Left—The C.T.C. control is located in Louisville Below — Typical station entering signal layout



Several sidings removed and the number of intermediate signals reduced to minimum thus adapting project to the operating needs of medium traffic

C.T.C. on 107 Miles of Single Track on the Louisville & Nashville

THE Louisville & Nashville has installed certralized traffic control on 107 miles of single track between Lebanon Junction, Ky., and Sinks, Ky., which is territory not previously equipped with automatic signaling. Referring to the accompanying sketch of part of the Louisville & Nashville, Lebanon Junction is 29.7 miles south of Louisville on the through route between Louisville and Nashville, which extends on to Birmingham, Montgomery, Mobile and New Orleans. Sinks is 152 miles south of Cincinnati on another important route of the Louisville & Nashville which extends between Cincinnati and Atlanta, Thus the new C.T.C. territory between Lebanon Junction and Sinks is an east-and-west connecting link between the two major north-and-south routes.

The trains operated over the Leb-

anon Line originate and terminate their runs at Louisville and at Corbin, which is 35.3 miles south of Sinks. The passenger trains run through between these terminals with the same make-up, but some of the freight trains pick up and set out cars at Lebanon Junction as may be required for connections with the north-andsouth routes.

Two passenger trains and two highball merchandise through freight trains are operated each way daily, and the number of extra freight trains depends on the volume of coal and other traffic. The total number of trains ranges from 8 to 10 each way daily. A large percentage of the traffic is loaded coal cars westbound and empty coal cars eastbound. Distilleries are located at several of the towns on this line. and, therefore, considerable work is done by the two local freight trains to deliver grain to these plants and haul away the finished products.

Why C.T.C. Was Installed

On the 100 miles between Lebanon Junction and Brodhead the railroad crosses rolling hilly country with numerous curves ranging up to about 3 deg., and short grades ranging up to about 1 per cent. On the 15 miles between Brodhead and Sinks, the country is mountainous with numerous 3-deg. curves and several up to 5 deg., with a few 7 deg. The grades are rolling, and range up to about 1.3 per cent. No automatic signaling had been in service on this Lebanon Line previously, and, therefore, track-circuitcontrolled signaling of some type was desirable as a means to improve safety

for train operations. Based on the benefits of centralized traffic control on several previous installations on the Louisville & Nashville, a decision was made to install C.T.C. rather than ordinary automatic block signaling on the Lebanon Line, and to take the necessary steps to minimize the materials required so that the project as a whole would be in proportion with the volume of traffic and operating

RAILWAY SIGNALING

If straight automatic block signaling had been planned, no sidings would have been removed, but, based on experience on previous projects, the Louisville & Nashville knew that fewer sidings were needed with centralized traffic control. Of the 24 sidings previously in service on this 107 miles, only 11 were equipped with semi-automatic C.T.C. controlled signals for authorizing train movements. Ten of these sidings were equipped with switch machines and the remaining one consists of a lap siding layout

stalled at only 11 of the original 24

August, 1946

10

SINKS

sidings. At Hemp there was previously a lap siding layout, and when changing to C.T.C. the necessary track changes were made to convert this layout to a section of double track 8,000 ft. long with No. 16 turnouts. As shown in Fig. 2, the switches are normally set to run trains on the right-hand track. and spring switch mechanisms were installed so that trains do not stop at either the entering or leaving end. Semi-automatic signals 28LA and 30RA are controlled by the C.T.C. system. The reverse running dwarfs 28LB and 30RB are fixed to display red only. The entering signals 1022



conditions on this territory. The important advantage of centralized traffic control is that train movements are authorized by the indications of signals which, together with the power switches, are controlled by a machine in the dispatcher's office at Louisville. which is 29.7 miles north of the west end of the C.T.C. at Lebanon Junction.



Signal 1022 at east end of Hemp

Haven, Loretto, Lebanon, Rileys, Cozatt, Junction City, Crab Orchard, Brodhead and Mt. Vernon, the short section of double track being at Hemp. The old No. 10 turnouts at these ten sidings were replaced using No. 16 turnouts at both ends of Hemp and No. 12 at the remaining locations.

Six old sidings were removed: at Santos, Mohawk, Amboy, Brumfield, Maywood and Maretburgh. At St. Mary's the siding was converted to a spur by removing one of the maintrack switches and turnouts. The siding at Parksville was left in place, but the hand-throw stands were left in service, no signals being required at this siding. The same practice was applied at the siding at Pine Hills. The result of these changes was that C.T.C. controlled signals were in-

Fig. 17 Map of the C.T.C. ter-Corbin ritory between Lebanon Junction and Sinks

Crab Orchard

MARETBURGH

Broodhead

pineHill

Verno

and 1011 are straight automatic signals. Ordinarily trains make meets on this section of double track, but not passes.

In addition to the 10 power sidings and the short section of double track, the C.T.C. system also includes the operation and control of the junction layout at Sinks, which has one single switch and a crossover, together with the customary home signals. The distance from this Sinks layout to the



Fig. 2-Section of double track with spring switches and C.T.C. signals



Signal layout between Rileys and Cozatt

control machine in Louisville is 136.9 miles, which is an unusually long mileage for controlling such a layout.

Savings in Number of Signals

If straight automatic block signaling had been installed, double signal head-block locations would have been required at all of the original 24 sidings because all sidings would have been retained. Thus the fact that sidings could be removed with C.T.C. was a help in reducing the cost of the C.T.C. as compared with automatic block.

Another important fact is that in a

BOSTON

the two locations of intermediate signals, thus saving one double location of signals.

The distance between the sidings at Boston and New Haven is 10.5 miles. The double intermediate location signals No. 361 and 362 is about 2.25 miles from the east end of Boston, and the double intermediate location signals No. 421 and 422 are about 2.25 miles from the west end of New Haven. This leaves about 6 miles between the two intermediate locations, thus saving two double intermediate locations.

In Lebanon there are numerous industries and freight houses which are

served by spurs leading from switches on the main track. Considerable time is required each business day for the local freight trains to switch these industries. In order to allow this work to continue as long as possible without delaying through trains, the two signals at the intermediate location about one mile east of Lebanon are Absolute signals, normally displaying the Stop aspect, and are arranged for C.T.C. control by the dispatcher. These are known as hold-out signals. With this arrangement, switching moves can be made in Lebanon and as far out as signal 44L, while at the same time a westbound train can leave Rileys,



Signal layout between Boston and New Haven

normally-clear straight automatic block system, the intermediate automatic signals must be located to provide head-on protection, whereas in a C.T.C. installation, the station-leaving signals provide head-on protection; therefore, only enough intermediate signals are required to serve as distant signals and to space following trains, depending on the volume of traffic and need for making following moves on close headway.

The distance between the sidings at Rileys and Cozatt is 9.5 miles. The double intermediate location No. 792 and 791 is about 2 miles from the east end of Rileys, and the double intermediate location No. 841 and 842 is about 2 miles from the west end of Cozatt, with about 5.5 miles between





Location of hold-out signals 44R and 44L, east of Lebanon

eight miles away, and continue on its way. In the meantime, as soon as the local train clears the main track, the dispatcher clears the westward holdout signal 44R, and the through train goes on its way without stopping.

The C.T.C. Control Machine

The C.T.C. control machine is located in the office at Louisville which is 29.7 miles north of Lebanon Junccannot clear the main track, the locks are controlled automatically by local circuits.

The remainder of the locks are controlled by push-to-turn thumb levers which are in a row at the bottom of the panel of the C.T.C. control machine. Each such lever controls the locks on one or more switches in a block between two sidings. The lever is normally on center, being thrown to the left to release the lock and estab-



Intermediate signals with motor car on set-off

tion. This machine is operated by the same dispatchers that formerly handled this territory by timetables and train orders. On the illuminated track diagram there is one lamp to repeat track occupancy between sidings, one lamp for each OS switch detector circuit, and one lamp for each section of main track opposite a siding, all of these lamps being controlled automatically in the conventional manner. On the line representing each siding there is a lamp which is lighted by the dispatcher throwing a small toggle switch below. This reminds the dispatcher of the location of the train when it is to be held on a siding for some time. The switch and signal levers with their indication lamps are arranged in the conventional manner.

Above each section of the diagram representing a section of track between sidings there is a pair of lamps with arrows. When the traffic direction is established eastward, the left lamp and arrow are lighted, or when westward, the other lamp and arrow are lighted. An automatic train graph, mounted in the desk portion of the machine, has 25 pens to record the operation of trains at the field stations.

As part of the project, electric locks were installed on the hand-throw main-track switches. At Churchill, Dants and St. Marys where the spurs are so short that a local freight train lish traffic direction for a train to depart from the spur track and proceed easward; or to the right to proceed westward.

Above each switch lever for a field station there is a small toggle lever. By throwing such a toggle lever up and pushing the code starting button, a control is sent to the corresponding field station to light the maintainer's call lamp on the track side of the instrument house at that field station.

On the illuminated track diagram there is a red lamp directly below the symbol for each power switch. Such a lamp is lighted when the a.c. power fails at the corresponding field station, this indication being brought in by transmission of a double switch indication code from the field station. The power-off indication lamp stays lighted until the dispatcher throws the small toggle switch above the corresponding switch lever, this toggle being the one which is used also to control the maintainer's call lamp at that field station.

Searchlight Plug-In Signals

The signals on this installation are the H-2 searchlight type with plug couplers so that mechanisms can be changed without disconnecting the wires. The operating coils are rated at 250 ohms, and are connected directly to the incoming line circuit, thus eliminating a line relay The signal lamps are the double-filament type rated at 5 + 3.5 watts for ordinary signals, but 13 + 3.5-watt lamps are used in signals with spread lenses. Approach lighting controls are in service for all signals excepting the leave-siding dwarfs.

Simplified Circuit Tagging

The circuit diagrams and wire tagging is in accordance with a new simplified idea of omitting the numbering. The relays, wires, etc., are



Metal case at typical intermediate signal

simply designated with the letter "R" for right, or "L" for left, as applying for a person facing any relay case. For example, RT means the track relay for the track circuit extending to the right from that particular location. RTP is the right track repeater relay, and RTFP is the right track front repeater. Thus one standard applies for the circuits, wiring, tagging and arrangement of relays at all similar for the dispatcher's telephone and also makes three channels available for other telephone service. A point of importance is that no new line wire was installed for the C.T.C. code line.

One set of office line coding apparatus using conventional d.c. codes, serves the entire project. This arrangement, without the use of carrier to cut the territory into separate operating sections, is possible because of



The relays are identified by a simplified use of letters only

locations such as double intermediates. This idea reduced the circuit drafting to one standard set of tracings. The only work required to apply a standard print to a certain location was to mark the signal number near the symbols for the signals. A further advantage is that much time was saved in making tags and when wiring the cases, because a routine, once established, applied to all similar locations.

Pole Line Work

The pole line, which is owned 100 per cent by the Louisville & Nashville, was rebuilt as required to accommodate a second arm. The telegraph and telephone wires were moved down to the second arm, thus leaving the top arm for the C.T.C. line wires. As a part of the project, all of the trees which might fall on the pole line were cut down; this included an area about 50 ft. from the pole line. This practice of cutting trees is considered an essential part of all C.T.C. projects on the Louisville & Nashville.

In order to conserve copper for war purposes, a pair of No. 8 bare copper line wires, previously used for a long-distance telephone circuit, was changed over to handle the C.T.C. line coding. A three-channel telephone carrier system was installed on the previously existing telephone train dispatching circuit which permits the continued use of the physical circuit the limited number of field stations, only 25, and the relatively few trains. Therefore, there is no code line congestion.

Automatic Line Circuit

The local automatic block signal line circuits are based on a scheme requiring only two line wires which, as applying to a station-to-station block, are used to clear eastward signals when an eastbound line-up is being established, or to clear westward signals for a westbound line-up. This circuit scheme is basically the same as installed on the Louisville & Nashville in 1942, as explained in detail with diagrams on page 426 of Railway Signaling for August, 1942. These line wires serve also to control the track-occupancy indication lamps for the corresponding station-to-station block, and a third use of this line circuit is to check track occupancy and the Stop aspect of signals in the control of electric locks located in station-to-station blocks. These two line wires are No. 10 bare copper.

Track Circuits

A great many highway crossing signals were previously in service on this territory, and the conventional d.c. track circuits for these signals were incorporated in the new C.T.C. system. Also conventional d.c. track circuits were installed for the OS detector track sections at switches as well as for other short track circuits. The rail joints are bonded with Cadweld bonds. Where the layouts permitted long track circuits, over 4,000 ft. in length, coded track circuit equipment was installed, a total of 59 of these coded track circuits being included in the project as a whole. These track circuits operate at 120 code only, and are used for detection of train occupancy; the control of signals to the yellow or green is accomplished by polarizing the line circuits.

The conventional d.c. track circuits are each fed from a set of three cells of 1,000-a.h. Edison primary battery connected in parallel. Each of the coded track circuits is fed from one cell of Edison B4H storage battery. At each field station there is a split set of 8 + 5 cells of 80-amp. hour lead storage battery which operates the switch machine. Five of these cells also operate the relays and lamps, and 8 operate the field coding units. Another set of 5 cells of lead battery operates part of the lamps and the line circuits. A 60-a.h. set of battery is used at each intermediate signal



Neat wiring in space at rear of case



Cecil Gates, assistant general signal construction foreman; Philip P. Ash, assistant signal engineer, and H. L. Petty, general signal construction foreman

location. On about half of the installation, the lead storage batteries are Exide, and on the remainder they are Gould.

The storage batteries are on floating charge from rectifiers which are fed from transformers. A 110-volt a.c. circuit, on two No. 6 copper wires, was extended in both directions from each station or other location where commercial power was available. Gaps of several miles were left between the end of one feed and the end of the next, thus saving line wire.

Well-Organized Construction

The construction headquarters was at Lebanon, where the materials were assembled, a freight house and platforms being assigned temporarily for use of the signal department. The signal masts and ladders installed on this project were reclaimed from materials removed when respacing base-of-mast semaphore signals on other divisions. The work of cleaning the old cases and masts, as well as cutting down the masts and ladders for use with searchlight signals, was done by the headquarters crew at Lebanon. This crew at Lebanon wired the sheet-metal instrument houses and cases as well as assembling the masts, ladder and switch machines ready for delivery by work train to the locations in the field. A Burro power crane was used in the yard to load the cars, and this same crane was included in the work train to unload the houses, cases and switch machines at the locations in the field.

A special feature of the work done at construction headquarters was that the power switch machines were mounted on switch ties with the plates and braces in place, as shown in one of the accompanying pictures. Each assembly, including the machine and two ties, was handled as a unit when being loaded, unloaded and installed in the track. The tie plates were drilled on a machine in the shop at Lebanon. The toe plates were riveted in place. The plates for use under the "near" rail, and which extend and are bolted to the switch machine, are $\frac{3}{4}$ in. thick, 7 in. wide and 4 ft. 9 in. long. The plates under the other rail are the same thickness and width, but are 3 ft. long. The holes in the tie plates are 13/16 in. Lag screws 3/4 in. by 5 in. hold down the plates, and two 34-in. bolts extend through each adjustable rail brace, plate and tie, with a $1\frac{1}{2}$ by $1\frac{1}{2}$ -in. angle iron on the bottom of the tie to serve as a washer and to prevent the heads of the bolts from turning.

When starting an assembly, two oak ties, 7 in. by 9 in. by 13 ft. were laid down on a loading platform. The switch machine was set and bolted in place, also the tie plates were attached to the ties and the T. Geo. Stiles adjustable rail braces were set in place. sections of straight rail and stock rail bent according to standard for a turnout, being used as templates. Righthand or left-hand layouts were constructed as required. Tie straps, 2 in. by 3/4 in., were installed to maintain proper spacing between the ties, and blocking was provided to hold the ties in line temporarily. Then the sample rail sections were removed. The unit. consisting of the two ties with the switch machine in place, was then loaded on a flat car. A third tie 8 ft. long, which is for installation in approach to the points of a switch, was also equipped with plates and adjustable rail braces.

When ready to change over a switch location, the local track crew helped the signal forces. The old handthrow stand and the old switch ties were removed. After digging to allow space, the new ties with the machine in place were slipped under the rails. Also the third new tie, equipped with plates and braces, was installed. During this operation, the rail braces on the "far" side of the rails were removed until the ties were tamped up in place. Then the remaining braces were installed and bolted down, and adjustments were made on the rail braces.

After the new rods were installed and connected to the switch machine, the selector lever was placed in the "hand-throw" position, and a strapiron clamp was installed and lagged in place, so that this lever could not be operated until such time as the C.T.C. system was ready for service. In the



At construction headquarters the switch machines are attached to ties, with plates and braces in place

meantime, the trainmen used the hand-throw operating lever of the dual-control to operate the switches in the usual manner. For protection in place of the regular switch-stand target, a target and lamp on a short shaft, mounted in a base attached to the end of the tie, was operated by a connection to the switch rod. These temporary targets were removed when the C.T.C. was placed in service.

When installing bonds one man operated the portable gas-enginedriven Mall tool to grind off the rail surface clean and also to grind off any lip that might be lapping over. One man followed to apply the Caldweld bonds, each connection being welded

RAILWAY SIGNALING

The wires from cases to track bootlegs is No. 9 single-conductor underground Okonite cable with outer covering of jute, lead sheath and steel tape. The runs from a case under the track to a signal on the opposite side are in No. 14. The insulated wire used in the cases and instrument houses is No. 16 and No. 12 flexible, the larger wire being used for motor controls and track connections.

The lead maintainer at Louisville is Fred Gates. Each maintainer on line has a helper. Ollie Larkin, maintainer, with headquarters at Lebanon Junction, has the territory including 15.2 miles of the C.T.C. from Lebanon Junction to New Haven, as well



by an individual charge of pyrotechnic lighted by a shot from a spark gun. On the average about 20 joints could be bonded in an hour.

Portable Concrete Mixer

The concrete foundations were poured in place. Removable portable wooden forms were used, the inside being coated with paraffin oil so that they could be removed easily from the finished foundations. The equipment used by this crew included a lightweight power mixer rated at 1/4 cu. yd. and driven by a small gasoline engine. The entire mixer could be easily loaded or unloaded from a push car and set up beside the form when mixing the concrete. The sand and crushed rock were distributed by local freight, and the cement was hauled out to the locations on push cars hauled by motor cars.

When making a signal foundation, a piece of 5-in. stove pipe was placed at an angle to form a chaseway for cable entrance, extending from the top surface to a point 2 ft. below ground line on the track side. Likewise, the foundations for the instrument houses and cases include chaseways for cables. Left—E. L. Pardue, assistant, and Ollie Larkin, maintainer, checking an adjustment of a switch Right—A set of primary battery to feed a short track circuit

as 25 miles of double-track automatic signaling on the north and south main line between Louisville and Nashville. W. S. Green, maintainer, with headquarters at Lebanon, has 31.5 miles of C.T.C. between New Haven and the north end of Rileys. N. F. Harper, maintainer at Junction City, has 38.5 miles from Rileys to Crab Orchard, and G. G. Blazier, maintainer at Mt. Vernon, has 22 miles between Crab Orchard and Sinks. Each maintainer has been assigned a new M-19 Fairmont motor car with a top and windshield, as shown in one of the accom-



panying pictures. Variations in the lengths of maintainers' territories depend somewhat on the number of highway crossing signals involved. With a total of 29 crossings protected by signals, there is an average of one such crossing every 4 miles.

This centralized traffic control was planned and installed by Louisville & Nashville forces under the direction of W. H. Stilwell, signal engineer, and P. P. Ash, assistant signal engineer, C. I. DeLong, chief signal draftsman, and H. L. Petty, general signal construction foreman. The foremen of the construction crews were W. R. Cassidy, M. Thomas, I. Curtiss and H. V. Coates. The major items of C.T.C. equipment were furnished by the Union Switch & Signal Company.



Typical rail joint with welded bond installed