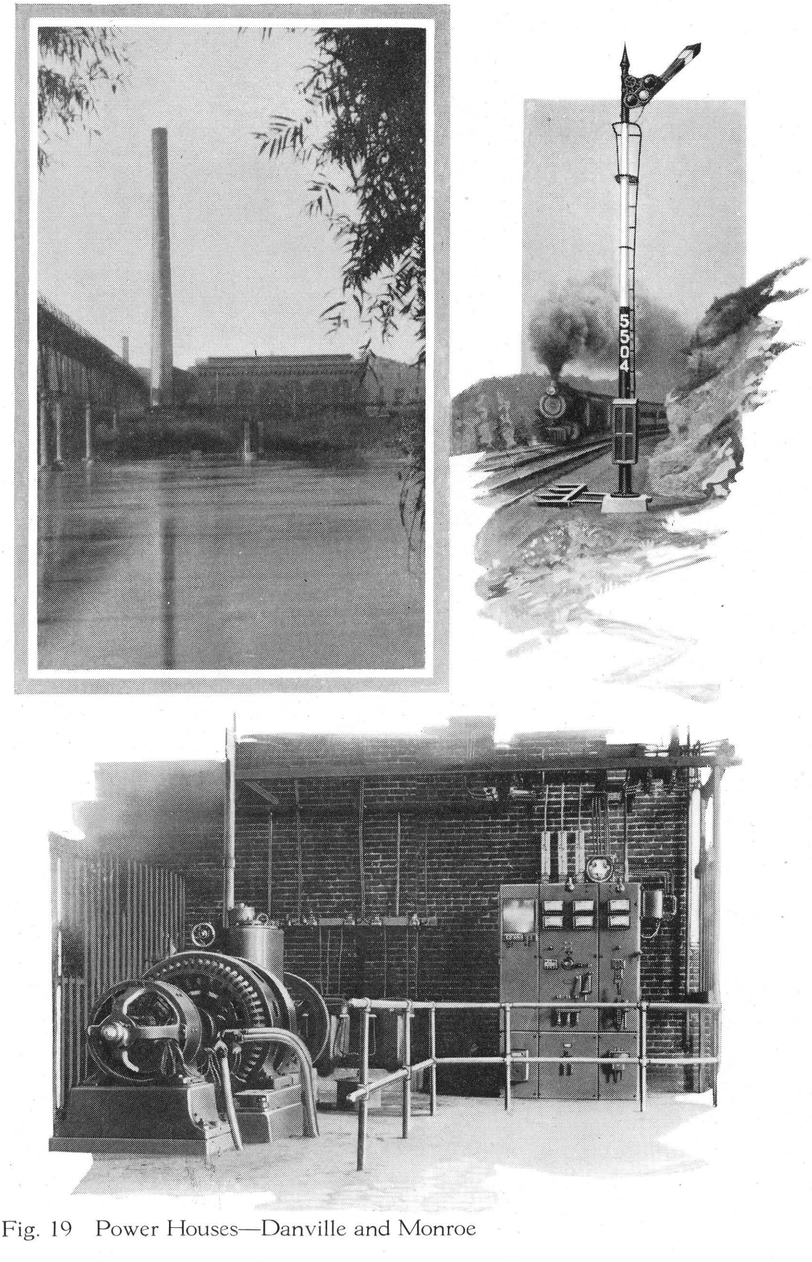


Fig. 19 Power Houses—Danville and Monroe

Four pole fixtures similar in design are also used at Charlottesville and Danville as switching stations. The current can be controlled from them as needed without having to get in touch with the Power Company's attendant to change switches, or in case of fire in the city involving shutting off of the city power. At Charlottesville (Fig. 4c), the transformers and lightning arresters for the interlocking plant are also mounted upon the platform, while at Danville (Fig. 4b), the switching station serves as one of the special fixtures necessary to hold the transmission line due to the long span over the Dan River. Outdoor sub-stations of the type described are not recommended for feeding the transmission line normally, neither are they recommended for use at other points where much switching is to be done.

Power Houses

The largest of the five emergency power plants is located at Spencer, N. C., in the power house of the Southern Railway shops where 240 volts direct current, steam power and the services of an Engineer are always available.

The plant was originally designed to normally carry the load from Greensboro to Charlotte, N. C., a distance of 100 miles. However, due to the increased load necessary to handle the shop business, this plant is now only used for the signal load on Sundays and in emergencies.

The apparatus installed includes a Westinghouse high-speed, single-acting, standard engine direct-connected to a 75-kva. three-phase, 60-cycle, 440-volt generator with a direct-connected, 7½-kw., 125-volt exciter. This set is used where the dynamos which supply direct current to the shop are fully loaded. The General Railway Signal Company furnished a 75-kw. motor-generator set which takes direct current at 250 volts and delivers a three-phase, 60-cycle current at 440 volts. It is used when the direct-current dynamos are running with less than full load. Both of the above sets are shown in Fig. 18.

Four 25-kva. transformers are installed upon a raised concrete platform back of the switchboard and are used to step up the 440-volt alternating-current generated to 4400 volts for the transmission line, three of the transformers being connected in delta and one held in reserve.

A three-panel marble switchboard, made up to match the existing d.-c. switchboard, carries the necessary instruments and controlling apparatus.

Six wires are carried into the switchboard so that the transmission line running north can be separated from that running south. The entire installation was designed to secure, as far as possible, uninterrupted service.

At Monroe, Va., (Fig. 19) and Greenville, S. C., the power-house apparatus is located in the Division Terminal round house next to the boiler room where the steam supply is readily accessible.

The vertical reciprocating steam engine at Monroe and the steam turbine at Greenville, both of Westinghouse manufacture, are each direct connected to a 62.5-kva. generator which delivers a three-phase, 60-cycle current at 240 volts. The voltage is stepped up by transformers to 4400 volts.

At Orange and Whittles, Va., special buildings were erected for housing the power equipment. In both cases fuel oil engines are used, the one at Orange being a Fairbanks, 40-h.p., Type N B and the one at Whittles a Samuel L. Moore & Sons, 50-h.p., "Crescent." Each engine is belt connected to a 30-kva., 240-volt generator which is excited by a belt driven 1.5-kw., 125-volt unit.

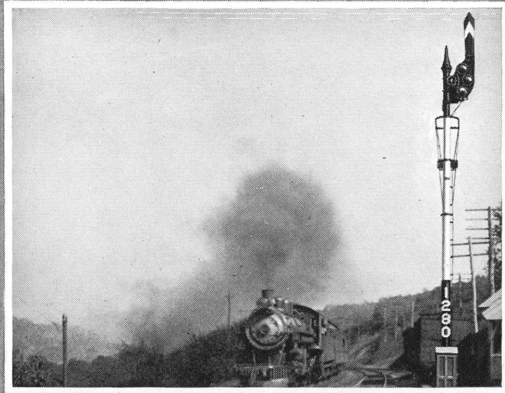
The engines are water cooled by the use of three galvanized iron tanks feeding in multiple to each engine. The tanks are located in the same building with the engine.

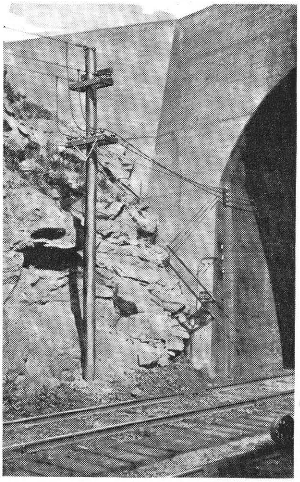
Fuel oil is supplied at each station from a 3000-gallon storage tank which is buried in the ground at a convenient location for filling. This tank supplies a 200-gallon reservoir which in turn feeds the engine.

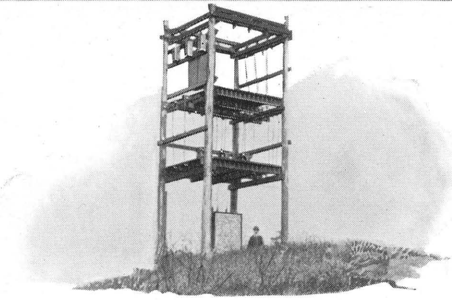
In all the power houses, the switchboards, Tyrell regulators, measuring instruments, lightning arresters, switches and bus bars are similar, and the arrangement is practically the same as in the substations.

The service obtained from commercial sources is very reliable and it is rarely necessary to use the emergency sets. They are frequently tested and used, however, to insure their being in condition for use in emergencies.

THE SOUTHERN SR SERVES THE SOUTH







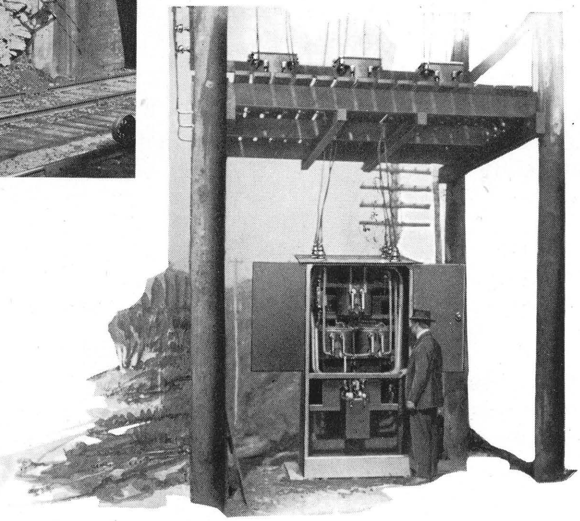


Fig. 20 Terminal Pole at Tunnel and Outdoor Sub-Station

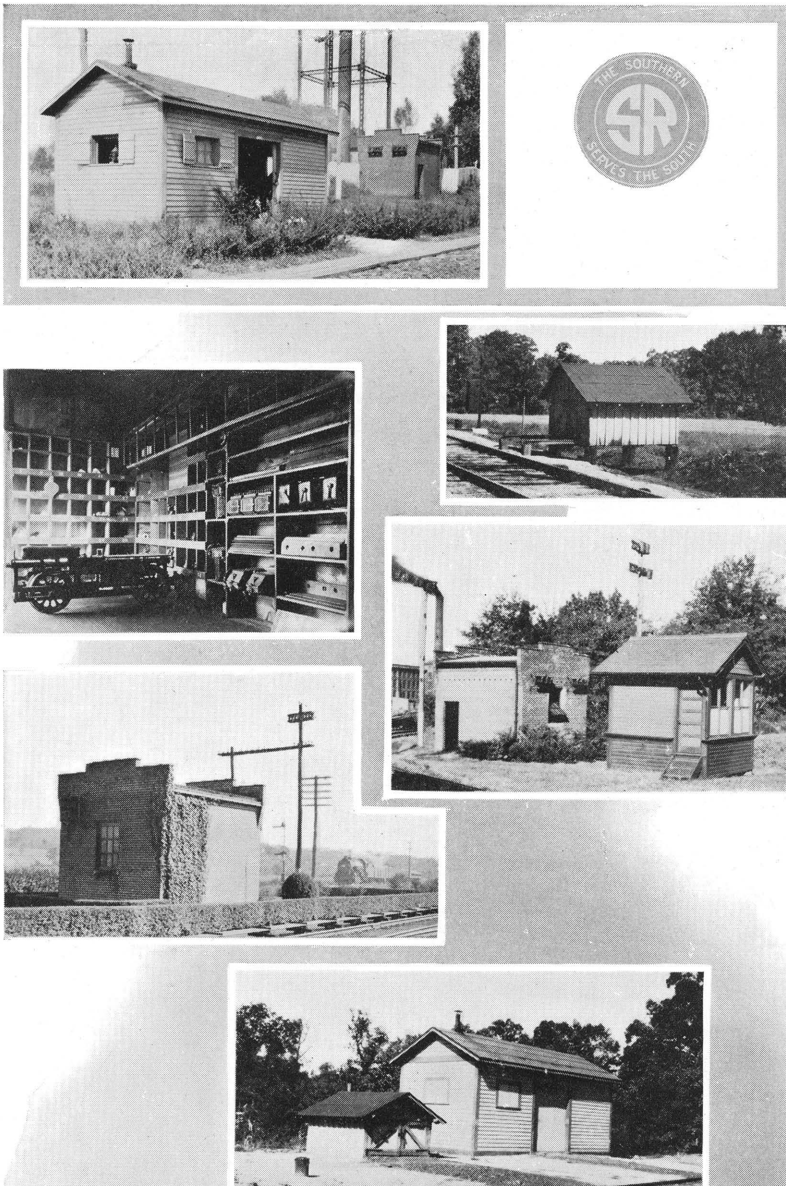


Fig. 21 Typical Signal Department Buildings

Signals

CAREFUL consideration was given to the type of signal to be used and the one finally selected was the Model 2A, top-of-mast, three-position type as manufactured by the General Railway Signal Company, Rochester, N. Y.

The top-of-mast signal has many advantages and practically no disadvantages for the territory through which the Southern Railway System operates. Some of the advantages are: high mechanical efficiency due to the direct connection of the mechanism to the semaphore shaft, its compactness, the ease with which all parts may be maintained, and its universality as the mechanism may be used wherever a power signal is required, for example, as a ground, bridge, bracket, suspended or dwarf signal.

In addition to the adaptability of the top-of-mast type of signal, the considerations which led to the choice of the Model 2A signal mechanism, Fig. 28, were:

First: The construction and arrangement of the several parts of the mechanism provide for quick inspection and adjustment. The circuit controller is placed at the top of the mechanism where all contacts are visible and may be easily arranged or re-arranged so as to control the various circuits.

Second: The elimination of slot and dashpot which materially increases the efficiency of the power signal and reduces the cost of maintenance since the mechanism requires less attention.

Third: The electrical means of retarding the falling signal arm just before it reaches the caution or stop position.

Fourth: The electrical means of holding the signal arm in the caution or clear position.

Fifth: The low operating and holding current.

Sixth: The quick clearing time.

Seventh: The ease of applying a Model 2A, top-of-mast mechanism to an existing mechanical signal, thereby converting the mechanical signal into a power signal. On account of the number of interlocking plants that were already in service, this feature was found very valuable when the automatic system was extended through the interlocking plants.

The signal masts (Fig. 32) are A.R.A. standard, 23 feet 9 inches from the base to the center of the spectacle bearing. The spectacle (Fig. 22) is the A.R.A. Type "A" giving the indications in the upper right-hand quadrant, the indications being:

Arm horizontal —	Red light —	Stop, then proceed
Arm 45 deg. upward—	Yellow light—	Approach next signal prepared to stop
Arm vertical —	Green light —	Proceed

The motor operating the signal (Fig. 29) is of the induction type, which has no commutator or brushes, and gives very efficient service with little attention other than an occasional oiling and inspection. Although the induction motor requires slightly more current than the series-commutating motor formerly used, the advantages which it affords more than offset the increased current consumption. This motor is known as a split-phase motor; in other words, it is a two-phase motor arranged to operate on single phase by means of the reactance unit which is connected in series with one of the stator windings in order to obtain the necessary phase displacement. Both stator windings are in service while the motor is operating which eliminates the necessity of contacting devices such as are ordinarily

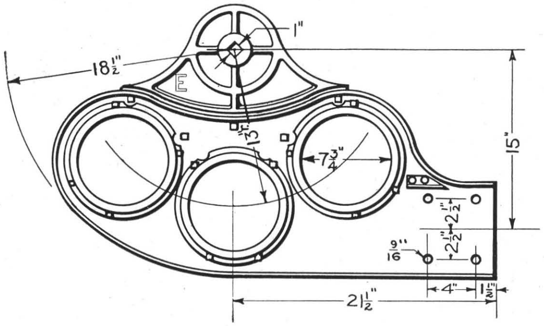


Fig. 22 Semaphore Spectacle

used with single-phase motors to interrupt the current through a starting winding after the motor has developed normal speed.

It is supplied with 110-volt, single-phase, 60-cycle current and will operate the signal arm from 0 to 90 degrees in ten seconds with a 20 per cent reduction in the normal operating voltage.

The signal is held in the vertical and 45-degree position by means of a solenoid, ratchet, retaining mechanism or hold clear device, Fig. 29J. The armature of the solenoid is attached to a movable arm carrying a dog or pawl which engages with a toothed disc on the motor shaft when the coils of the solenoid magnet are energized. A stop pin is fixed on the movable arm above the dog or pawl so that when the solenoid is energized the motor armature and toothed disc can rotate in a direction to clear the signal, but are prevented by the stop pin from rotating in the opposite direction, thus holding the signal in the position to which it has been operated. When the home relay is de-energized, the circuit through the hold-clear coil is opened, the armature drops away and disengages the pawl and toothed disc, and the semaphore arm falls to the stop position.

Neither slot nor dashpot are necessary since the energy developed by the backward rotation of the mechanism and motor is absorbed by a buffer spring thereby preventing shock when the signal goes to the stop position.

No slow-acting relays are required in the 45 to 90 degree operation of the signal, as it will return to the full proceed position without first going to the stop position when current is interrupted and quickly restored. It has been found that this feature is a valuable one, since it obviates the necessity of synchronizing the power-house generators with the line voltage. This simplifies, very materially, the changing of power on the line from the power house to the sub-station or vice versa.

All that is necessary in case of a power change, is for the operator at the station, which is to come on to the line, to close his switches when he sees the volt meter needle start to zero. Current is thus re-established on the line before the signals have moved more than a very few degrees and no noticeable interruption occurs.

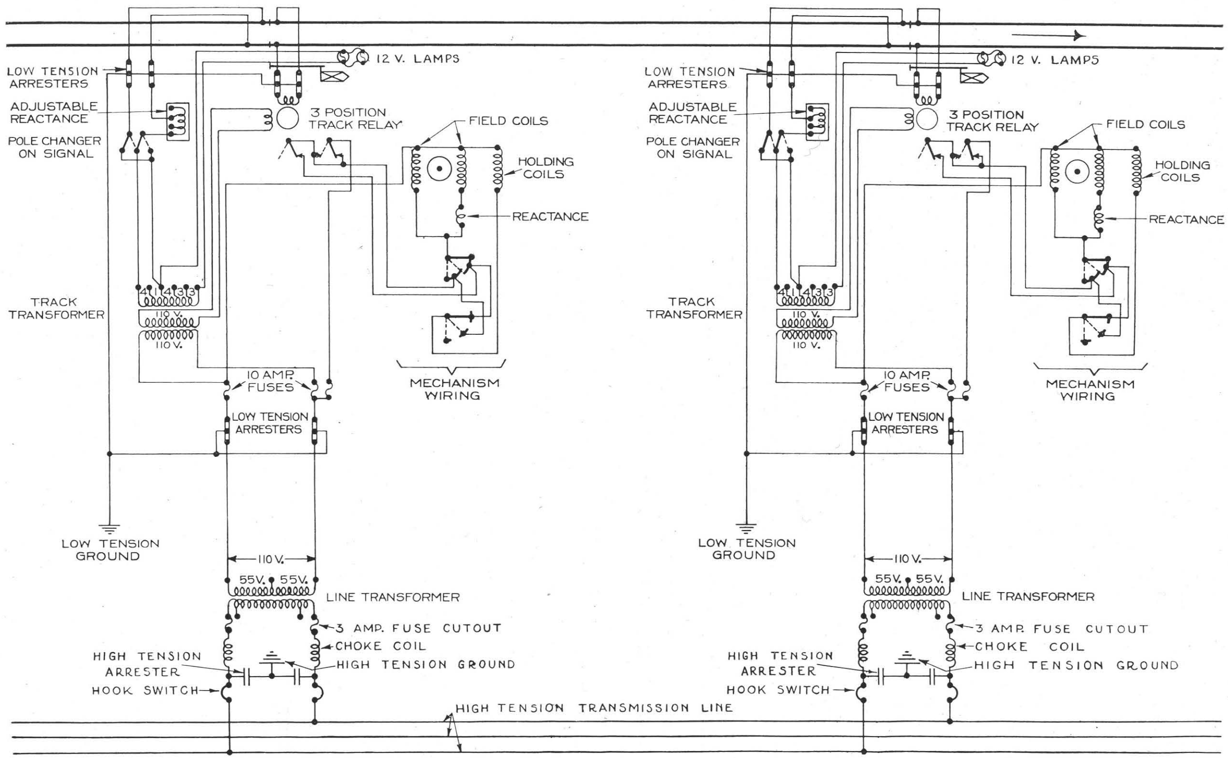


Fig. 23 Simplified Wiring Diagram

Veeder counters, reading to five figures, are provided with each signal to record separately the movements of the signal arm from 0 to 45 degrees and from 45 to 90 degrees. This permits an accurate record to be kept of the performance of each signal.

Local conditions of view, track spacing and arrangement required a few special signals and mountings. Some of these special signals are shown in Figs. 24 and 25.

The two arm signal, Fig. 25, is typical of a number that were installed to take care of special conditions which exist at Danville, Va., Salisbury, N. C., Atlanta, Ga., and at other locations. Approaching these stations, all passenger trains leave the main tracks about 300 ft. in advance of the signal to enter upon one of the tracks into the station. The station tracks are long enough to hold two trains and many times a day it is necessary to move the entering train upon an occupied track. To prevent stopping practically every train, the lower arm was added to these signals to govern trains entering the station. This arm moves between 0 and 45 degrees only, and is controlled by the position of the switches leading to the station tracks and a short track circuit up to and including the diverging switch. The upper arm is a regular three-position arm and governs straight through on the main track.

Operating data of Model 2A, three-position, high signal:

Voltage range of motor	110 volts
Phase	Single
Cycles	60
Maximum motor current	3.75 amps.
Energy to clear signal	260. watts
Time required to clear signal	10. seconds
Minimum working voltage motor	90. volts
Minimum working voltage hold clear	90. volts
Hold clear drop away	65. volts
Hold clear energy 70 deg. F	50. volt-amp.
Hold clear energy 70 deg. F	6.5 watts
Electric lamps (2)	4. watts

Test by means of a watt meter on secondary of 110-volt line transformer gave .6 kw-hr. per day for all current used at a single signal location including track circuit.

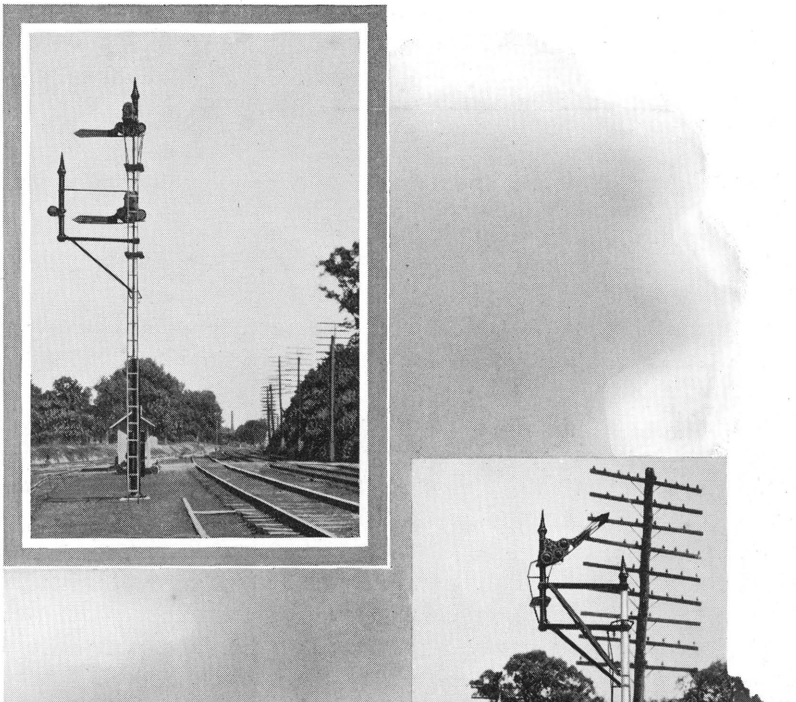


Fig. 24 Special Signals

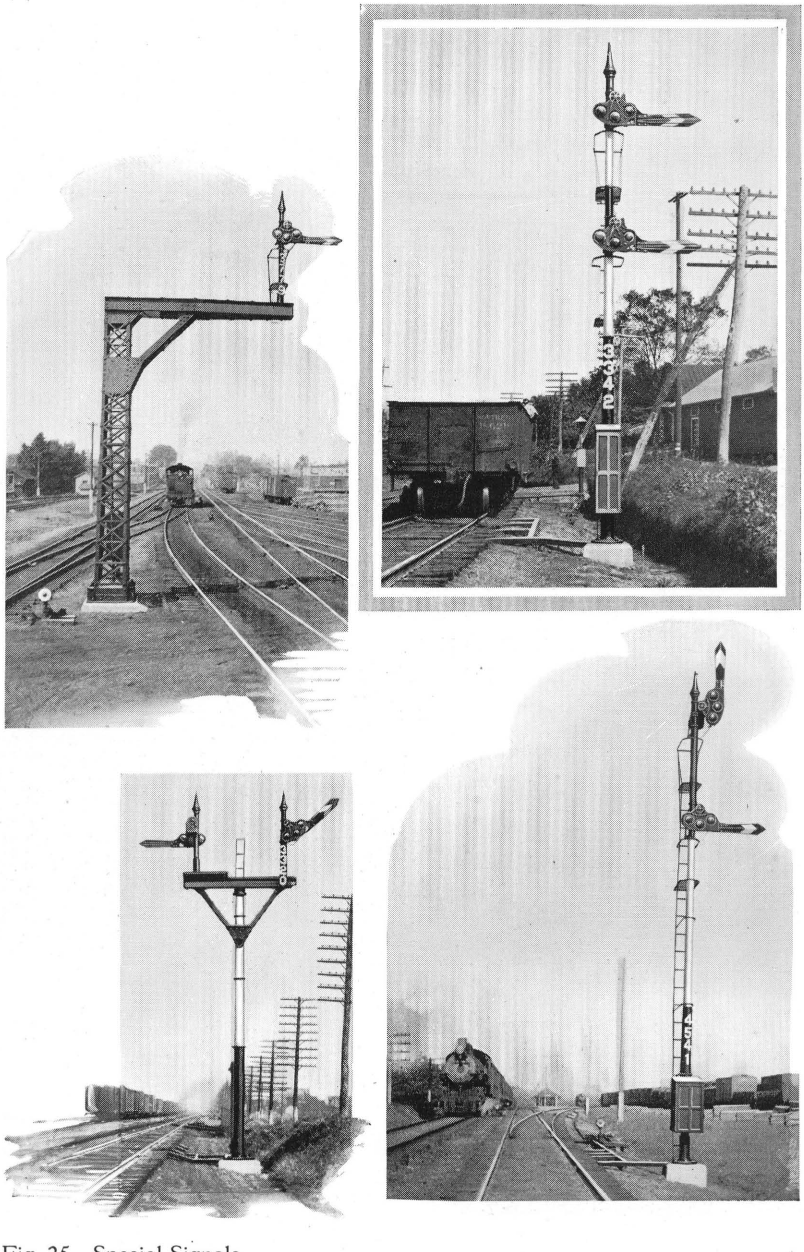


Fig. 25 Special Signals

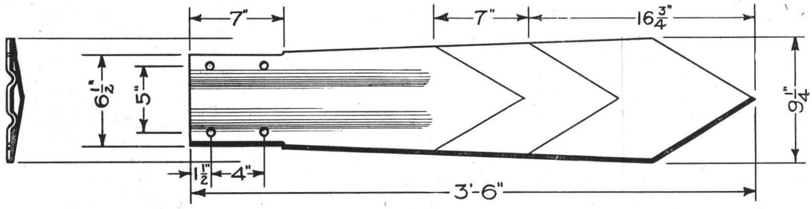


Fig. 26 Signal Blade

Signal Blades

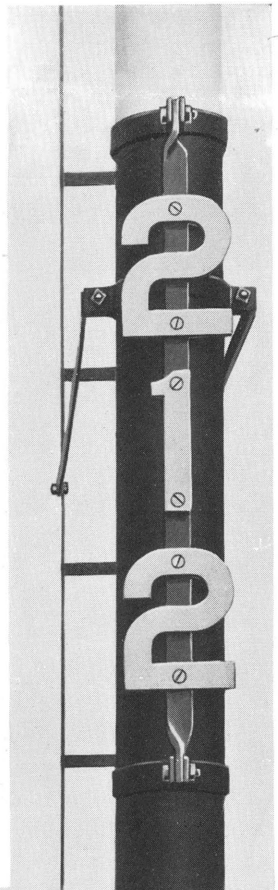
The signal blades follow the recommended practice of the A.R.A. as to shape, bolt holes, spacing and striping. They are of steel, heavily enameled; face red with white stripe, and back all black with no stripe. They present a handsome appearance and are easily kept clean.

Signal Numbers

All of the signals are numbered to represent not only their location, but also the direction of traffic they govern. That is, south-bound signals are numbered to the nearest odd tenth of the mile and north-bound to the nearest even tenth of the mile. Thus signal 3306 is located between mile post 330 and 331 from Washington and is for north-bound trains, north-bound trains having even numbers and south-bound, odd numbers on this section of the Southern Railway.

The numbers are of cast iron, 8½ inches high and they are used on all signals including interlocking signals. They are mounted upon a 1½-inch wrought iron strip by means of small bolts, the strip being fastened to the pole by clamps. The numbers are painted white and are very plain and distinct against the black background of the signal mast. No skill is required to paint them, and they are free from any chipping or flaking that enamel numbers would possibly be subjected to.

Due to the new alignment caused by the construction of the double track between Washington and Atlanta, the distance was shortened by approximately 10 miles which necessitated the re-numbering of all signals to correspond with the new mile posts. The use of the type of signal number, described, greatly simplified the work since the changing of individual numbers at each signal was all that was required. The work was done by the maintainers in one day. The change was very inexpensive compared to what it would have been had new solid number plates been required at each signal.



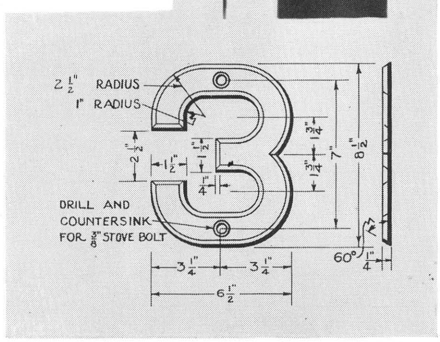
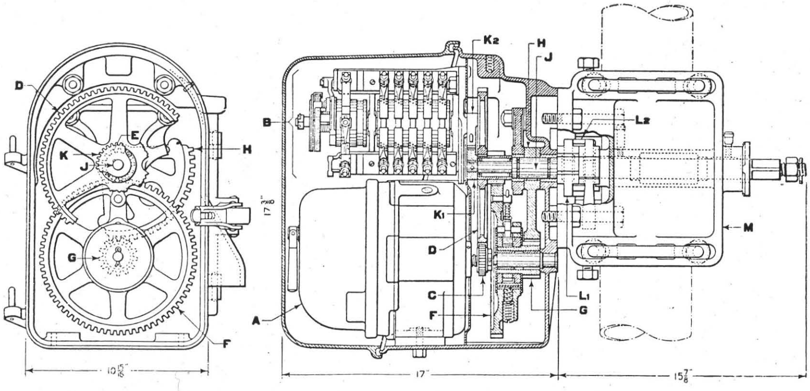
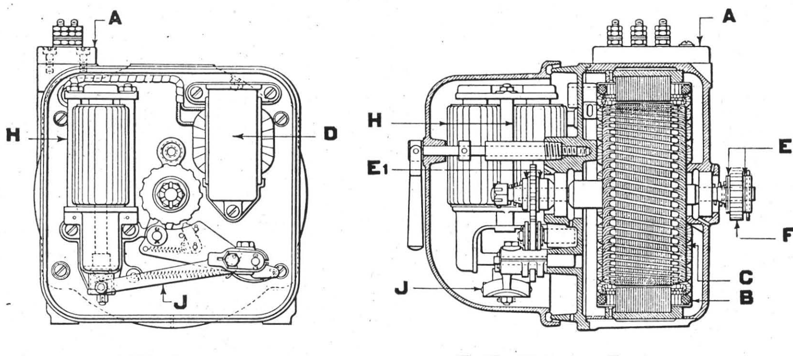


Fig. 27 Detail of Signal Number



A Motor
B Circuit Controller
C Driving Pinion
D First Intermediate Gear
E First Intermediate Pinion
F Second Intermediate Gear
G Second Intermediate Pinion
H Operating Sector
J Driving Shaft
K_1 K_2 Segmental Gears
L_1 L_2 Universal Coupling

Fig. 28 Model 2A, 110-Volt, 60-Cycle Mechanism



A Terminal Block
B Stator
C Rotor
D Impedance
E_1 E_2 Friction Disks
F Motor Pinion
H Hold-Clear Coils
J Hold-Clear Armature

Fig. 29 110-Volt, 60-Cycle, Induction Motor

Relay ARM

Push / Pull

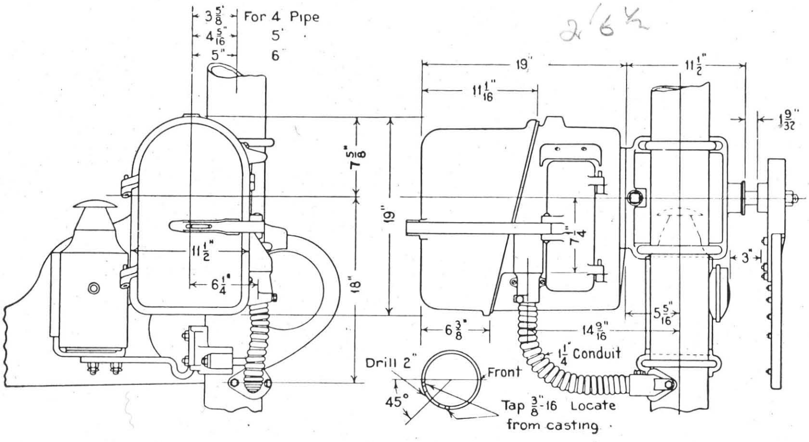


Fig. 30 Dimensions, Model 2A Signal

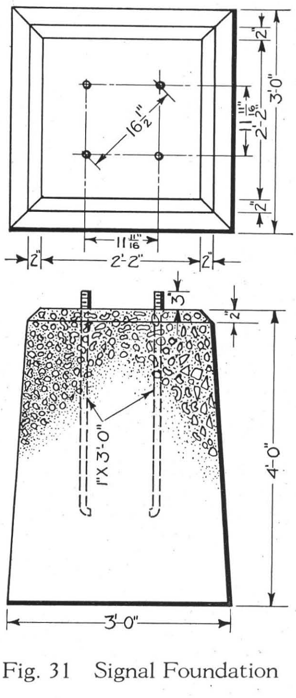


Fig. 31 Signal Foundation

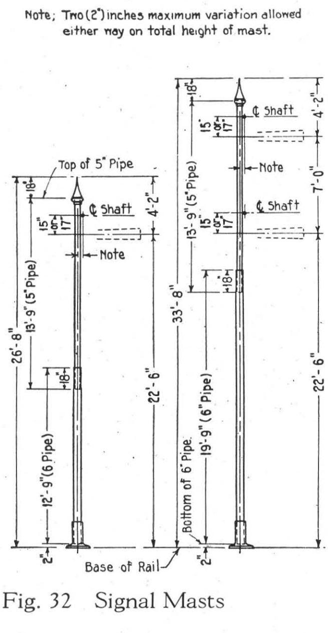


Fig. 32 Signal Masts

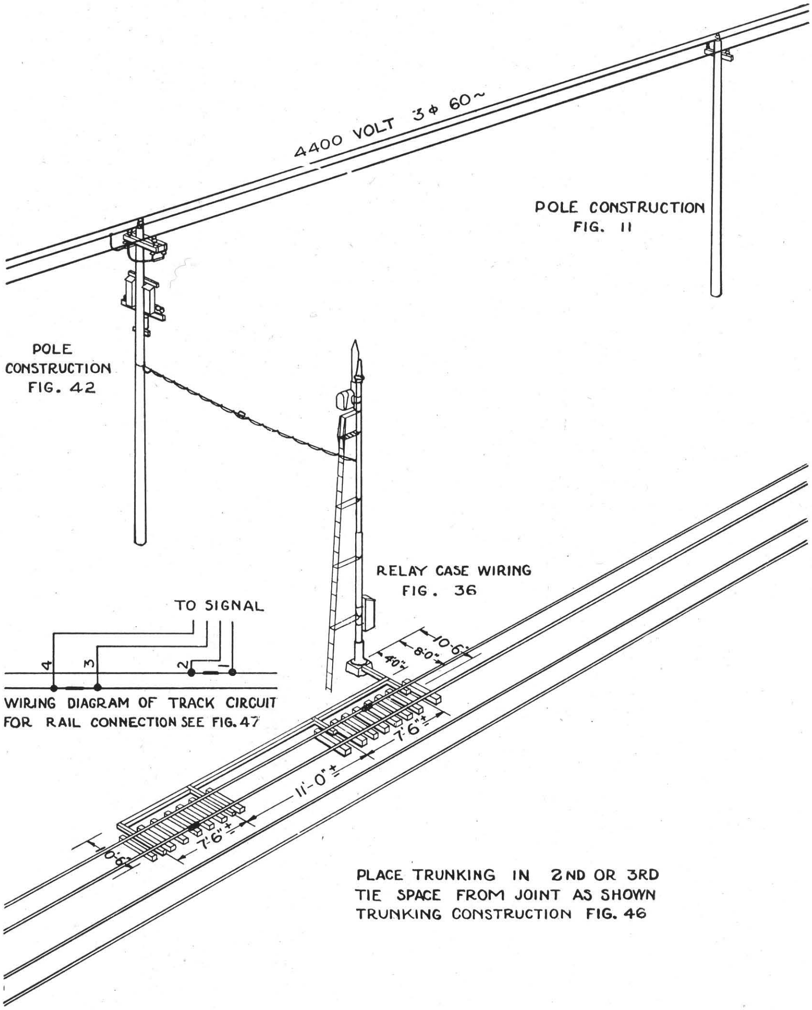


Fig. 33 A.-C. Automatic Signal Layout

Signal Lighting

EACH of the signals is provided with two 12-volt, 2½-watt, Mazda lamps in multiple. These lamps are mounted in porcelain receptacles in a small cast iron lamp box, provided with a sliding cover and guides so that it slips on to a standard A.R.A. oil lamp bracket.

The lamps are kept burning continuously on the 8 or 10-volt tap of the track transformer. On account of the very white character of the light given by tungsten-filament lamps, they can be burned very much under their normal operating voltage and thus enormously increase their life. In spite of the decrease of candle power due to the reduced voltage, the light on the signals is much superior to any oil light which we have been able to obtain. The 12-volt lamps burned on the 10-volt circuit last at least a year and in most cases, much longer. The total current consumed by the two lamps is approximately four watts per signal.

Relay Boxes

Relays, track transformers and impedances are housed in wooden boxes secured to the signal mast. The box for each location is made of 1½-inch clear pine lumber, and the top is covered with galvanized

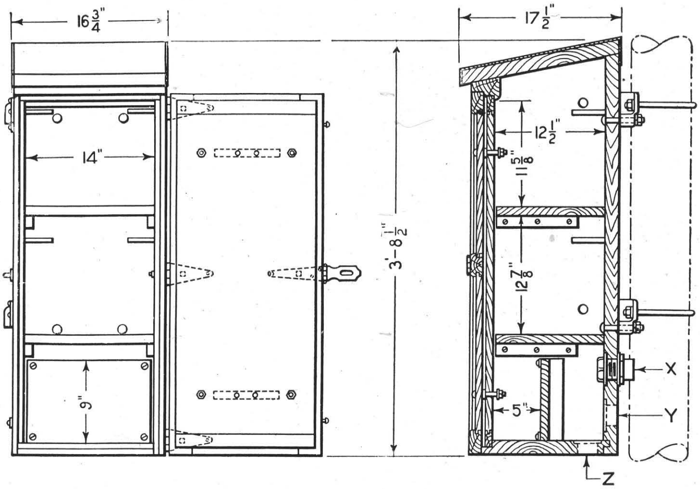


Fig. 34 Relay Box

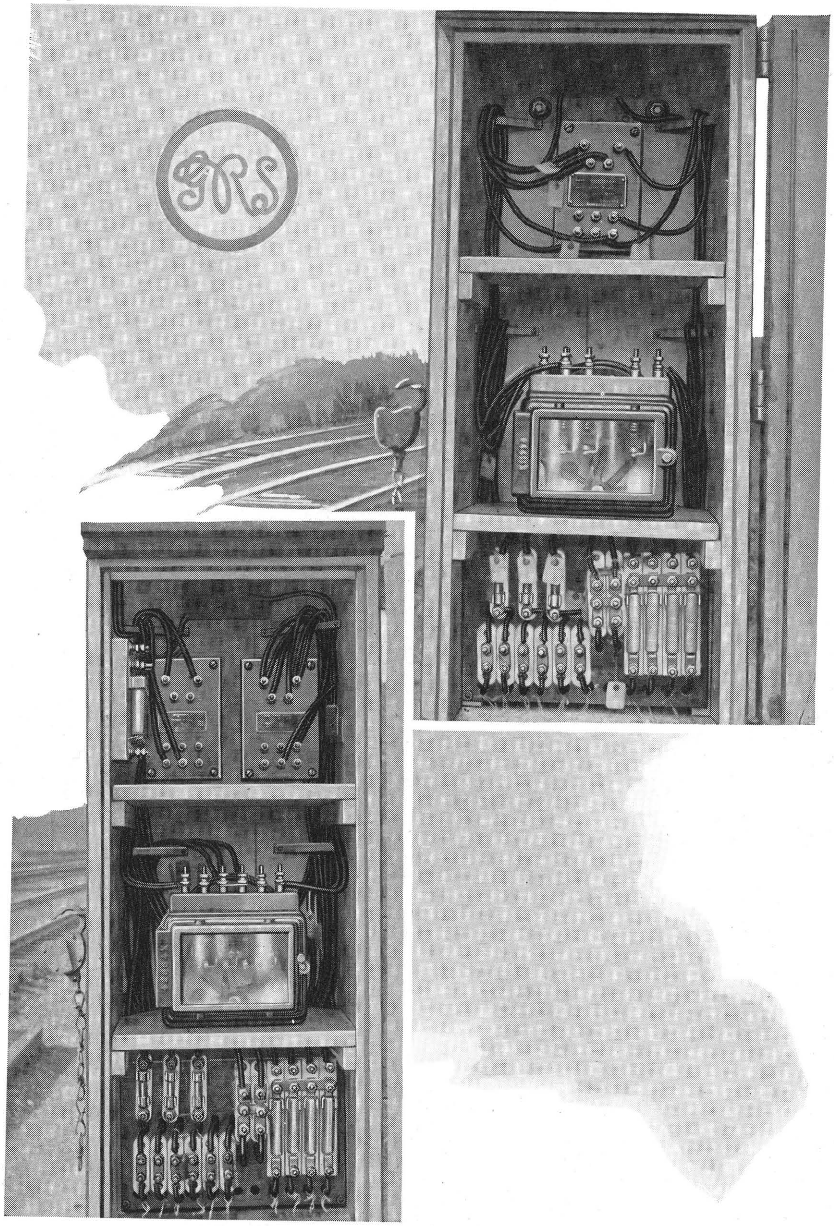


Fig. 35 Relay Wiring Box

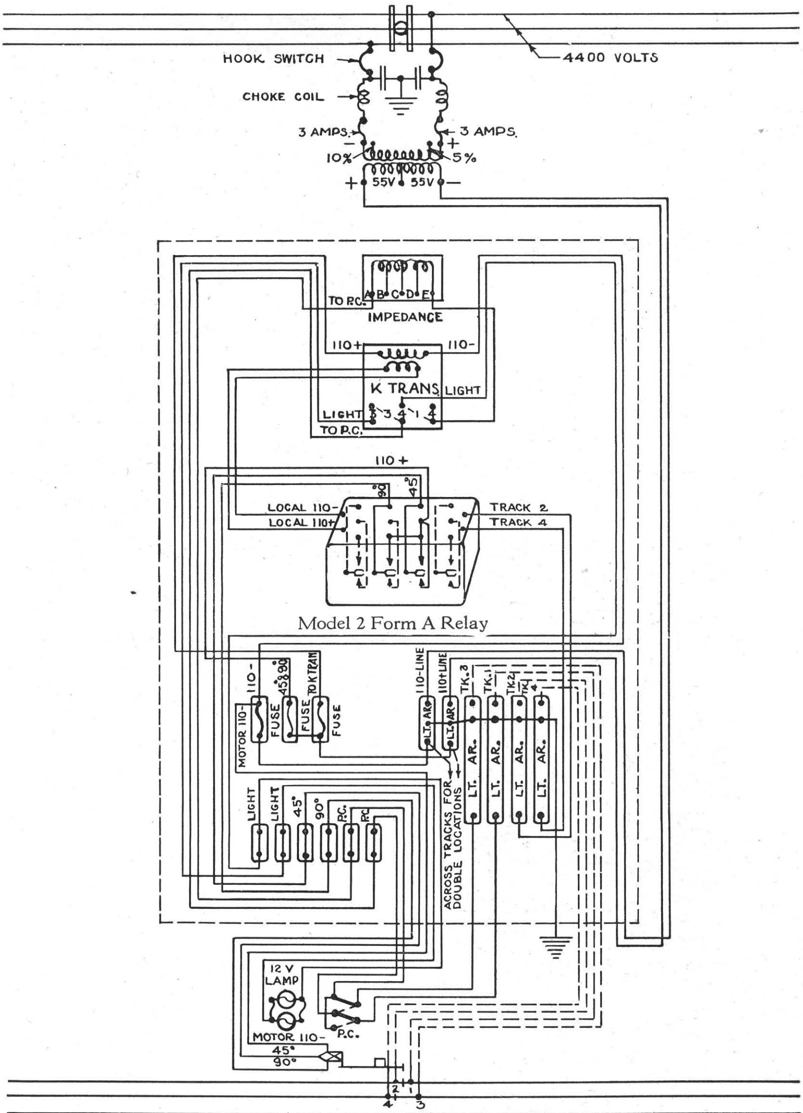


Fig. 36 Typical Detail Wiring

iron. Shelves in the box are loose so as to permit free access to the apparatus. All relay boxes are wired as nearly as possible alike to simplify testing.

At single signal locations, where the signal is on the opposite side of the track from the pole line, the relay box is mounted on the signal mast. The 110-volt lines from the signal transformer are brought to an iron cable post set upon a concrete foundation, and thence to the relay box through trunking. This reduces very greatly the amount of wire required, and makes the wiring of the relay boxes uniform.

Line Relays

The few line relays that are used in the installation are of the General Railway Signal Company's Model 2 Form "B" type, Fig. 37. This is a two-position, polyphase relay which operates on the same general principle as the polyphase track relay. It is designed for mounting on the walls of the relay boxes, and the glass case protecting the contacts can be removed by unscrewing the retaining nut at the bottom. The relay is approximately the same size as a d.-c. relay of the same number of contacts.

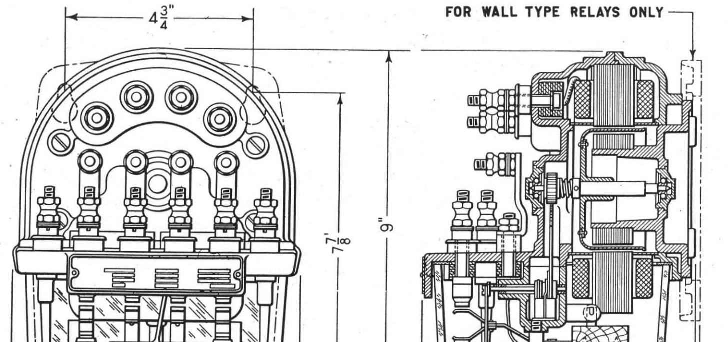


Fig. 37 Model 2B Line Relay

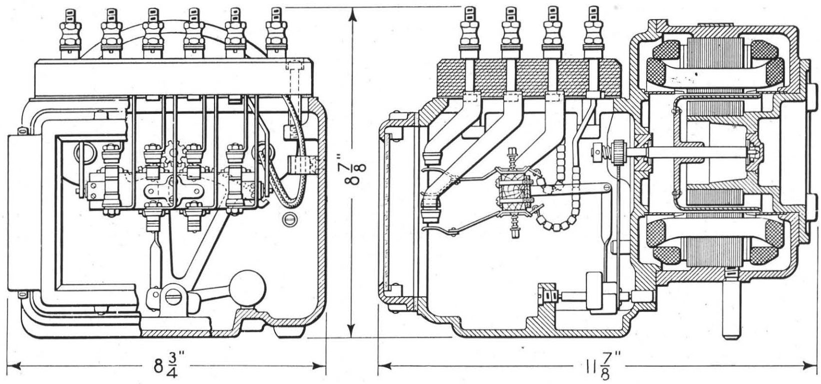


Fig. 38 Model 2A Track Relay

Track Relays

THE track relays are the General Railway Signal Company's Model 2 Form "A" three-position type as shown in Fig. 38.

The relay is operated by a polyphase motor which consists of a non-magnetic shell or rotor and fixed inner and outer cores, the outer core being the stator on which the windings are placed. These windings are designed and connected so as to produce (with alternating current applied) a rotating magnetic field, which in turn will induce currents in the non-magnetic rotor, causing it to operate. Direct currents cannot produce this rotary field and cannot, therefore, operate the relay. The rotor is connected to the contacts by means of a pinion and sector arrangement, thereby multiplying the torque of the rotor and permitting the operation of a large number of contacts with a very small amount of energy applied. Furthermore, as most of the energy for the operation of the stator is obtained from a local transformer, only a small amount of energy is required from the rails to operate the relay.

These features permit the operation of very long track circuits without the use of cut sections or a prohibitive amount of energy. The contacts are unusually heavy in construction, having a wide opening; and by rubbing through the last 1/16 in. of their stroke in closing, they maintain a clean, low-resistance contact. Any combination of front, back or front and back contacts can be secured, and changes in contact arrangement can be made on the ground if desired.

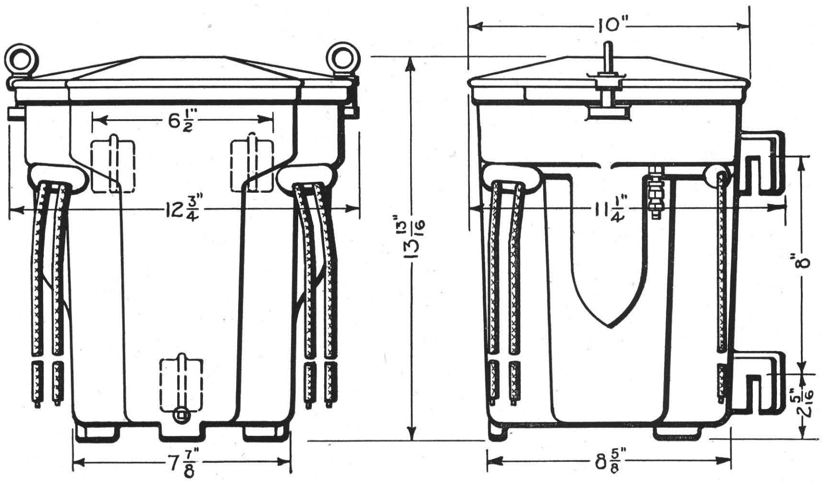


Fig. 39 Type L_1 Transformer

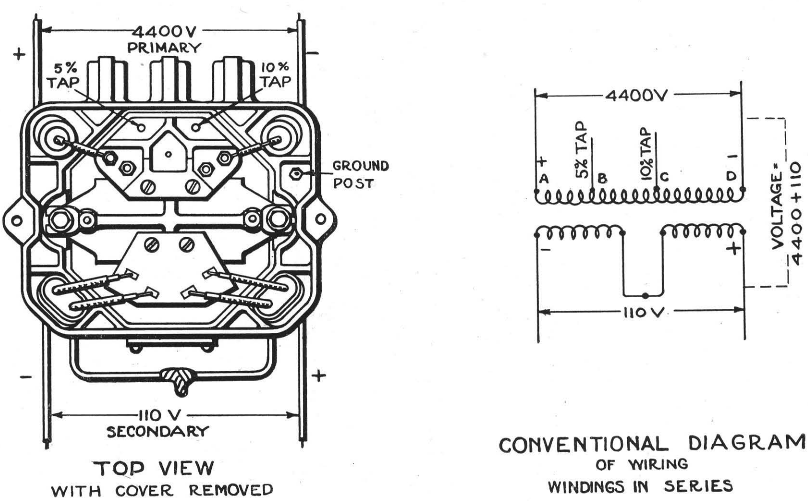


Fig. 40 Connection Diagram—L_1 Transformer

Line Transformers

SEPARATE line transformers are used for each signal location to step down the transmission-line voltage to the 110 volts required for the operation of the signals. These transformers are the General Railway Signal Company's Type "L_1", oil cooled, 600-volt-ampere, pole type, single-phase, 60-cycle, 4400-volt primary, 110-55-volt secondary. They are provided with a primary terminal block which has binding posts for 5 and 10 per cent primary taps. These transformers are designed in accordance with A.R.A. specifications and to reduce the core and copper losses to a minimum. They have good regulation on low power factor, low exciting current and high insulation. Each transformer is provided with a binding post in the cast iron shell for grounding the case to guard against danger from a broken down primary winding.

The standard layout for a typical transformer location is shown in Fig. 42.

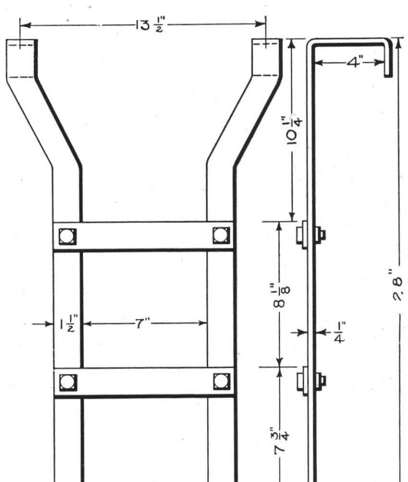


Fig. 41 Hanger for Transformer

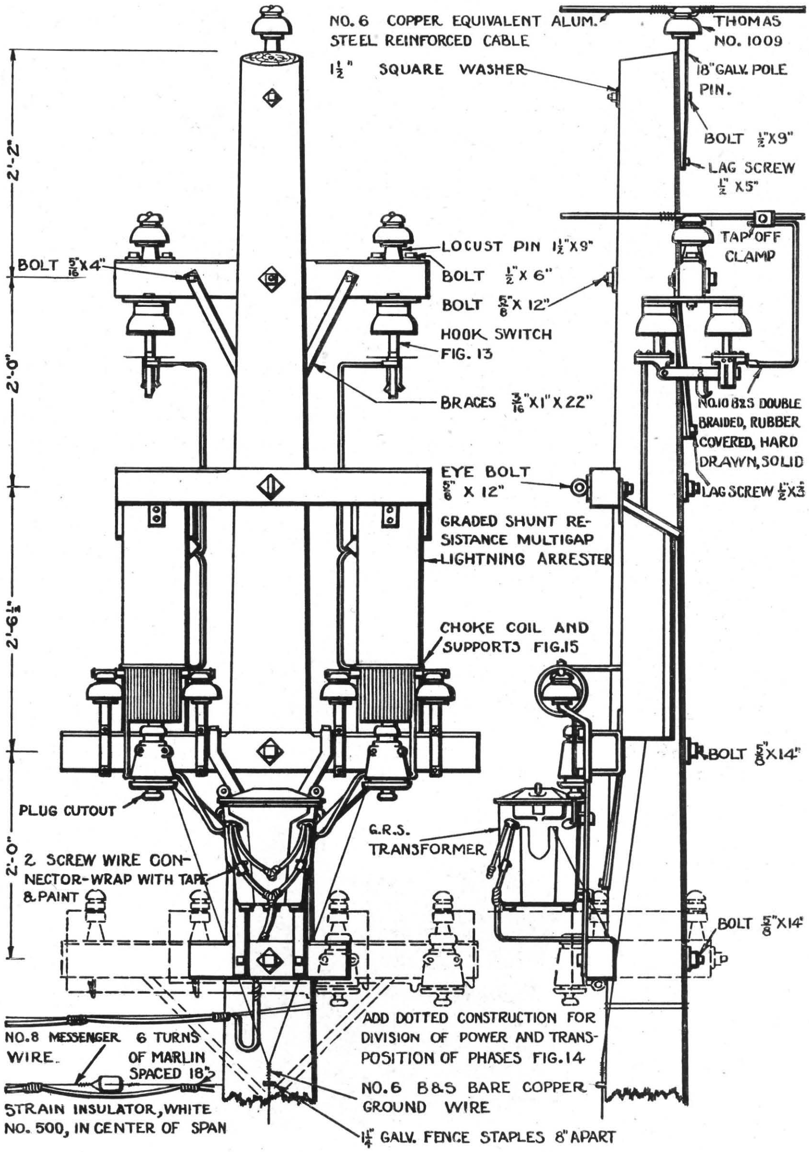


Fig. 42 Transformer Pole Construction

Track Transformers

TO make the installation as simple as possible and to minimize danger to the maintenance force, the various voltages required for lighting, track circuits, etc., are not obtained from the main transformer, but from a track transformer with a voltage of 110 on the primary side. This arrangement requires but two wires from the pole line to the relay box, and the maintainer is not required to work in close proximity to the high-voltage line when making adjustments and inspecting apparatus. This additional safety and simplicity is believed to more than offset any loss that might be due to the use of two transformers.

The track transformer, Fig. 43, is the General Railway Signal Company's Type "K_1", which is provided with a 110-volt primary and two secondary windings, one of 110 volts for supplying the local phase of relays and the other arranged with taps from one to fifteen volts for feeding the track circuits and signal lights. Greater protection against the burning out of relay locals by lightning is secured by the use of a 110-volt secondary on the track transformer. The average voltage required for a two-mile track circuit is 8 volts. The signal lights are operated on 10 volts.

The track transformer is air cooled; it is small and compact, being enclosed in a neat iron case with A.R.A. standard terminals on the cover. It may be wall or shelf mounted, but in this installation, all track transformers are mounted on the inside wall of relay cases near the top.

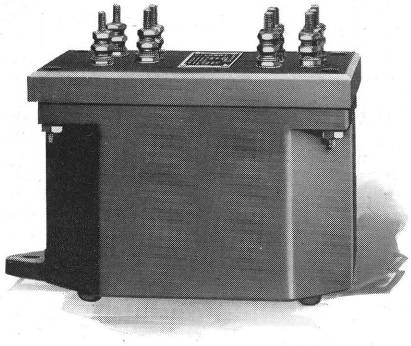


Fig. 43 Type K_1, Track Transformer

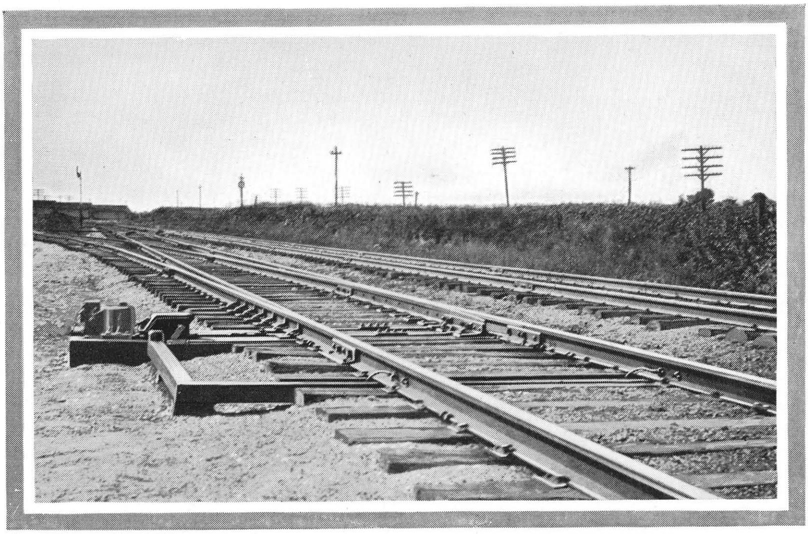


Fig. 44 Typical Switch Layout

Switch Boxes

CIRCUIT controllers, or switch boxes, shown in Fig. 44, are attached by means of $\frac{5}{8}$-inch adjustable rods to the normally closed points of all non-interlocked switches. They are also used on all side track derails not pipe-connected to main track switch stands. These switch boxes are the General Railway Signal Company's Model 5 as listed in their catalog Plate K0103, Fig. D, and are designed so that all parts are accessible and readily adjusted. Four normal and four reverse contacts are provided in a separate compartment, which is furnished with supplemental cover. They are thus protected from frost and condensation and, when the main cover is open, from rain. The contacts are arranged so that they will make or break when the switch points are moved from the closed position $\frac{3}{16}$ of an inch for facing point switches and $\frac{1}{4}$ in. for trailing switches. The contacts are mounted on slate, so that they can be removed without changing the contact adjustment. They are forced open or closed without reliance upon spring action. The binding posts are in a separate compartment and are A.R.A. standard.

Track Insulation

Joints

Compared with a d.-c. system of signals, there was a considerable less number of insulated rail joints required. The joints were of the Continuous one-end type for main line and Weber full-insulated type for crossovers and switches. They were manufactured by the Rail Joint Company.

Switch Rods

The work of insulating the switch rods, gage plates, etc., was done by the railway company's forces; the force being moved from place to place and the work performed in the field. Holes were punched and the switch rods cut by means of a portable hydraulic punch and shear. This tool proved very valuable in that it enabled the work to be done rapidly and economically. The type of switch rod insulation is shown in Fig. 45. This type permits the use of the ordinary switch rod without any special parts other than the plates, bolts and fibre parts which are A.R.A. standard. The bend in the switch rod, shown in Fig. 45, is provided so that no part of the bolts will project above the top of tie to be a menace to workmen or others walking on the track.

Gage Plates

No insulation was used upon the gage plates, instead, about 6 inches was cut out of the middle of the plate and the ends of the plate securely fastened to the tie with lag screws.

Trunking

All trunking used was cypress or yellow pine 3 in. by 4 in. in section, and before being installed was treated with two brush coats of Avenarious Carbolineum preservative compound in lieu of paint. This compound gives a very pleasing brown finish to the trunking, and, as tests have shown that it has no deteriorating effect upon the

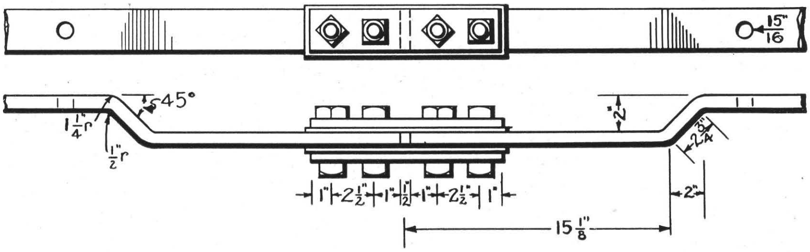


Fig. 45 Insulated Switch Rod

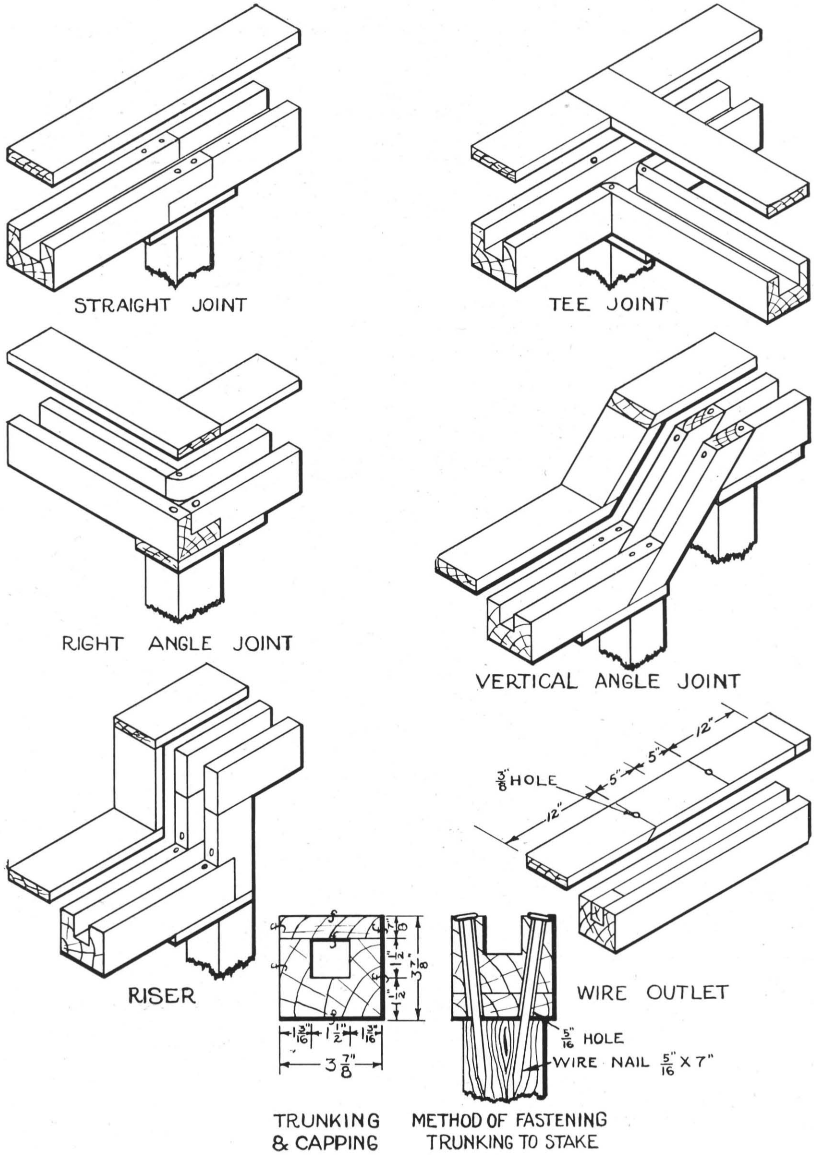


Fig. 46 Trunking Construction

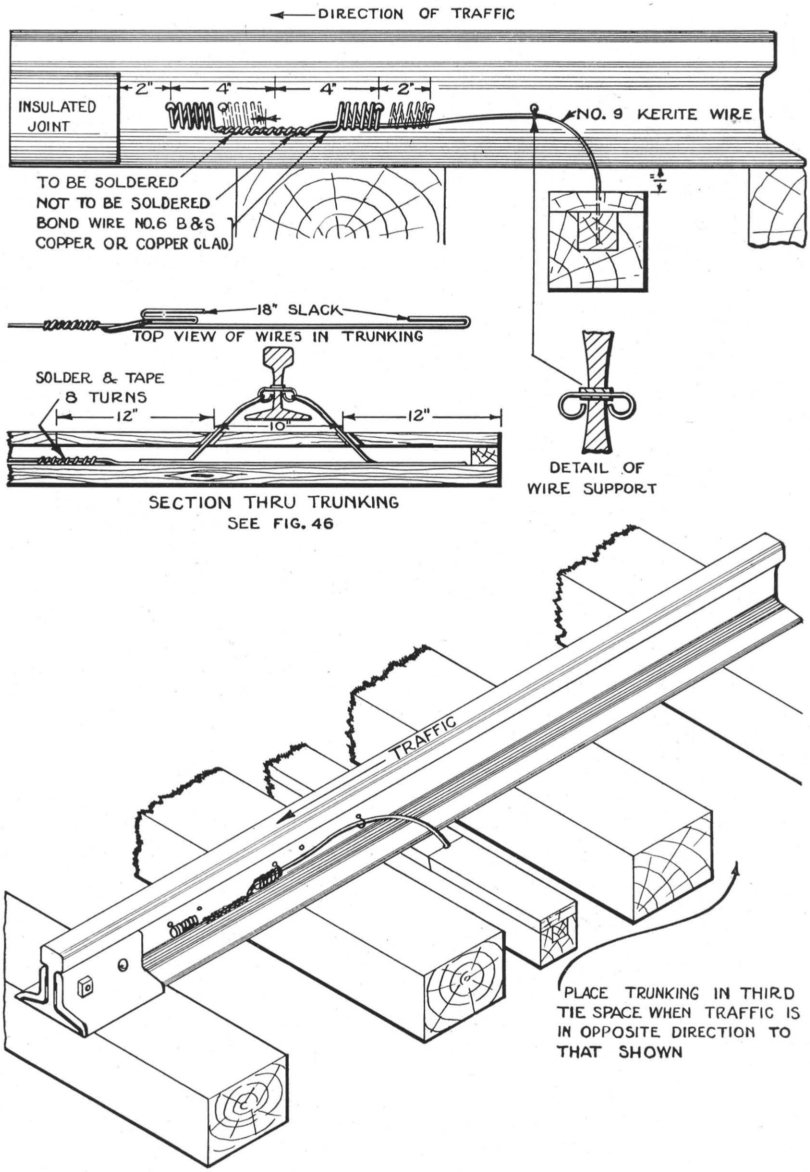


Fig. 47 Rail Connections

rubber insulation of the enclosed wires, it is believed that it will materially prolong the life of the trunking and prove more economical than painting. All trunking is supported by a short length of capping upon cedar stakes not over 5 feet apart. As the trunking is not buried beneath the ballast, particular care was taken with the carpenter work, in fitting, so as to make as neat an installation as possible.

Wire

No wire smaller than No. 14 B & S gauge is used and the thickness of wall of rubber insulation is in accordance with the recommendations of the A.R.A., each wire being covered with one layer of tape and one braid. Joints and splices are made as shown in Fig. 48.

Number and size of wires used for various purposes are as follows:

Insulated Wires.	
Signal control wires	No. 14 B & S
Transformers to rail	No. 9 B & S
Relays to rail	No. 9 B & S
Fouling shunt wires, 2 to each rail	No. 9 B & S
Switch circuit-controller connections, 2 to each rail	No. 9 B & S
Line to cable post, overhead, cabled and supported to messenger wire by marlin	No. 12 B & S
Terminals to relays, etc., stranded	No. 14 B & S
Choke coils	No. 10 B & S
P. C. wires in signal mast	No. 12 B & S
Line Wire	
Copper clad steel, bare	No. 12 B & S
Aluminum strand, bare, steel center	No. 4 B & S
Ground Wire	
Copper S. D. bare	No. 6 B & S
Guy Wire	
1/4″ stranded steel wire, galv.	
Messenger Wire	
No. 8 steel galv.	

All insulated wire and cable was manufactured by the Kerite Insulated Wire and Cable Company, New York.

Bonding

Two 48-inch No. 6 Copper Clad steel wires were used on the gauge side of the rail behind the angle bars for bonding rail joints, Fig. 49. Through platforms and road crossings, four No. 6 Copper Clad steel wires were used, two on either side of the joint outside of the angle bars. Tin-coated channel pins were employed throughout.

Bootlegs

Standard bootlegs or rail connections were made as shown in Fig. 47. The bootleg consists of a piece of capping with two holes bored in it, at an angle, and then sawed through the holes making three short pieces, and the wires arranged as shown. It will be noted that there is an independent connection to both sides of the rail and that the parts are very low so that there is practically no chance for these connections to be broken by dragging equipment.

Signal Wiring

Wires from the relay boxes to the signal mechanisms are carried through iron conduit into the mast in each case, then up the interior of the mast and out to the mechanism case through a length of steel-armored flexible Sprague conduit, making a very neat and permanent construction.

Track Wiring

Fig. 50 shows typical track wiring at switches. It will be noted that the signal control wires are not carried through the switch circuit controller on double track, but the signal is controlled by the switch through the track circuit entirely. Trailing point switches shunt the track circuit while facing point switches both break and shunt the track circuit. On single track the switch control of the signals is secured by carrying the signal wires through the switch circuit controller. The track circuit is not shunted.

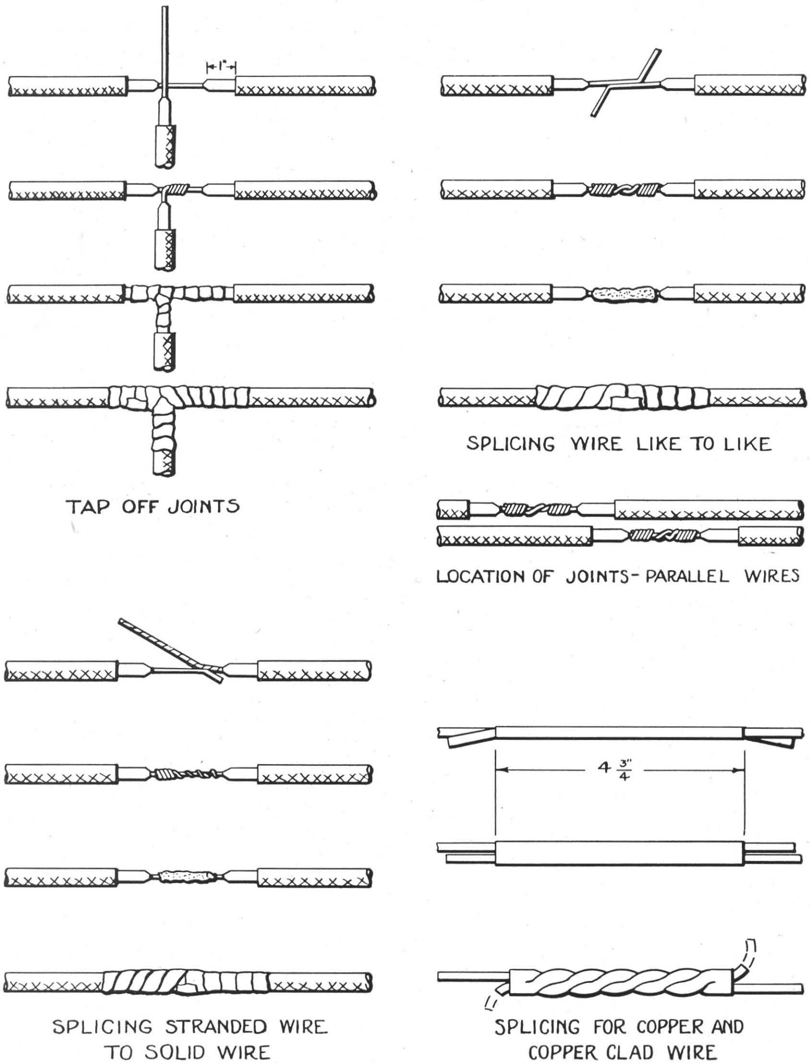


Fig. 48 Joints—Low Voltage Wires

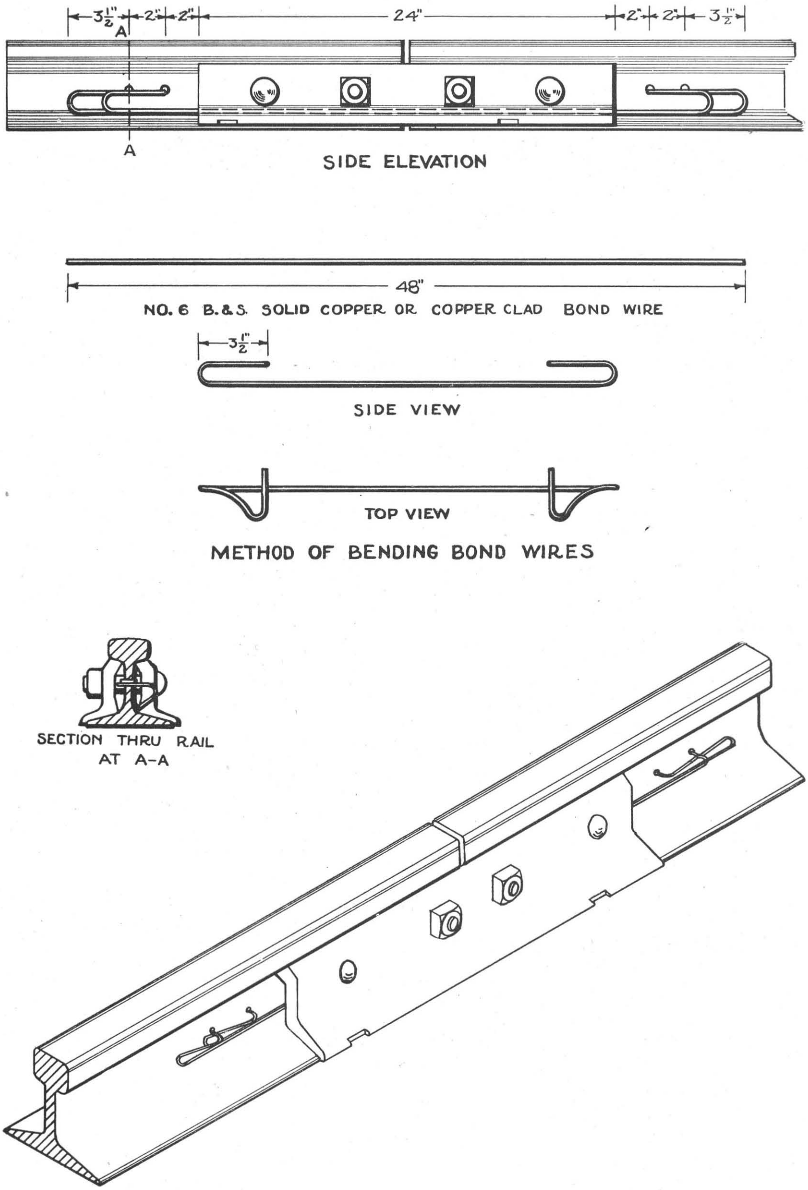
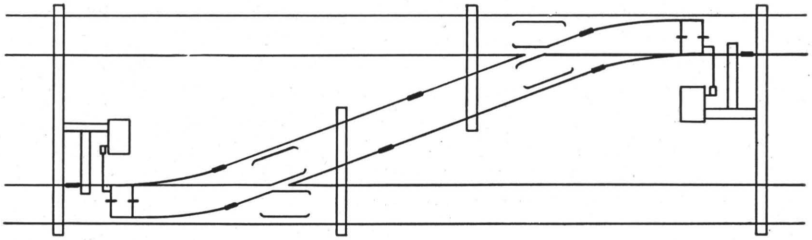
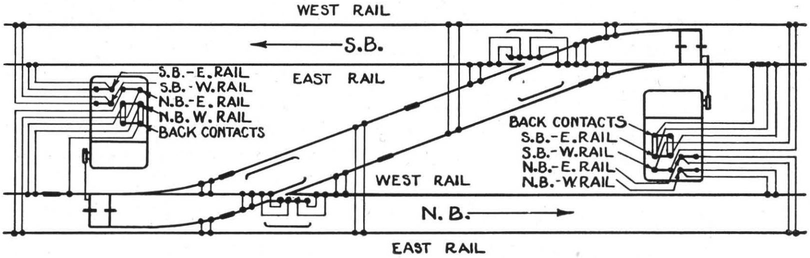


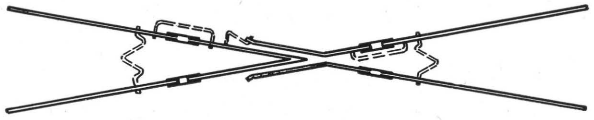
Fig. 49 Rail Bonding



LAYOUT OF TRUNKING



WIRING DIAGRAM



METHOD OF BONDING FROGS

Fig. 50 Wiring for Facing Point Crossover

Interlocking Plants

TYPICAL views of interlocking plants throughout the automatic signal territory are shown in Figs. 51 and 52. The plants vary in size from 8 to 42 levers and have been equipped with approach and route locking as well as annunciators which indicate the arrival of trains at the second automatic signal from the plant in each direction. All of the mechanical machines are of the S & F type and the signal indications, both high and dwarf, are given in the upper quadrant; 3 pos., for the high signals and 2 pos., O and 45 degrees only, for the dwarf signals.

At Charlottesville, Va., where the C. & O. R. R. crosses the Southern, an all-electric interlocking plant was installed. The machine is a 72 lever, G-R-S Model 2, unit-lever type, 110 volts d.-c., equipped with individual polarized relays, approach, route and detector locking. An illuminated track diagram of the miniature light type is mounted 2 feet above and to the back of the machine, which gives an unobstructed view from any position in front of the machine. The high signals are all top-of-mast, Model 2A, 110 volts d.-c., and the dwarf signals are Model 3, solenoid type, 110 volts d.-c. Alternating-current power is obtained from the transmission line through transformers and used for the track and detector circuits, lighting the tower and signals, and for operating the motor generator set for charging a set of Edison Storage batteries for the d.-c. circuits.

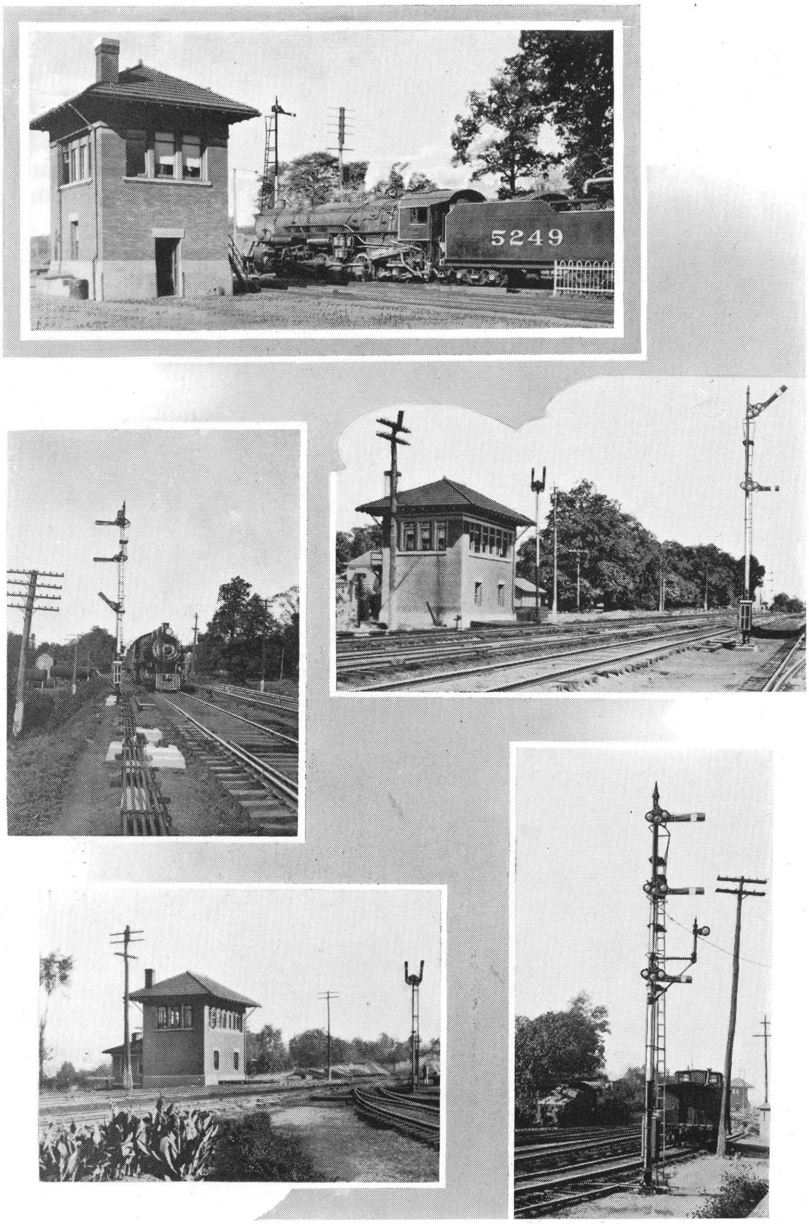


Fig. 51 Interlocking Plants

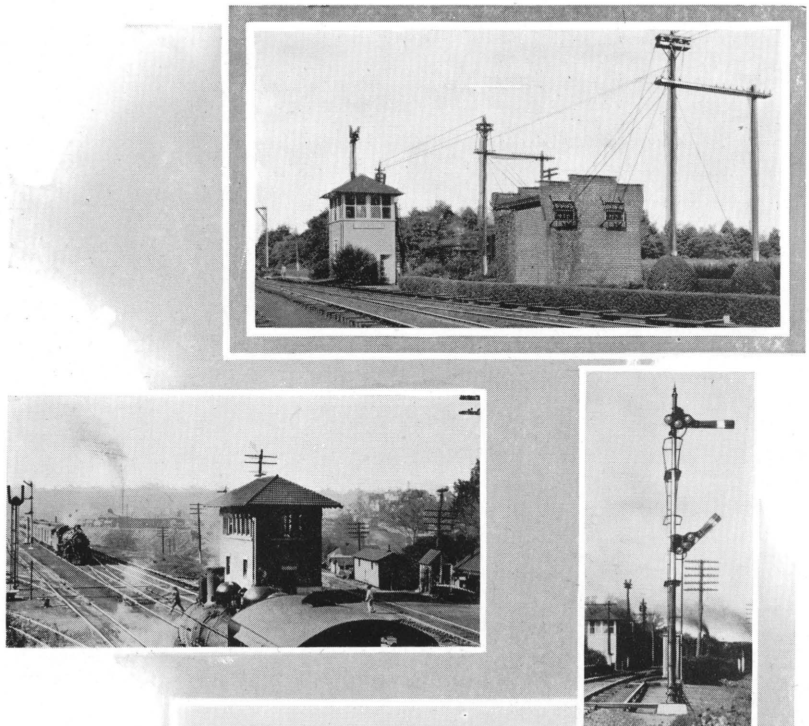


Fig. 52 · Interlocking Plants

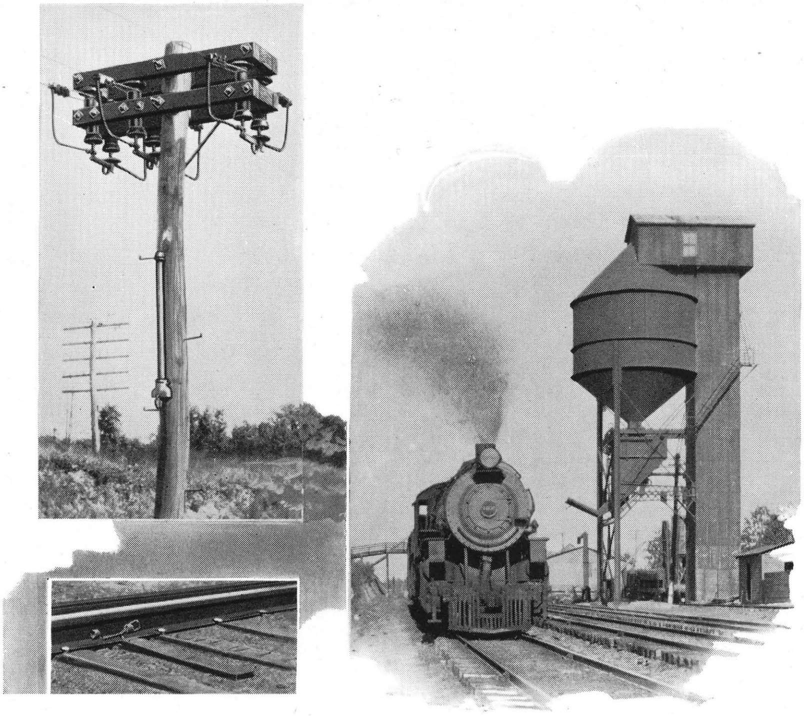
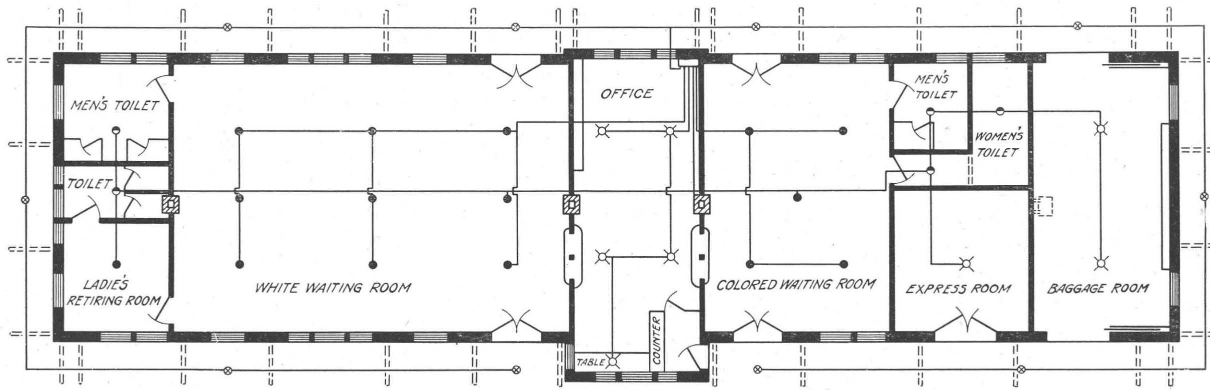


Fig. 53 Sectionalizing Switches
Coal Chute—Lula, Ga.

Electrically Operated Coal Chute at Lula, Ga.

THIS coaling station, Fig. 53, is operated from the signal transmission line. It has a capacity of 300 tons consisting of one overhead coal storage pocket of 285 tons capacity and one overhead scale pocket of 15 tons capacity, and is known as the "V" bucket conveyor type. The foundation and receiving hopper are of concrete, and the super-structure is of steel. It is designed so that engines can be coaled from two tracks. One track is located directly underneath the coaling station and one on the side. The coal is brought in on the receiving track and is dumped from hopper bottom coal cars or from center and end dump gondolas into a receiving hopper located directly underneath receiving track. It is then automatically conveyed from the hopper to elevating machinery and elevated to the overhead storage bin. From the storage bin, the coal runs by gravity to scale pocket from which it is delivered to engine tenders by means of steel aprons. The elevator which conveys the coal from the receiving hopper to the storage bin has an elevating capacity of 50 tons of coal per hour. It consists of 24 in. by 30 in. "V" buckets mounted on two strands of roller chain and travels at a speed of about 100 ft. per minute. The coaling station is operated by means of a Fairbanks Morse 15 hp., Type "D", squirrel cage motor, 900-rev. per min., 60-cycle, 3-phase, 220 volts, with type C C starter, the motor being located in monitor of coaling station. The current for operating the motor is furnished from the signal transmission line, stepped down to 220 volts, 3 phase, with three 5-kw. transformers.

The general illumination consists of ten 100-watt Nitrogen lamps in Benjamin Reflector sockets No. 5402. The scale beams are lighted with three 40-watt lamps in Crouse-Hinds receptacles No. CC-227. The pit is illuminated with two 40-watt lamps in G. E. portable lamp guards No. 42681.



ALL WIRING CONCEALED EXCEPT FOR OUTSIDE LIGHTS.
PANEL BOX LOCATED IN OFFICE AT MOST CONVENIENT POINT.
DEEP CONE TIN SHADES IN OFFICE.
WIRE GUARDS IN BAGGAGE AND EXPRESS ROOMS.

● = A.B. UNIT FIXTURE #G25—40 WATT MAZDA LAMP.
⊖ = CEILING RECEPTACLE FLAT TIN SHADE, 25 WATT MAZDA LAMP.
⌧ = DROP LIGHT, 40 WATT MAZDA LAMP.
⊗ = WEATHER-PROOF SOCKET—40 WATT MAZDA LAMP

Fig. 54 Typical Arrangement of Lighting at Stations

Station Lighting

A REGULAR 600-va. transformer identical with the signal transformer is used for lighting each of the smaller stations and a General Electric Type "H" single phase transformer is employed at each of the larger stations. The G. E. Type "H" transformers vary in capacity from three to ten kilowatts. All transformers are designed in accordance with the requirements of the A. I. E. E. as regards heating, insulating, etc.

All of the stations not already wired for electric lights were wired by the railway company forces. Two different methods were used in carrying the low tension wire from the transformer to the buildings. Where the transmission line was on the same side of the track as the station, the wires were carried directly through the air from the transformer to the station, no messenger wire being used. At stations where the transmission line is on the opposite side of the track from the station, a pole was set on the station side and the lighting wires carried over the tracks into the station or the wires were run in conduit beneath the tracks.

All station wiring was done in compliance with the rules and regulations of the National Board of Fire Underwriters. Knob and tube or open cleat wiring was installed in the smaller stations and conduit work in the larger stations. Rubber covered N. C. S. copper wire was used for mains and branches and heavy reinforced cord for drop lights. Waiting rooms were equipped with ceiling fixtures and holophane reflectors. Mazda lamps ranging from 25 to 150 watts were used for all lighting, the former being used in the majority of outlets and the latter to replace enclosed arc lamps. A typical station wiring plan is shown in Fig. 54.

Practically all of the railway company's buildings such as stations, gate houses, interlocking towers, etc., were equipped with electric lights. The cost of wiring was small. In a number of instances, the transformers provided for the operation of a signal adjacent to the station are also used for lighting the station. The total saving over the use of oil lamps and including the difference in the cost of electricity at the stations where it was previously purchased from the local light companies is amounting to about $3,000.00 per year.

Temporary Lighting for Maintenance of Way Department

A VERY important feature of an alternating-current signal installation is the many uses that may be made of the current from the transmission line. One of these uses has been the providing of illumination for emergency work. An installation made for illuminating the site of a burned bridge so that night work could be carried on continuously was so satisfactory that arrangements were immediately made to equip the wrecking train with a transformer and two 500-watt flood lights. Suitable connectors and fuses are provided so that light can be had at any point desired by simply making temporary connection to the transmission line. This is done without interference with the signals, and the arrangement has proved very useful on several occasions.

Tunnel Lighting

Figure 20 shows the end of a tunnel where a permanent installation of lighting has been made for the protection and convenience of track workers. The lights in weatherproof sockets are installed at intervals along the side of the tunnel and are controlled by two 3-way switches, one at each end so that the lights can be lighted or extinguished from either end of the tunnel. The construction shown in Fig. 7 is now used for dead-ending the line instead of as shown in the photograph, Fig. 20.

Construction

The transmission line was built by the Railway Company forces and, so far as known, is the longest (667 miles) in the United States, if not the longest in the world. This force was provided with two motor cars, a large gang car, and a small three-man car. The cars were of great assistance, the large car in transporting men and material, and the small car in enabling the foreman to oversee all parts of the work, the men in the gang being often spread out over four or five miles of territory. Cross-arms, pins and insulators were applied to the poles before erection, the poles having previously been dropped from a work train at the location marked. All poles were erected and guyed before any wire was strung. The stringing of the wire was done at a very rapid rate on account of the light weight of the aluminum strand and the ease with which it could be handled.

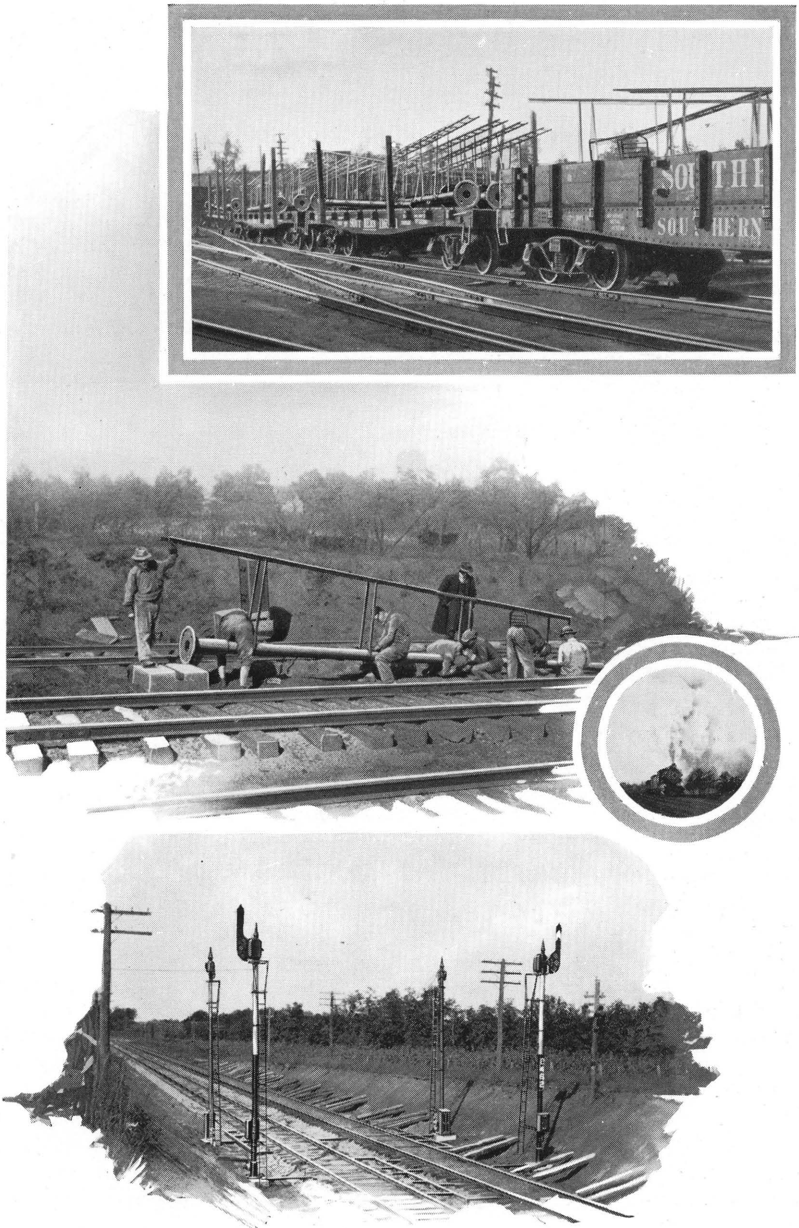


Fig. 55 Construction Views

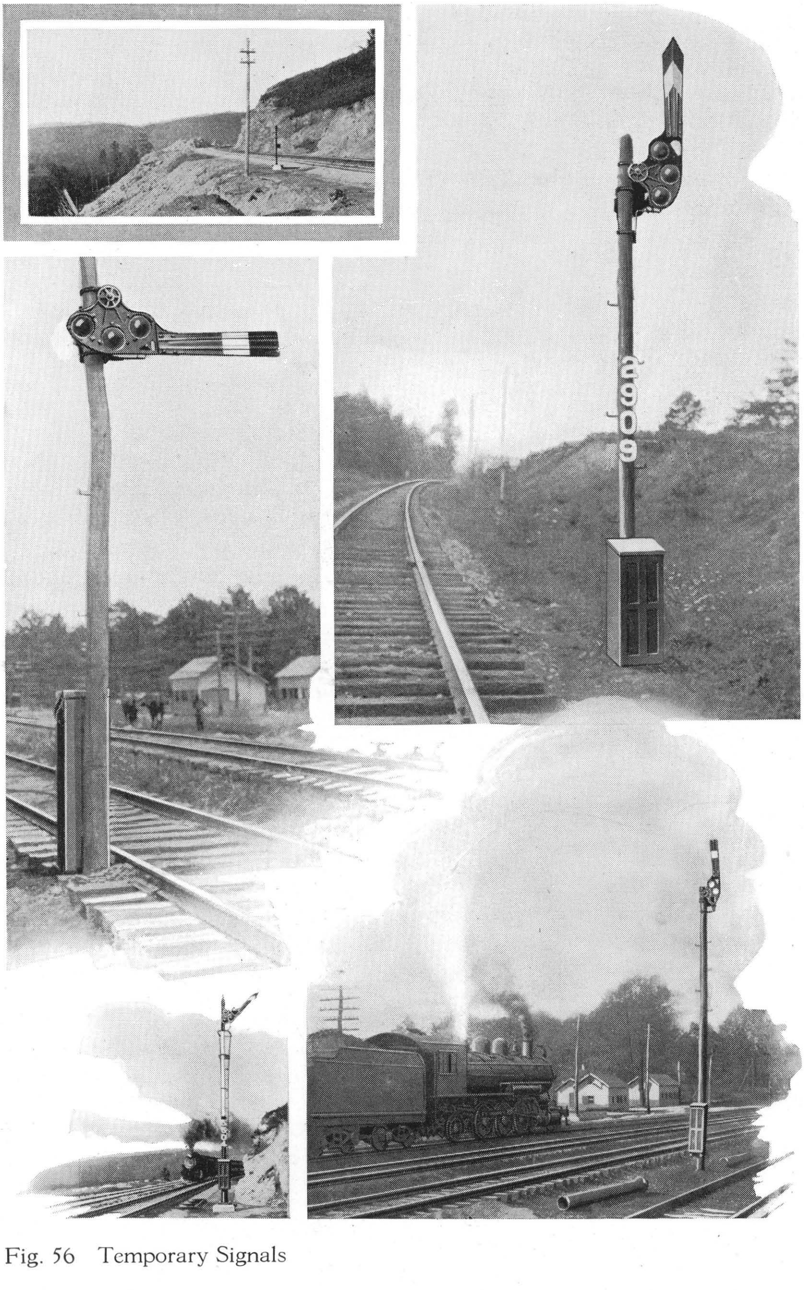


Fig. 56 Temporary Signals

The ¾-mile coils of wire were placed on the large motor car and all three-phase wires erected at the same time. The work in connection with switch rods, pipe line insulations and electric wiring for all depots, towers and buildings on the railway's right-of-way was done by the railway company's own forces. The General Railway Signal Company furnished all of the signals, relays, switch boxes, signal transformers, signal material and the necessary labor for their installation.

A simple form of graphical progress report was devised (Fig. 58), and upon this was shown the various details of the work and divisions corresponding to the mile posts. A very few moments' work enabled the general foreman to indicate upon this form all of the details of work done the previous week and just where it was performed.

This was done by supplying him with a copy, blue printed on cloth, and at the end of each week, he marked on the chart in red the work completed between the appropriate mile posts. The report was sent in to the office where the week's work was transferred to a permanent record, the red lines covered with black ink and the print returned to the foreman for his use the following week.

He thus used the same blank for the entire job. This method required him to mark only the current week's work instead of all previous work done as is the usual way when graphical progress reports are used. The report saved a large amount of letter writing and the state of the work on all sections could be seen at a glance.

Temporary Signals

While constructing the second main track along the line where single track A. P. B. block signals were in service as well as at places where traffic was temporarily diverted due to the second track construction, it became necessary to change signal locations on very short notice. The work was greatly simplified by using the top-of-mast mechanisms which could be quickly mounted on a telegraph pole set in the ground thus avoiding the necessity of iron poles on concrete foundations. In a few instances even a telegraph pole was not available, in which cases a tree was cut and the Model 2A mechanisms clamped to its trunk. With the number plate and relay box fastened to the pole, a signal in complete working order was thus secured in a very short time. The men took much pride in seeing how short a time would be required to install a signal or move one to a temporary location without delay to traffic. It was only a matter of minutes at times and these temporary arrangements gave splendid service. Some of them are shown in Fig. 56.

Placing in Service

ABOUT two weeks before the signals were placed in service, a bulletin plan showing signals, switches, mile posts, signal aspects, etc., was prepared and posted upon all bulletin boards on all divisions concerned. In addition to the plan, a printed set of rules, based on the Standard Code, was issued to all trainmen.

After a study of the plan and printed rules had enabled the trainmen to become familiar with the location of the signals and the governing rules, meetings were held by the superintendent with the employees affected to insure that all understood the indication of the signals and the rules. Twenty-four hours before the signals were placed in service, a 31 order was issued to all trains notifying them that after a certain hour trains would be governed by the signals. The sections, as they were put in service, varied from five to fifty miles in length and were placed in operation without confusion of any kind.

Maintenance Forces

On account of the double track work being put in service in sections which varied in length and since such sections were not always adjacent, the maintenance force has been shifted and re-arranged several times but always with the final scheme in mind.

For the total 700 miles of automatic signals together with the 12 interlocking plants, 25 signal maintainers and 22 assistant maintainers are required.

The men are so located that they can be reached quickly by dispatcher and one of them is always able to reach, almost immediately, the site of any trouble. These men also look after the electric lighting of the stations and other electric work on their sections.

Six Signal Supervisors have direct jurisdiction over the Maintainers and are in complete charge of signal maintenance and construction on the main and branch lines in their respective territories.

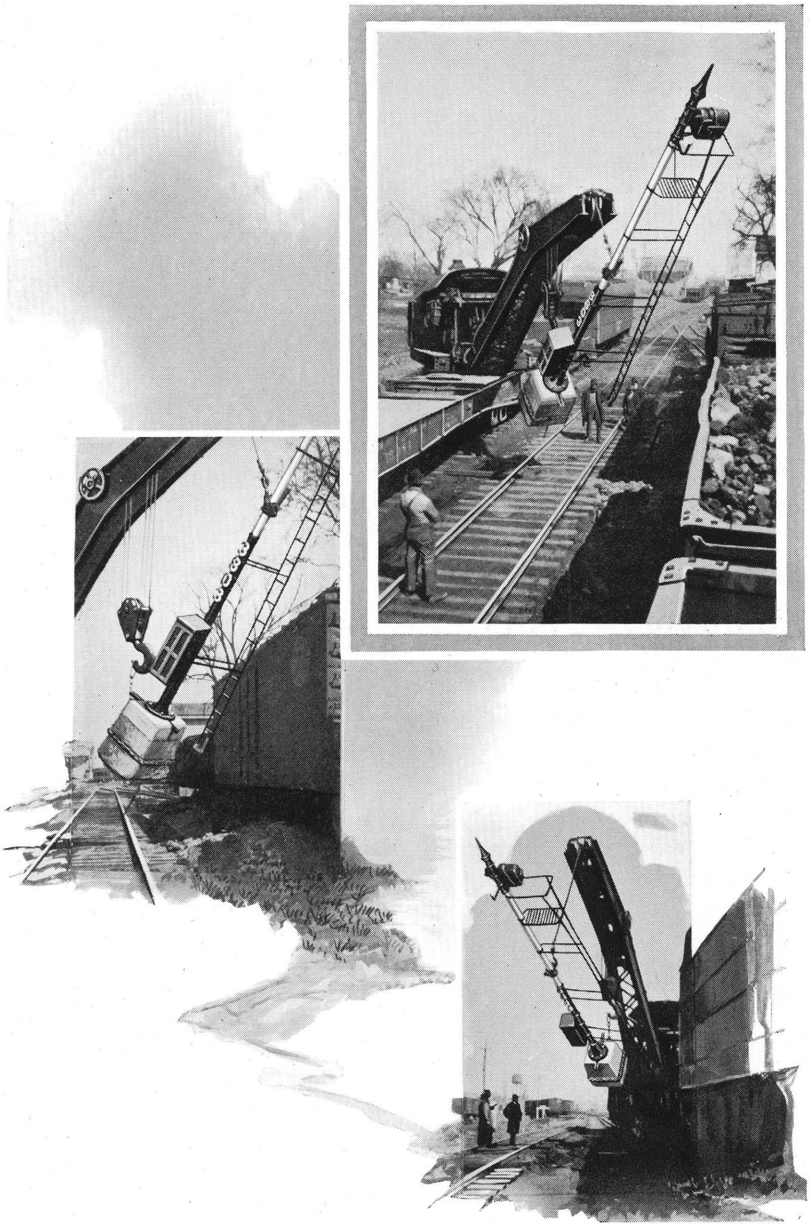


Fig. 57 Construction Views, Moving Signals

SOUTHERN

AUTOMATIC SIGNAL PROGRESS REPORT

MILES FROM WASHINGTON	623	DULUTH 622	621	STRICKLAND CROSSING 620	619	618	SUWANEE 617	616	WORK COMPLETED WEEK ENDING	
SIGNALS LOCATED										
POLE LINE STAKED										
POLES DISTRIBUTED										
POLE TOP PINS CEMENTED										
HOLES DUG										
POLES SET										
ANCHOR RODS SET										
CROSS ARMS DISTRIBUTED										
CROSS ARMS ON POLES										
POLE TOP PINS IN PLACE										
INSULATORS ON PINS										
POLES GUYED										
LIGHTNING ARRESTERS IN										
SECTIONALIZING SWITCHES IN										
HIGH TENSION WIRES UP										
LOW TENSION WIRES UP										
POLE LINE COMPLETED										
SWITCH RODS INSULATED										
TIE PLATES CUT										
STATIONS WIRED										
INSULATED JOINTS DISTRIBUTED										
INSULATED JOINTS INSTALLED										
SAND AND STONE DISTRIBUTED										
CEMENT DISTRIBUTED										
SIGNAL FOUNDATIONS DUG										
SIGNAL FOUNDATIONS IN										
CABLE POLE FOUNDATIONS IN										
SWITCH BOXES DISTRIBUTED										
SWITCH BOXES INSTALLED										
SIGNAL MASTS DISTRIBUTED										
FITTINGS DISTRIBUTED										
FITTINGS ON MAST										
MAST SET										
TRACK BONDED										
TRUNKING IN PLACE										
TRUNKING PAINTED										
TRANSFORMERS DISTRIBUTED										
TRANSFORMERS INSTALLED										
RELAY BOXES INSTALLED										
RELAY BOX FITTINGS IN										
TRACK WIRING COMPLETED										
OVERHEAD WIRING COMPLETED										
SIGNALS WIRED										
SIGNALS PAINTED										
BLADES FITTED										
SIGNALS TESTED										
SIGNALS IN SERVICE										
GRADING COMPLETED										

SPECIAL WORK	% COMPLETED		

Fig. 58 Progress Report

Method of Maintenance

THE supervisors, maintainers and assistant maintainers have been provided with motor cars which have been of great assistance in obtaining satisfactory maintenance and prompt clearing of failures.

Each Maintainer has been provided with a Signal Department standard tool and store house. This is a frame building 12 ft. by 30 ft. with two rooms. At one end, a 9 ft. by 12 ft. room is used as a combination office and supply room for the smaller articles of stock. This room is equipped with a stove, writing table, testing rack, locker and shelves for stationery. The larger room is used for storing heavy material and for working in inclement weather. It is provided with work bench, racks, bins, and shelves for material. It is entered from the center by means of a large sliding door which will admit the maintainer's motor car. The car is run into the house over removable rails so that it is placed in the center of the building where it is accessible from all sides for overhauling and repairing. It is stored in this position clear of all material and can be quickly placed in or removed from the house.

All of the compartments, bins and shelves are numbered in accordance with a standard plan and each space is used for a specific material or part and no other. The amount of each kind of repair material for a maintainer's section has been standardized and a list giving the bin number, the catalogue reference and the quantity to be kept on hand is furnished each man. A glance at the list and a glance at the corresponding bin enables one to know at once the amount of stock carried and if the proper material is at hand. The standard list which is employed in reporting material used and wanted has materially lessened the amount of clerical work required of the maintainers. It has also resulted in better handling of material since no useless surplus stock is carried at any point and there is no likelihood of a maintainer overlooking needed material when making up his monthly requests. Providing a place for each item has resulted in the men taking great pride in keeping their storehouses in a remarkably clean, orderly and neat condition.

A standard set of tools is furnished each maintainer in accordance with the list appearing on Pages 94 to 97 inclusive. Except for pliers and small screw drivers which each man provides to suit his individual preference, the standard list of tools includes everything necessary for efficient performance of the work.

The efforts of the Management of the Southern to provide the maintainers with adequate material, tools, motor cars, work and storehouses and other facilities for doing their work under favorable conditions has been justified by the efficient and satisfactory service now being obtained from the signal system.

Change in Color Signals

EXCEPT for a distance of about 50 miles, all of the signals had been put in service using white for the proceed color. Early in 1919 the use of green for proceed was authorized for the System and as rapidly as material could be obtained all signals, markers, switch lamps, etc., were changed to conform to the new proceed color. Due largely to a thorough preparation, this work was done rapidly and without confusion of any kind, although each operating division was changed in a single day. The preliminary work was as follows:

Bulletins were printed in colors and distributed to practically all employees previous to the change. Enough surplus switch and marker lamps were equipped with the new colored lenses to supply the first Division; globes were provided for the necessary colored hand lanterns; bezel rings were taken off of the signal spectacles, nuts loosened and oiled and the yellow roundel inserted in the extra bezel ring and left in the relay case. Necessary changes were made in the spectacles of the train order signals.

All of the automatic and interlocking signals had already a standard three-light spectacle casting so it was only necessary to procure a yellow roundel for each signal, move the green roundel and insert the yellow in its place. This was done by the signal maintainers on the day designated, the section men changed the switch lamps and repainted the switch targets, and at terminals, trainmen were supplied with new markers.

The lamps replaced were sent to the Railway Shop where they were overhauled and new lenses supplied. These were used on the second division and the work performed on a division at a time until the entire system was covered.

Records

A CARD index is maintained in the office of the Signal & Electrical Engineer with a card for each signal. The card gives the type, date of installation and other characteristics of the signal. Each failure is entered in this record monthly from the report so that a complete history of each signal is always available. Many of the signals have an absolutely clear record after over eight years of serivce.

Enginemen are provided with a supply of postal card forms for reporting detentions due to signals. When a detention occurs, one of these cards is filled out and left at the first open telegraph office where the information is sent to the dispatcher by wire and he notifies the maintainer. The operator mails the Enginemen's report to the Signal & Electrical Engineer where all records are kept and it is checked against the maintainer's daily report.

Maintainers forward a report each day whether they have had any failures reported to them or not and on this report they give the details of all work done at signals and at other points during the day. It is believed that by the method outlined a very accurate record of the performance of each signal is obtained.

The average number of operations per signal failure is 44687.

Standard List of Tools for Signal Maintainers

1 Axe, 4½ lb. with CX handle, S. H. Co., No. 14054.
1 Axe handle, S. H. Co., KNB No. 4.
1 Adz, carpenter, S. H. Co., KC No. 3½.
1 Bit, auger 9 in., Set, S. H. Co., No. KSB-13.
2 Bits, ship auger, 18 in. 9/16 in., S. H. Co., No. KSC-9.
2 Bits, ship auger, 18 in. 11/16 in., S. H. Co., No. KSC-11.
1 Bit, expansion ⅞ in., to 3 in., S. H. Co., No. KKL.
1 Brace, ratchet, 12 in., S. H. Co., No. 8012.
2 Belt, body, 2¼ in., M. K. & S. No. 384.
1 Belt, safety, 1¾ in., M. K. & S. No. 384.
1 Bar, tommy.
1 Bar, digging, M. K. & S. No. 418B.
1 Bar, tamping, M. K. & S. No. 397.
1 Bar, claw, Southern standard (Interlocking only).
1 Block with hook, 3 in. double sheave for ⅜ in. rope, S. H. Co., No. WD-7.
1 Block with becket, 3 in. double sheave for ⅜ in. rope, S. H. Co., No. WD-8.
1 Block with hook, 5 in. double sheave for ¾ in. rope, S. H. Co., No. WS-13.
1 Block with becket, 5 in. double sheave for ¾ in. rope, S. H. Co., No. WS-14.
2 Bags, tool, S. H. Co., No. K-20.
2 Brushes, wall, 4 in., S. H. Co., No. 340-R.
2 Brushes, round, 1 in., S. H. Co., No. 24-B.
1 Brush, stencil, S. H. Co., No. 60.
1 Bellows, hand, S. H. Co., No. H-8.
1 Broom, hand, Southern standard.
2 Climbers, (2 prs.), M. K. & S. No. 382.
2 Climbers, straps (2 sets), M. K. & S. No. 382.
1 Chisel, wood, ¼ in., S. H. Co., No. KA-¼ in.
1 Chisel, wood, ¾ in., S. H. Co., No. KA-¾ in.
1 Chisel, wood, 1¼ in., S. H. Co., No. KA-1¼ in.
6 Chisels, cold, ⅞ in. by 7¼ in., S. H. Co., No. E-78.
1 Chisel, track, Southern standard.
1 Can, oil, 9 in. curve, S. H. Co., No. 4009.
1 Can, oil, 4 in. straight, S. H. Co., No. 3004.
2 Cans, jacket, bent spout, S. H. Co., No. 605.
1 Cutter, pipe, Beaver, No. 5 (Interlocking only).
1 Cutter, extra for Beaver No. 5 pipe cutter (Interlocking only).
2 Clamps, splicing, for No. 6 aluminum stranded.
1 Clamp, splicing, for No. 6 wire and smaller, M. K. & S. No. 309-E.
1 Clamp, saw, S. H. Co., No. 3.

1 Drill press, upright, self feeding, $\frac{1}{2}$ in. straight shank drills, without pulley, No. 4, Fig. 6598, F. M. Co. (Interlocking only).
1 Drill, breast, Fig. 6572, F. M. Co.
2 Drill machine, bonding, Buda Wilson, high duty.
1 Drill, ratchet, 12 in. square shank, S. H. Co., No. 12.
1 Drill, for drill press, 1 set $\frac{1}{4}$ in. to $1\frac{1}{2}$ in. straight shank No. 112, Fig. 5828 F. M. Co. Sizes as follows: $\frac{1}{4}$ in., $\frac{3}{16}$ in., $\frac{5}{16}$ in., $\frac{7}{16}$ in., $\frac{1}{2}$ in., $\frac{9}{16}$ in., $\frac{5}{8}$ in., $\frac{11}{16}$ in., $\frac{3}{4}$ in., $\frac{13}{16}$ in., $\frac{7}{8}$ in., 1 in., $1\frac{1}{16}$ in., $1\frac{1}{8}$ in., $1\frac{1}{4}$ in. and $1\frac{1}{2}$ in. (Interlocking only).
1 Drill, for breast drills, 1 set $\frac{1}{32}$ in. to $\frac{1}{2}$ in., sq. shank.
48 Drills, bonding, $\frac{9}{32}$ in. high speed, Whitman & Barnes.
1 Drill, for ratchet, $\frac{9}{16}$ in., $\frac{11}{16}$ in., $\frac{13}{16}$ in., $1\frac{1}{16}$ in.
1 Deadman, M. K. & S. Co. No. 3950.
1 Furnace, soldering, C. & L. No. 5.
1 Funnel each—1 pt. and 1 qt.
2 Files, 8 in., round, smooth.
2 Files, 10 in., round, bastard.
2 Files, 8 in., flat, smooth.
2 Files, 10 in. flat, bastard.
2 Files, 8 in. square, smooth.
2 Files, 10 in., square, bastard.
1 File, wood rasp, 12 in.
2 Files, saw, 9 in., reversible.
2 Grips, new Chicago, No. 0 and smaller.
2 Grips, new Chicago, No. 6 and smaller.
1 Grinder, hand emery, Belknap No. 5.
2 Hammers, machine, $2\frac{1}{2}$ lb., S. H. Co., No. HK-4.
2 Hammers, machine, 2 lb. (Interlocking only).
1 Hammer, claw, S. H. Co., No. E-1.
1 Hammer, sledge, 8 lb., S. H. Co., No. KK-8.
4 Handles, machine hammer, S. H. Co., No. EH-18.
2 Handles, claw hammer, S. H. Co., No. K-14.
1 Handle, sledge hammer, S. H. Co., No. SSAA-34.
1 Handle, adz, S. H. Co., No. SZAA.
1 Handle, hand axe, S. H. Co., No. KB-16.
1 Handle, axe, single bit, S. H. Co., No. CSXX-36.
2 Head bands, leather, W. E. Co., No. 156-W.
2 Hooks, lug, M. K. & S. Co., No. 465.
1 Hook, cant, S. H. Co., No. 399.
1 Knife, draw, S. H. Co., No. E-12.
1 Level, spirit, S. H. Co. No. 104-H.
2 Ladles, $2\frac{1}{2}$ in., M. K. & S. Co., No. 555.
2 Lanterns, hand, Southern standard.
2 Lanterns, Inspector's, Dietz Acme.
2 Lantern globes, hand, Southern standard white.

2 Lanterns globes, hand, Southern standard red.
2 Lantern globes, Inspector's, Dietz Acme.
1 Measure each—1 gallon and 1 pint.
1 Maul, spike Southern standard (Interlocking only).
1 Plane, jack, 15 in., S. H. Co., No. 605½.
1 Pot, soldering, for C. & L. No. 5 furnace.
2 Pike poles each—14 ft., 18 ft., and 20 ft.
1 Punch, blacksmith, round point, ⅝ in., S. H. Co., No. RP-⅝.
4 Punches, Black Jack, S. H. Co., No. K-358 (Drift end).
4 Punches, solid machine, S. H. Co., No. K-632 (starting).
1 Punch, center, Bay State, S. H. Co., No. B-15.
1 Pick, clay, Southern standard.
1 Pail, water, 12 qt.
1 Puller, nail, S. H. Co., No. K-10.
75 ft. Rope, ⅜ in.
100 ft. Rope, ¾ in.
2 Receivers, telephone, 70 ohm, W. E. Co., No. 131-W.
1 Reamer, Green River, solid spiral, S. H. Co., No. 400, ⅝ in. (Interlocking only).
1 Reamer, Green River, solid spiral, S. H. Co., No. 400, ⅞ in. (Interlocking only).
1 Reamer, Green River, solid spiral, S. H. Co., No. 400, 15/16 in. (Interlocking only).
2 Shovels, square-point, short handle, S. H. Co., No. KHTS-20.
1 Spoon, digging, M. K. & S. Co., No. 439.
1 Saw, hand, 6 points to the inch, S. H. Co., No. 12/26.
12 Saw blades, hack, 12 in.
12 Saw blades, Schmidt, Victor No. 4.
1 Saw, rail, Schmidt.
1 Saw, hack, adjustable, S. H. Co., No. K8/2.
1 Saw, hand, 9 points to the inch, S. H. Co., No. 12/26.
1 Square, tri, 6 in., S. H. Co., No. K-1226.
1 Square, steel, 24 in., S. H. Co., No. KC/3 (Interlocking only).
1 Stock & Dies, pipe, set ½ in. to 1¼ in. Beaver cross bar No. 210 (Interlocking only).
1 Stock & Dies, bolt, set ⅛ in. to 1 in. Beaver Jr., No. 3.
1 Stone, oil, S. H. Co., No. KCK-72.
1 Saw set, S. H. Co., No. B-16.
2 Screw drivers, 10 in., M. K. & S. Co., No. 708.
2 Sets, channel pin.
1 Snips, Tinners, M. K. & S. Co., No. 50.
1 Soldering copper, 3 lb., S. H. Co., No. 4-H.
1 Torch, blow, 1 qt., S. H. Co., No. 32.
1 Tape line, 50 ft., S. H. Co., No. RR-50.
1 Vice, pipe, S. H. Co., No. 12 (Interlocking only).

1 Vice, bench, S. H. Co., No. 5023½ (Combination).
1 Wrench, socket, single head, for ½ in. lag screw 1 in. head.
1 Wrench, socket, single head, for ¾ in. lag screw 1 in. head.
1 Wrench, track, Southern standard, 1¾ in. opening.
1 Wrench, Coe, 8 in. S. H. Co., No. KSH-8.
1 Wrench, Coe, 10 in., S. H. Co., No. KSH-10.
1 Wrench, Stillson, 14 in., S. H. Co., No. K-14.
1 Wrench, Stillson, 18 in., S. H. Co., No. K-18.
1 Wrench, Wescott, 8 in., S. H. Co., No. WP-8.
1 Wrench, Wescott, 12 in., S. H. Co., No. WP-12.
1 Wrench, lag, M. K. & S. Co., No. 326.
2 Wrench, socket, A. R. A. ¼ in. nut, G-R-S. Co.
2 Wrench, motor car, F. M. Co., No. 27.
1 Wrench, motor car, F. M. Co., No. 69.
1 Wrench, motor car, F. M. Co., No. 33.
1 Wrench, motor car, F. M. Co., No. 727.
1 Wrench, motor car, F. M. Co., No. 701-A.

Blacksmith Tools, Interlocking Only

1 Anvil, Black Jack, S. H. Co., No. K-100.
1 Forge, Bay State, S. H. Co., No. B-152 (Portable).
1 Chisel, hot, S. H. Co., No. A-1, ¼ in.
1 Chisel, cold, S. H. Co. No. B-1, ¼ in.
1 Top Filler, S. H. Co., No. TF, ⅝ in.
1 Bottom Filler, S. H. Co., to fit anvil No. K-100.
1 Punch, S. H. Co., No. RP, ½ in.
1 Top Swage, S. H. Co., No. TS, ⅝ in.
1 Top Swage, S. H. Co., No. TS, 1 in.
1 Bottom Swage, S. H. Co., ⅝ in. to fit anvil No. K-100.
1 Bottom Swage, S. H. Co., 1 in. to fit anvil No. K-100.
1 Regular tong, S. H. Co., No. S/18.
1 Regular tong, S. H. Co., No. S/20.
1 Bolt tong, S. H. Co., No. B/12.
1 Bolt tong, S. H. Co., No. B/16.
1 Flatter tong, S. H. Co., No. SF-2, ¼ in.