Electric Interlocking at Aulon, Tenn.

Plant Near Memphis Installed for Four Railways; Method of Protecting a Boulevard Is a Feature

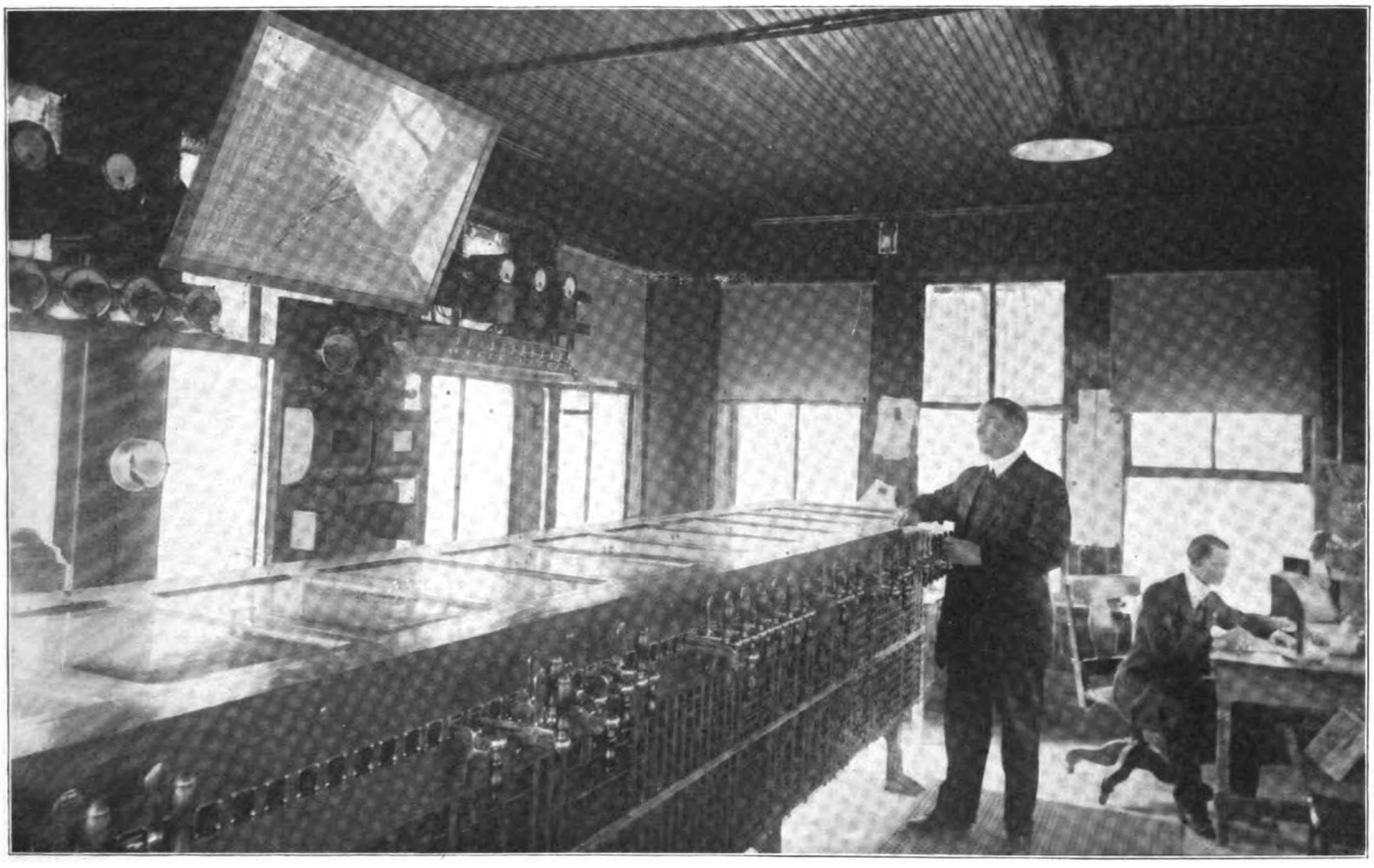
An all-electric interlocking plant was recently put in service at Aulon, Tenn., which is owned by the Nashville, Chattanooga & St. Louis, the Louisville & Nashville, the Illinois Central and the Union Railways. The construction was begun in May, 1914, and the total cost was about $60,000. The machine is of the unit-lever type, containing 88 spaces, having 53 working levers operating 61 functions, and 27 spare spaces. In addition, the automatic flagmen and electric bells protecting Poplar boulevard are partially controlled by the interlocking plant. The track circuits are alternating current with d. c. mechanisms and control.

The plant is located on the main line of the Nashville, Chattanooga & St. Louis, to Nashville, and on the main line of the Illinois Central, to New Orleans. The Louisville & Nashville uses the Nashville, Chattanooga & St. Louis tracks from Aulon to Memphis. The Union Railway is a small belt line which handles freight to and from local factories, and transfers freight between different railroads.

The switches were previously operated by switchtenders and by hand signals. The switch layout indicates the scattered arrangement of the signals and shows the difficulty of this method of operation, and the possibility of delay. Three switchtenders were formerly employed by the Nashville, Chattanooga & St. Louis for throwing the switches connecting with the Louisville & Nashville. This road also had three switch operators who lined up switches, and they were retained at the same posts because telegraphic block is being used. The switchtenders lined up the switches for through trains only, and all freight train and switching crews had to line up their routes themselves, and also protect trains, if necessary, by flags.

SIGNAL TOWER AND WORKSHOP.

The interlocking tower, with a large and roomy workship adjoining, was designed and constructed by the forces of the Nashville, Chattanooga & St. Louis. The tower is a two-story brick structure of artistic design, with an ornamental tile roof. The tower is located on a concrete foundation, both the upper and lower floors being concrete reinforced with old rails. This floor provides ample rigidity for the interlocking machine without any other support. At times the tower is completely surrounded by moving trains, but no objectionable vibration is experienced.

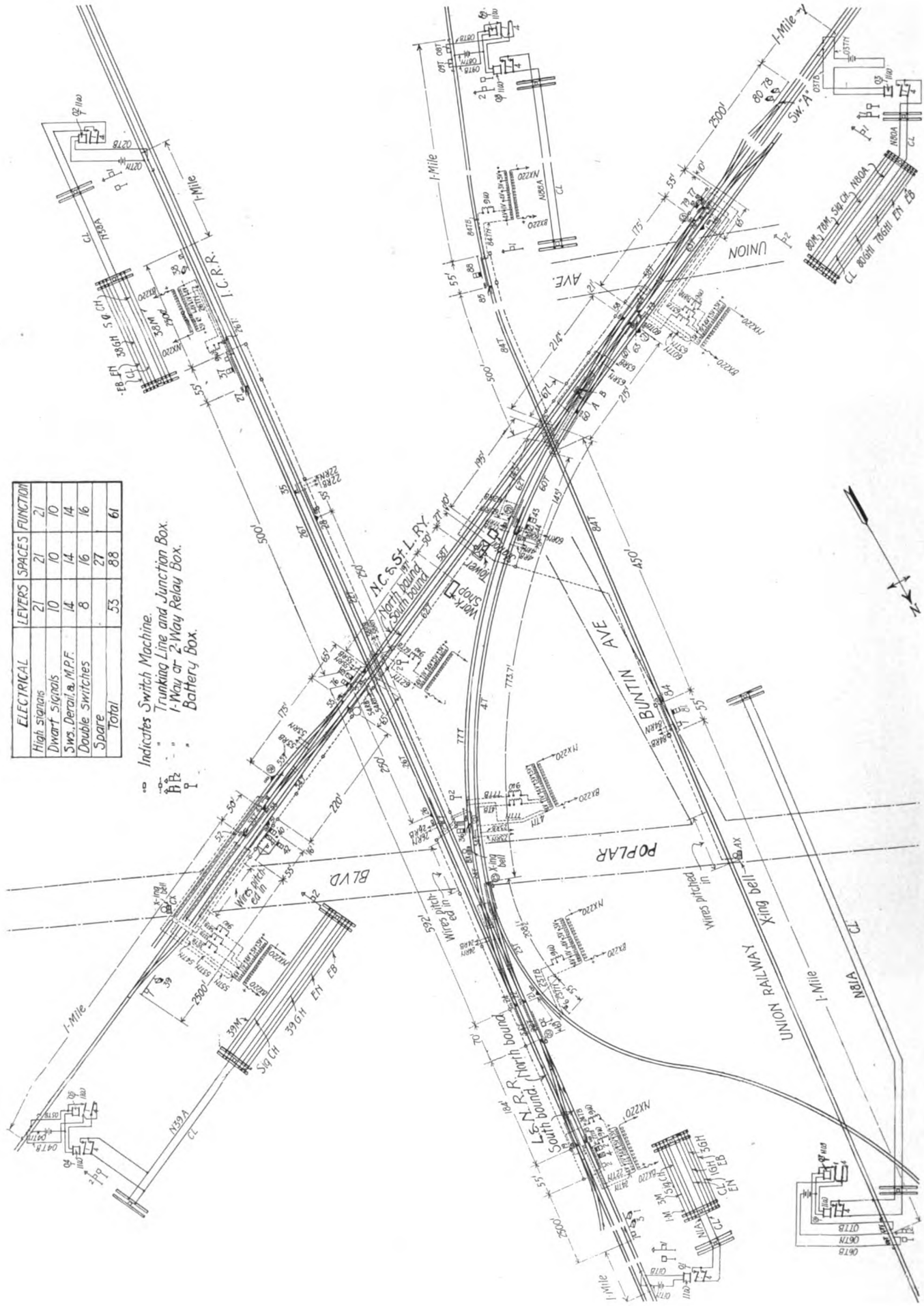


Interior of Tower, Showing Machine Levers and Spare Spaces.

The upper floor, in addition to serving as a telegraph office, contains the interlocking machine, and the lower floor is used for the storage batteries, transformers, mercury-arc rectifier and relay cabinet. The building is located fronting on the Nashville, Chattanooga & St. Louis tracks, those of the Louisville & Nashville being also in plain view from the front of the building. The location is practically at the center of the plant. An exceptionally good view of Poplar boulevard is obtained at this location, which will preclude the likelihood of the leverman clearing up a route in case the tracks are blocked by a team or an automobile stalled on the crossing.

POWER.

The power is furnished at 220 volts, a. c., with a frequency of 60, by the Memphis Consolidated Gas & Electric Company.



Track Plan and Signal Layout, Aulon Interlocking.

The current is transformed to 110 volts, d. c., for both the tower and signal lights and for one winding of each track relay. A double-throw knife switch is provided so that lights may be operated by either alternating or direct current. Direct current is obtained by using a mercury-arc rectifier. A 4-H type, Edison storage battery, consisting of 90 cells of 150 a.h. capacity, is used in cases of emergency for supplying power to the interlocking machine, and to all switch and signal motors, as well as for lighting purposes. Two watt-hour meters are used, one to register the energy used in lighting, the other to register the energy used in charging the mercury-arc rectifier and the a. c. track circuits.

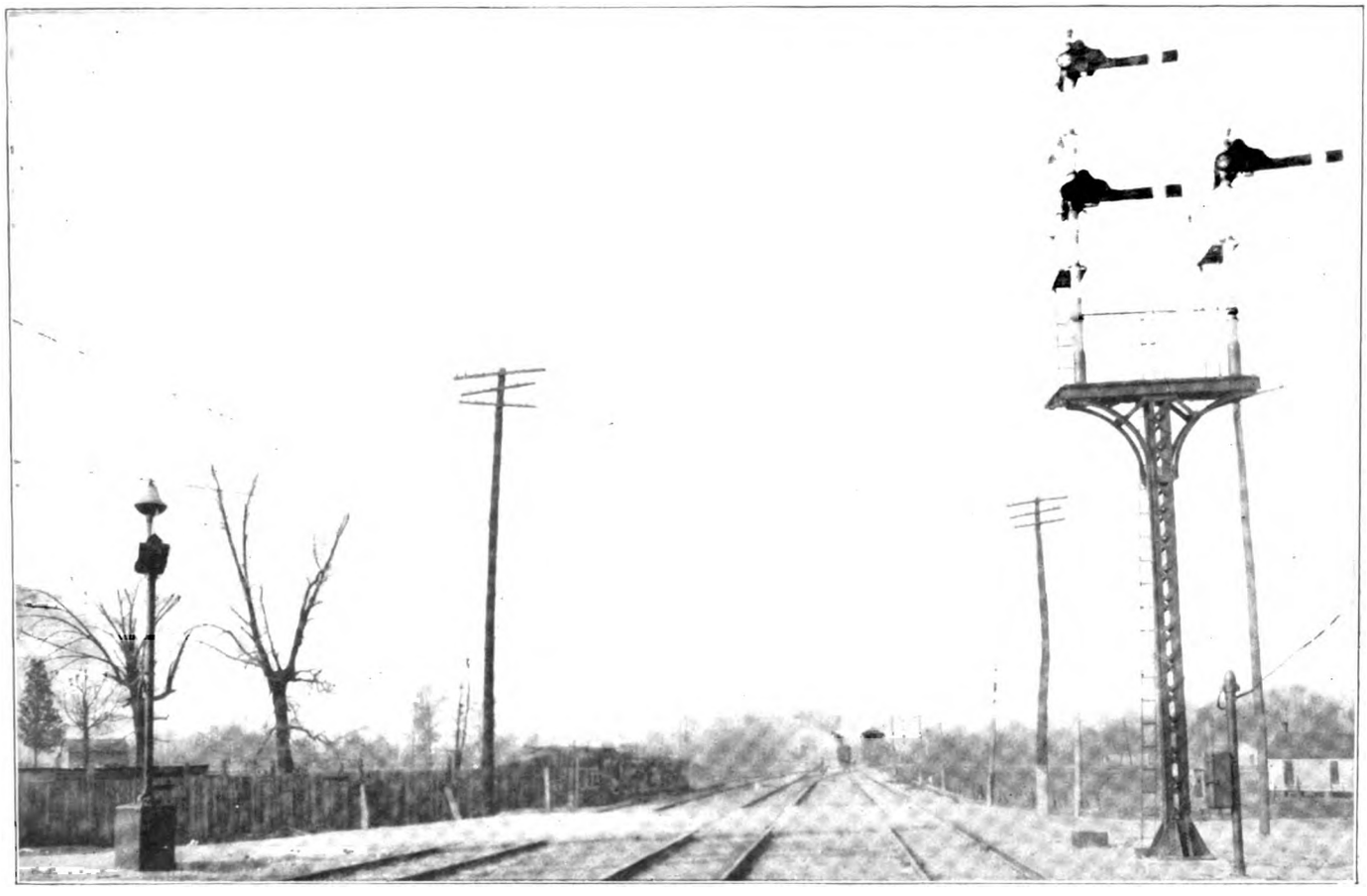
SIGNALS.

The high signals are G. R. S. model 2-A, with top-post mechanism, mounted on iron posts. Home signals are semi-automatic. All home signals operate in the upper right-hand quadrant, the high-speed signals operating in three positions wherever possible, the vertical position of the blade indicating proceed, diagonal position, proceed with caution, and the horizontal position indicating stop. The 0 to 45 deg. position of all three-position signals is controlled by the interlocking machine, but the 45 to 90 deg. position is controlled by the position of the next home signal in advance. The signal will assume a 90-deg., or clear position automatically, when the signal in advance is in the proceed position. Home signals governing main-line movements are made to operate in three positions wherever there is another home signal in advance; otherwise they operate in two positions. When the three-position signal is in the clear position, the indication is "proceed, the home signal in advance is at clear," and if the three-position signal is at the caution position, the indication is "proceed, expecting to find the next signal at danger." The signals are operated by four-pole, d. c. 10-volt motors, and are lighted by 110-volt, 2-c.p. carbon lamps in multiple. The blades, except dwarf signals, are made of enameled steel.

Distant signals are two-position, operating from 45 to 90 deg. Each distant signal is operated by a lever in the tower and a circuit breaker on the signal in advance. The locking in the machine is so arranged that no distant signal can be cleared until all home signals in advance are cleared, giving a clear route through the entire plant at the maximum speed, which is 20 miles per hour.

Dwarf signals are G. R. S. model 3, solenoid type. The overall dimensions of these signals are such as to allow them to be placed where the available clearance will not permit the use of many types of dwarf signals. The signals operate in two positions only, from 0 to 45 deg., and are controlled by the interlocking machine.

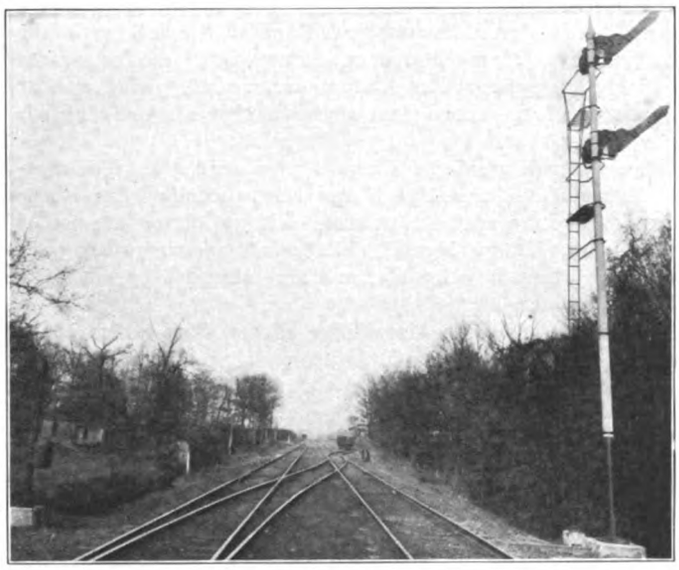
An audible signal—a low-voltage electric horn which has a peculiar tone, unlike that of horns used on automobiles—was placed on the top of the signal tower. This audible signal is used to call the attention of switch-engine crews to through movements and to warn them so that they may get into the clear. It is used, also, for calling the maintainer when he is needed. A special code of signals has been adopted for this purpose.



Home Signals 40, 41 and 42, Looking Toward Tower.

NIGHT INDICATIONS.

Green is being used for clear. The use of this color is especially advantageous for dwarf signals in terminal layouts, as the spectacle glasses are near the ground where they are more likely to be broken. Instances are on record where derailments have occurred at night on account of over-running a dwarf signal in the danger position, which gave a white light indication. The use of green for clear also eliminates the possibility of mistaking a clear, white light, which, on account of some defect, might shine through the back of a spectacle casting, for a proceed indication. At this interlocking plant, which is near the entrance to the large terminal at Memphis, there are an unusually large number of white lights for residences, streets and varied purposes, which frequently come in direct line with the signal lights. The other color indications are yellow for caution and red for danger.



Two-Position Distant Signals, 78 and 80, Operating from 45 to 90 Deg.

AUTOMATIC FLAGMEN AND CROSSING BELLS.

Traffic is very dense on Poplar boulevard, which crosses all four railroads. A great many automobiles travel along this road, especially at night, and it was realized that on account of the noise made by the machines, the occupants would frequently fail to hear the ringing of the ordinary crossing bell, and even the sound of approaching trains. It was therefore thought necessary to install some highway protective device that would be more effective than the ordinary gong. The Brach type automatic visible and audible signal was selected. It contains eight stationary lamps located between red lenses so that the light from these lamps is shown on both approaches to the crossing. These lamps are lighted one after the other in a manner to give the effect of a swinging red lantern. Above the lights in large lettering is the sign "Railroad Crossing," and a locomotive type bell of high carrying power is also provided, which sounds as the train approaches the crossing.

SWITCHES AND DERAILS.

All crossing sidings on conflicting routes are protected by derails. Morden lifting derails are used on main lines for high-speed movements, and Hayes lifting derails for main-line low-speed movements and siding protection. The turnout and crossovers in the interlocking plant are No. 9. Switches and derails are operated by G. R. S. model 2 switch machines.

As an extra precaution, in addition to detector circuits, 53-ft. detector bars are used; one or two bars, as the conditions demand, being placed at each switch or derail. These bars fit closely against the outside of the rail and are operated simultaneously with and by the same motors that operate the switches. When the switch is operated, the bar rises 1 in. above the top of the rail.

INTERLOCKING MACHINE.

The G. R. S. interlocking machine contains 88 spaces, with 53 working levers operating 61 functions. The possibility of an enlargement of the plant made it advisable to provide an especially large number of spare spaces. The machine is of the unit-lever type, that is, one lever is employed for each signal, and one for each switch or derail when operated entirely independent of any other switch or derail. Where two switches or two derails, or a switch and a derail would of necessity always operate together, the two levers are tied together and are operated by one handle, the locking and the indication, however, being separate and independent. The locking is in the front of the machine in the vertical plane. The G. R. S. dynamic indication is used, the principle of which is too well-known to require explanation.

CIRCUITS.

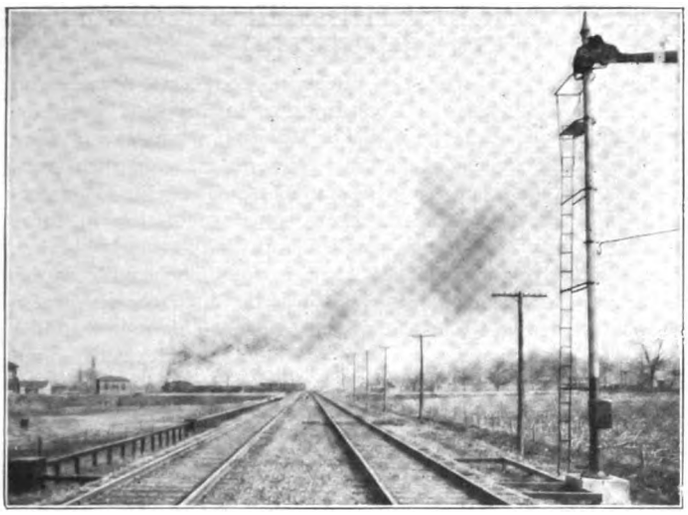
The track circuits are alternating current, the track transformer consisting of a primary coil which is fed from the 220-volt main, and a secondary coil which feeds current to the track circuit at voltages from 1 to 4, so that the latter may be varied according to the length of the track circuit. A variable resistance is used on the lead of each track connection to the secondary coil, so that one secondary wiring feeds all track circuits at one location. This arrangement provides protection for the transformer when any track is short circuited. Each primary coil is protected by a fuse.

Track relays are G. R. S. model 2-A, for alternating current. The relay contains two energizing windings, one of which is energized constantly from the 110-volt main. The other winding is energized from the track circuit by the energy supplied by the secondary winding of the track transformer at the opposite end of the track circuit. This type of relay has a capacity of 12 independent circuits and any combination of front and back contacts can be used within these limits. The relays operate with a high drop-away and, of course, they are practically immune to foreign current. On account of the high energy which can be used in their operation, the action is positive and reliable. The use of alternating current at this point was especially desirable, as there are several trolley lines crossing the tracks just outside of the interlocking limits, and foreign current is very much in evidence. Keystone insulated rail joints of the non-symmetrical type were used. The bonding consists of two copper bond wires.

The tower annunciators are normally de-energized, the circuits being completed by the closing of contacts in relays which are also normally de-energized, but which are closed by an approaching train. An additional relay is added on single track at the track circuit, which accomplishes a traffic-direction feature, so that the bell only rings when a train is approaching. The annunciator starts are placed out one mile from the distant signals.

The unusual conditions under which the automatic flagmen and crossing bells were to operate were taken into consideration and special circuits were designed. As all the railway lines cross Poplar boulevard, in every case a proceed signal must be given before it is necessary for the automatic flagmen to start operating. The control circuits for the flagmen were, therefore, looped

Double-Blade Home Signal Governing Crossover and Wye Switch.



Home Signal 37 at Danger; Train on Wye Track.

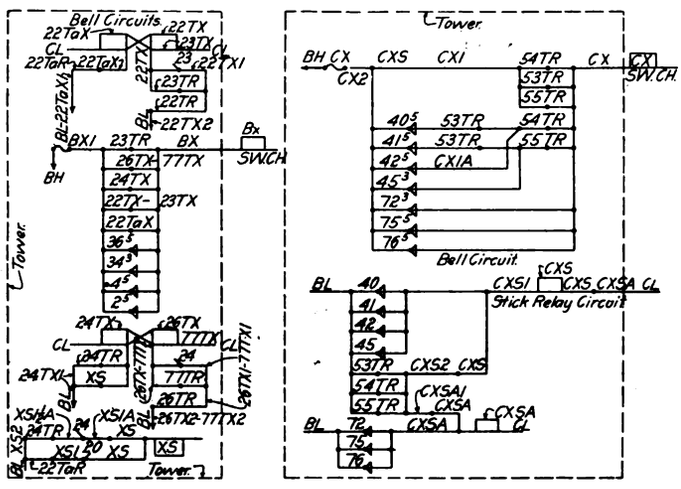
in multiple through the circuit breakers on all of the home signal levers for signals which are next to and govern the routes over the crossing, except the northbound home signal on the Union Railway. Here the bell rings through the track circuit for northbound moves; this circuit is long enough to give sufficient warning. As all signals are normally at danger, these contacts are normally open, and are closed when the lever is in the reverse indication or full reverse position. The automatic flagmen, therefore, will continue to operate as long as the signal governing over any particular crossing is in the clear position; but since the signals go to danger automatically just as soon as the train passes them, the automatic flagmen would cease to operate unless other control were provided. Most of the signals go to danger while the train is still several hundred feet from the crossing. In order to give a continuous indication until after the train has reached or passed over the crossing, the control wire was looped in multiple through the back contacts of all the track relays which govern the track sections at the crossings. This causes the bell to continue to ring through the track relay control, after the signal has gone to danger.

But, since wherever possible, the alarm control is looped through the track relay on each side of the crossing, unless some extra appliance were added to give a traffic direction selection the bell would continue to ring after the train had passed the crossing; or on the Union Railway, until the train had moved

Concrete and Brick Interlocking Tower.

entirely out of the track circuits between the home signals. This would cause the alarm to be given by trains bound for South Memphis for a distance of 1,200 ft. after the actual danger was over. The difficulties on the Union Railway were overcome by using a single stick relay.

Two stick relays are required to eliminate an incorrect danger signal, or lack of danger signal, on the Nashville, Chattanooga & St. Louis at CX crossing. This bell is rung by reversing any of the southbound signals 40, 41, 42 or 45, and the bell stops ringing just as soon as the train gets to the crossing, instead of stopping after the whole train has passed the crossing. This prevents passengers from hearing the bell, which is objectionable at night, and is a control used by the Nashville, Chattanooga & St. Louis wherever possible. When any southbound signal is cleared, it picks up stick relay CXS, which, under ordinary conditions, prevents the train which has accepted the signal from giving the alarm through the track circuit just south of the bell. If, however, north and south bound signals are given simultaneously, for instance, signals Nos. 42 and 75, and the southbound signal were accepted first, it should not prevent the alarm from being given by the train that has accepted signal No. 75. If this were not taken care of, the alarm would not be operated



Circuits for BX Alarm.

Circuits for Crossing Alarm on N. C. & St. L.

at the most critical moment, namely, when two trains were approaching the crossing simultaneously. In that case, the first train would lock the relay so that the second would fail to operate the alarm. This condition is taken care of by stick relay CSXA. Reversing lever 75 de-energizes CXS and causes the bell to ring through track sections 53-TR, 54-TR and 55-TR.

To give the proper alarm at BX crossing, it was necessary to add an extra track section, otherwise sections 22-TR and 22-TaR could have been made into one section. In addition to two interlocking relays, a stick relay was added so that a train going from signal 34 to signal 5 would not give the alarm through the track section for No. 24. The interlocking relays and the stick relay on the Union are provided with special high-voltage contacts which carry the current at a voltage of 110.

ROUTE AND STICK LOCKING.

Switches, derails and movable-point frogs are protected by detector circuits from the possibility of being moved under a train, by breaking the indication control of the levers through the track relay. All high signals are provided with stick locking so that when a signal is once cleared the route governed by that particular signal cannot be changed until a predetermined period of time has elapsed, or until after the signal has been accepted and the train has passed out of the section immediately ahead of the home signal. Emergency releases are provided whereby the contacts on the d. c. track relays can be shunted and the leverman continue to operate switches and derails even though the alternating current is cut off.

LINE WIRES AND TAGGING.

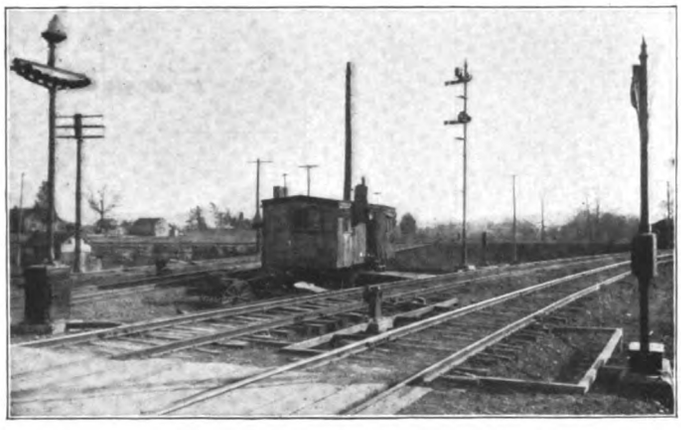
Crossarms, pins and insulators necessary for the wires were put in place by the Western Union Company's forces. The line wires were strung by the G. R. S. Company's forces, in accordance with the arrangement shown on the general location plan. The information on signal wires given on this plan is of great assistance to the maintainer when trying to locate trouble.

In a plant of this kind where a large number of units are controlled, it is very necessary that a comprehensive system of identification be provided for the various wires not only to give prompt identification when wiring a plant, but also that the maintainer may locate any part of the circuit in the shortest possible time; and so that in the absence of the maintainer one who is less familiar with the plant may readily locate any part of a circuit. In order to provide fully for these contingencies, the wiring plans were made and bound into a booklet of convenient size showing the arrangement of all wires, and having each wire numbered in accordance with a recognized standard used by various railways and signal companies. Terminal boards were provided in the relay cabinets and at each signal location. A fiber tag, its number corresponding to that on the wiring plan, is attached to each terminal on which is stenciled the number of the particular circuit which is to be attached.

INSTRUCTIONS TO TRAINMEN.

Several weeks before the plant was put into service a complete descriptive chart was compiled by the signal engineer of the Nashville, Chattanooga & St. Louis and posted on the bulletin boards of the several roads, so that all trainmen would have ample time to familiarize themselves with the rules, indications and signal movements. In order to simplify this plan as much as possible, single instead of double lines were used for the tracks, and all detailed information regarding the signals and circuits was omitted. The layout was also shortened and was not made to scale. On this plan each type of signal is illustrated in its different positions at the left of the drawing, with an explanation of each indication. At the bottom, the signal numbers are listed under four headings, one for each road. Information for the guidance of trainmen on each road is given in these tables, for instance, signal No. 77 has the following information listed with it: "Northbound main-line signal via switch 58 to signal No. 36, and to all low-speed diverging routes via switch No. 65." All other symbols which are likely to be misunderstood, but which it was necessary to use on the plan, are illustrated and their significance explained in a table at one side of the drawing. The signal indications for three-position, upper-quadrant signals, in general, are explained, this being necessary because some of the trainmen had been familiar with lower-quadrant, two-position signals only.

The apparatus was furnished and installed by the General Railway Signal Company, under the supervision of G. S. Pflasterer, signal engineer of the Nashville, Chattanooga & St. Louis. The rubber-covered wire, of which there is 160,000 ft., was furnished by the Kerite Insulated Wire & Cable Company.

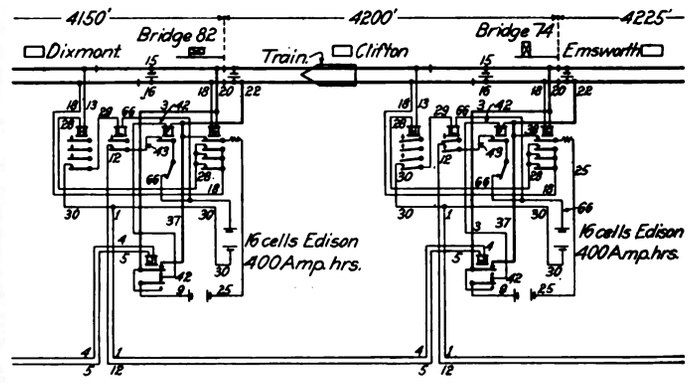


Brach Highway Crossing Signals.

TESTS OF GRAY-THURBER AUTOMATIC TRAIN CONTROL*

On February 12, 1914, the Interstate Commerce Commission notified the Gray-Thurber Company that further tests would be made on its apparatus, and on April 4, 1914, arrangements were made with the Pennsylvania Lines West to carry on such tests. The installation was from Bellevue, Pa., to Glenfield. This section of track has automatic block signals operating in three positions, lower quadrant, installed with a full block overlap. One locomotive was equipped for the test. The engine equipment comprises the apparatus shown in the diagram, which also shows the method of insulating the tender. The understanding with the Pennsylvania was that the block signal system must not be interfered with, and the Gray-Thurber system was therefore installed, not as an adjunct, but in parallel with it. The underlying principle of this automatic train control is the insulation of the locomotive tender from its trucks and also from the cars in the train.

In order to include the short insulated track sections in the track circuit controlling the signals, however, the railroad company's track relays H are controlled by the short-section track relays G. The short insulated track section at the entrance of each block consists of two 33-ft. rails on one side, and one and one-half 33-ft. rails on the other, this section being sufficiently long to permit a locomotive, exclusive of the tender, to stand between the insulated joints. In normal operation, when a train



Typical Circuits for Gray-Thurber Train Control System.

passes a signal location, the first pair of wheels entering the short track section shunts the short-section track battery, de-energizing relay G. When the armature of relay G drops, it breaks the detector circuit controlling relay F, and also breaks the circuit to relay H, and the opening of relay H, in turn, breaks the circuit through relay L. The opening of either relay F or relay L breaks the circuit leading to relay J at the signal location in the rear. When the train passes out of the short track section, relay G is again energized by the short-section track battery, and when its armature picks up, it again closes the circuit for relay F. Relays H and L, and relay J at the signal in the rear, however, remain de-energized until the train has passed into the next block section. Relay H is then energized by the long-section track battery, and when its armature picks up, it completes the circuit for relay L, which in turn closes the circuit for relay J at the signal location in the rear. A defective or broken down insulated joint permits a large amount of current to flow through multiple paths around relay F, in this way producing a danger indication.

LOCOMOTIVE APPARATUS.

The locomotive tender is insulated from its trucks by two sheets of fiber with a metal detector plate between them, as shown in the illustration. There are two sets of electrical circuits, one operated by two cells of Edison storage battery, with a potential of 1.2 volts; the other by a Gould storage bat-

*From the 1914 report of the Chief of the Division of Safety of the Interstate Commerce Commission.