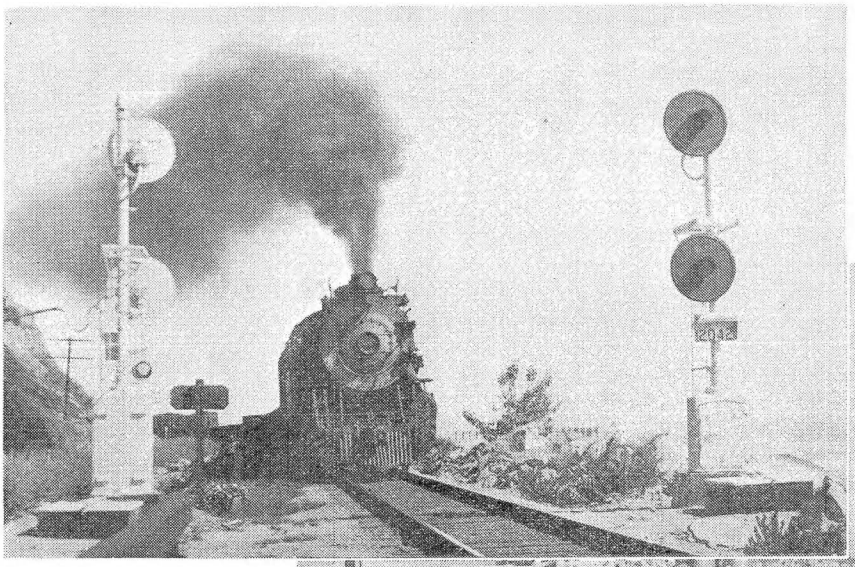
Santa Fe



Above—A local freight train at intermediate
Right—The southbound San Diegan at Oceanside

New signaling facilitates operations on single-track line handling heavy through traffic, numerous switching moves and helper locomotives on grades

BETWEEN San Diego, Cal., and Bandini, which is a suburb of Los Angeles, the Atchison, Topeka & Santa Fe has installed centralized traffic control on 99.4 miles of single track and 17.3 miles of double track. In brief here, the new signaling facilities have been an important factor in expediting train movements and relieving congestion which was the result of heavy war-time traffic on a single-track line which previously had been operated by timetable and train orders.

Between San Bernardino and Los Angeles, 59 miles, the Santa Fe has two main lines, the one via Pasadena handles the through passenger trains, while the one via Bandini and Fullerton handles the freight traffic and, in addition, the passenger trains to and from San Diego use the portion between Fullerton and Los Angeles.

As a part of the general improvement program during the past few years, second main track was constructed from Los Angeles eastward for 9.8 miles to Bandini, and from Fullerton westward 12.9 miles to DT Junction. However, second track was not constructed between DT Junction and Bandini because steel was not available to build bridges for the additional track over the Hondo and the San Gabriel rivers. Between Fullerton and San Diego, 102.5 miles, the main line is single track, except for three short sections of double track totaling 5.4 miles, as shown on the track diagrams.

Sudden Increase in Traffic

Previous to 1941, the traffic between Los Angeles and San Diego was comparatively light, the passenger as well as freight traffic being handled by trains which were operated mostly as locals. Starting early in 1941, the traffic increased so rapidly that the facilities could not be changed fast enough to prevent congestion. Whereas most of the local freight had previously consisted of outgoing fresh fruits, there was a sudden large increase of local freight to and from various training camps and ports. The freight traffic handled on this district increased from 315,554 ton miles during the first three months of 1940, to 636,111 ton miles in the same period of 1941, and to 864,112 ton miles for the same period of 1942.

In order to handle the increasing war-time through passenger traffic between Los Angeles and San Diego, new light-weight streamlined cars and Diesel-electric locomotives were purchased to operate four trains each direction daily. These trains make only one scheduled stop, at Oceanside, with a flag stop at Santa Ana, and make the 138-mile run between Los Angeles and San Diego in about 2 hours 43 minutes. In addition, conventional coaches and steam locomotives are used for a local train in each direction daily. Extra passenger trains are operated as required, as many as 10 to 12 such trains being required on some days. Roughly the total number of trains daily increased from 16 per day in 1941, to 25 per day in 1942, and to about 42 per day in 1943.

One scheduled through freight train is operated over night in each direction daily. Extra through freights are operated as required, and on a recent day there were 9 extra eastbound freight trains and 12 westbound. On the same day there were 5 light helper engine movements between Linda Vista and Sorrento, and 5 such movements between Linda Vista and Elvira. Local freight trains are scheduled each way daily except

Installs C.T.C. on 115.6 Miles

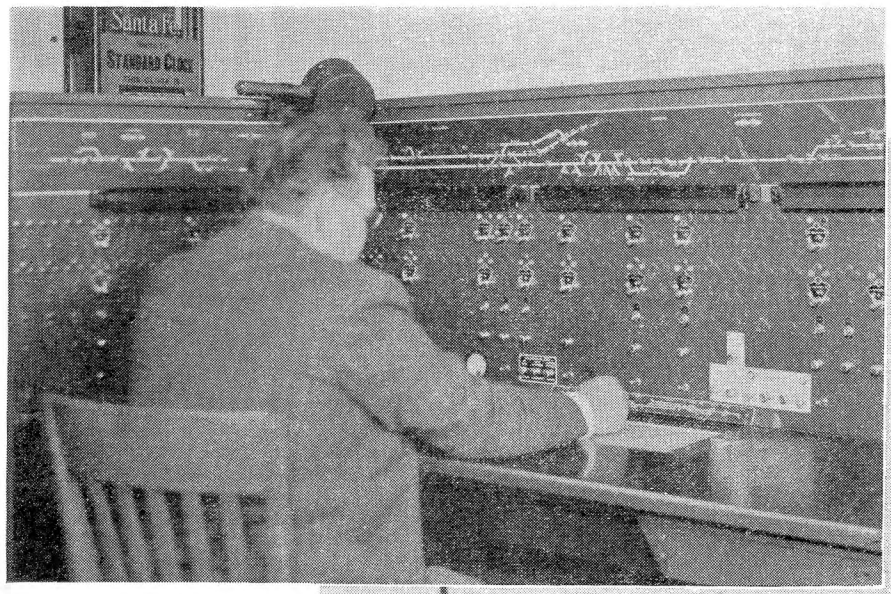
Los Angeles to San Diego

Sunday. Counting all trains, as well as light engines, the total number of train movements varies from about 42 to 45 daily.

The increases in traffic resulted in so many additional train movements that the timetable and train order method of authorizing train movements was entirely inadequate. In numerous instances, when track was available, trains would have to wait in yards or on sidings for hours, simply because the dispatcher could not issue orders fast enough to keep up with the rapid changes in train operating conditions. Local trains, which had finished their switching at certain towns, were frequently required to wait an hour or more before receiving orders to enter the main track and proceed. Helper locomotives, used to assist tonnage trains up the grades between Selwyn and Sorrento, lost a great deal of time when waiting for orders to return light to the bottom of the grades. Therefore, a decided improvement in railroad transportation between Los Angeles and San Diego was an important item in the overall program to win the war. The construction of second track would have required large quantities of scarce materials, and no men were available for such programs. A further consideration is that the additional track might not be justified after the war. For these reasons, a decision was made to make certain track changes and additions, as well as to install centralized traffic control, including power-operated switches and signals for authorizing train movements, thus dispensing with the delays which were inherent in the timetable and train order system, and reducing the delays occasioned by the use of hand-throw switches at passing tracks.

Character of the Line

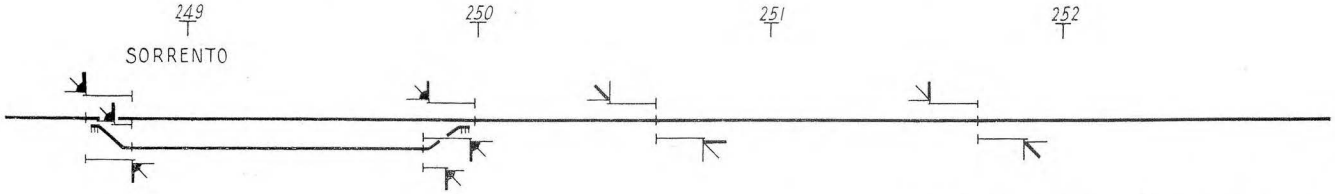
Between Fullerton and San Juan Capistrano the railroad passes through rolling country. In this section between Como and El Toro, the grade ascends southward at a maximum of 1.4 per cent for about 9 miles, and then descends at varying rates up to 1.2 per cent for 11 miles to Serra. Between Serra and Sorrento, about 49 miles, the railroad follows along close to the Pacific coast, the grade being nearly level



Above—The C.T.C. control machine at Fullerton Right—Southward signal at San Juan Capistrano

except at places where the line ascends from the beach to a higher bench or returns to the beach.

Between Sorrento and Pacific Beach the railroad passes over a ridge. From Sorrento to Linda Vista, the grade is 2 per cent, plus or minus up to 2.2 per cent maximum for 3 miles, and then descends at about the same grade for 4 miles to Elvira. Furthermore, the curvature is excessive, with numerous curves ranging up to 8 degrees and five curves more than 10 degrees. On account of the grades and curvature, helper locomotives are required on all tonnage trains southbound from Sorrento to Linda Vista, and northbound from Pacific Beach to Linda Vista. Between Elvira and San Diego the grades are rolling, with a maximum of about 0.8 per cent.



Track and signal plan of the section from Sorrento

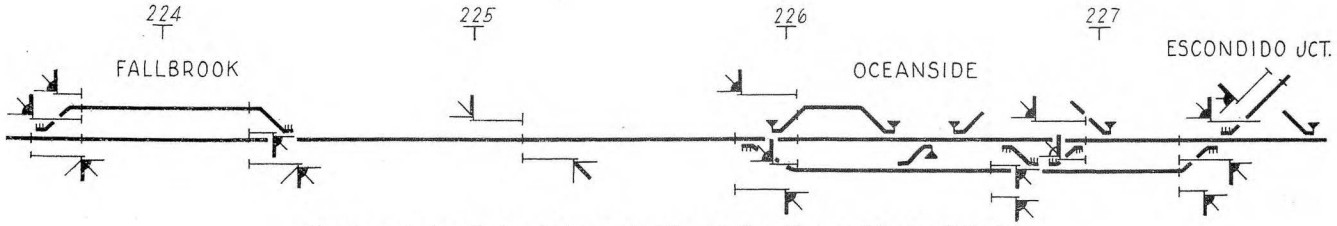
Changes in Track Layouts

Previously some of the passing tracks held about 48 cars, and, therefore, in order to handle longer trains, nine of the principal sidings were lengthened, the names of the towns, the old car capacity and the new capacity being as follows: Venta, 52 to 87; Irvine, 47 to 112; El Toro, 51 to 82; San Juan Capistrano, 44 to 80; Serra, 72 to 92; San Onofre, 64 to 92; Agra, 49 to 90; Ponto, 46 to 102; and Encinitas, 32 to 85. In order to increase the track capacity on the heavy grade, a new second track was added on 4.2 miles between Linda Vista and Elvira. A new No. 20 turnout was installed at the Elvira end of this second track and a No. 14 turnout at Linda Vista. New No. 10 crossovers were installed, one at the west end of Linda Vista and one at Selwyn.

Changes at Oceanside

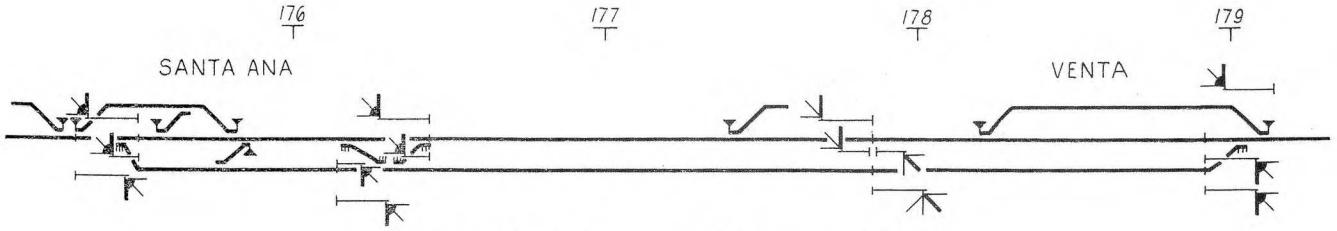
Oceanside is an intermediate terminal, where all trains stop, and most of them take fuel and water. Local freight trains work out of Oceanside in each direction, as well as to and from the branch lines to Escondido and to Fallbrook. Through passenger trains meet at Oceanside. Under the previous method of operation, congestion of trains occurred quite often. For these reasons, when making improvements, a second main track was extended through from the north end of Oceanside to Escondido Junction, about 2 miles, and a set of two crossovers were provided at a central location. A new passing track, with a capacity of 85 cars, was installed at Fallbrook Junction, and the junction switch for the branch line to Fallbrook, which formerly connected with the main line, was changed to connect with the passing track.

In the territory through Orange, Santa Ana and Venta, there are numerous side tracks and spurs for serving fruit packing houses. In the peak season for shipping oranges and other citrus fruits, several switch engines and local freight trains are assigned to this territory. In order to carry on this switching without interfering with through train movements, a second track was extended on one section about a mile long through Orange and on nearly 4 miles between Santa Ana and Venta. In these sections, both main tracks are signaled for train movements in both directions, so that if one track is occupied by a local train or switching movement, the thorough trains can be run around on the other track.



Track and signal plan between Fallbrook Junction and Escondido Jct.

A branch line extends north from Orange through Olive to Atwood where it connects with the through main line between Fullerton and San Bernardino. Many of the local trains which handle fruit are operated from Orange to the main freight yard at San Bernardino by way of Olive and Atwood, rather than by way of Fullerton, thus relieving the traffic volume on a part of the Fullerton-San Diego line.



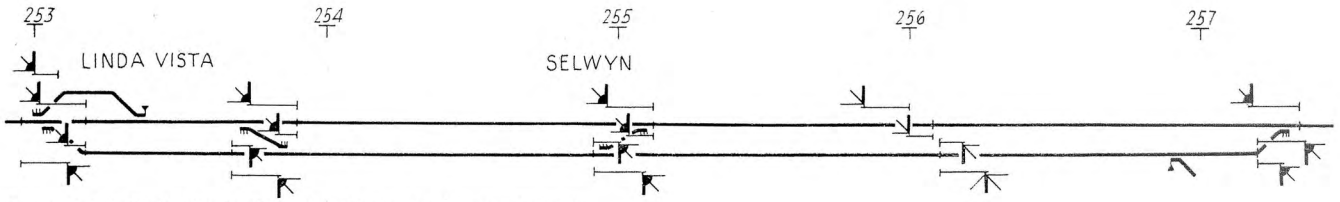
Track and signal plan between Santa Ana and Venta

Operation of Switches

Low-voltage d-c. electric switch machines with dual-control were installed at the ends of double track, at

the crossovers between main tracks, at junctions and at the ends of those sidings which are used regularly for the meeting and passing of trains, a total of 58 switch machines being installed between Fullerton and San Diego. The switch machines in the junction layout at Fullerton are the 110-volt d-c. type with dual-control. New machines were installed as a part of the recent program.

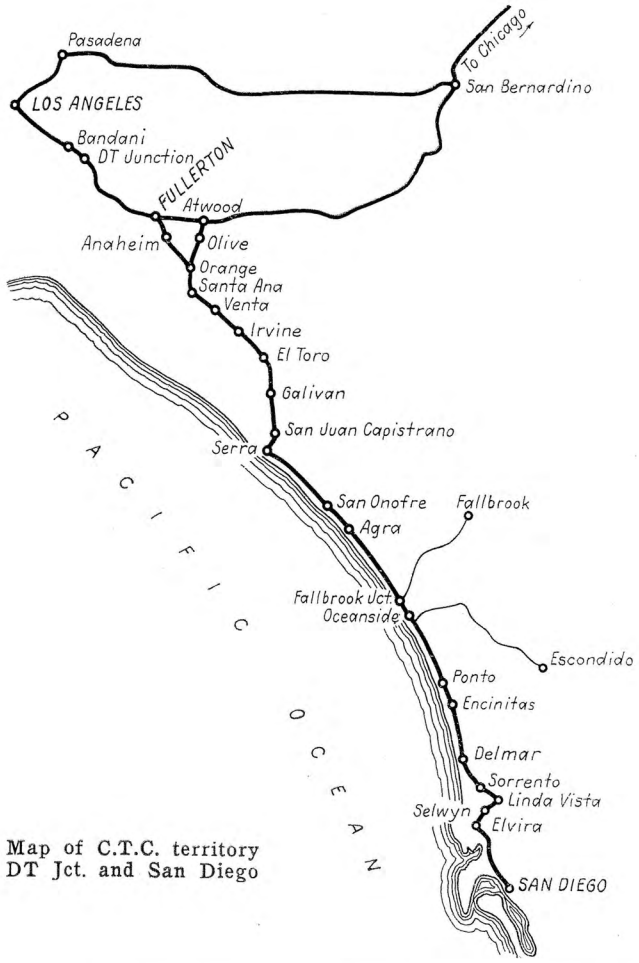
At each switch, insulated gage plates and adjustable rail braces are used on four ties. On two ties the plates extend and are attached to the switch machine, thus preventing lost motion. Under normal conditions, the switch machine is located on the side of the track adjacent to the normally-closed switch point, and a low target, with two colored disks and corresponding reflector lenses, is mounted on the side opposite the switch machine. However, some of the switch machines are on the open-point side to conform with local conditions. When the switch is in the normal position, a green disk and green lens is displayed toward a train approaching the facing point. When the switch is reversed, a yellow disk and lamp are displayed.



through Linda Vista to Selwyn where grades are heavy

Signaling Changes

Automatic block signaling using color-light signals controlled on the single-track overlap principle, had been in service between Fullerton and San Diego since 1931. As a part of the new construction, the signals were relocated where necessary, most of them being searchlight type although some existing Style-R color-light signals were reused at intermediate locations.



Map of C.T.C. territory DT Jct. and San Diego

The signals are located at the right of the track governed. At one end of each siding, the track was thrown over to 18-ft. centers, in order to locate the station-leaving main-line signal at the right of the main track. These signals are on masts 18 ft. high, and the searchlight signal is mounted on top the mast with the center of the lens in line with the center of the mast. Ladders, but no platforms, are provided. All these special features make it possible to conform with standard clearances with the tracks at 18-ft. centers. By thus reducing this distance, a saving is made in the cutting or filling which may be required. At Oceanside and some other places on the double-track sections, overhead cantilever-type signal bridges were installed, the signals being mounted over the right rail of the track governed.

Each semi-automatic C.T.C. controlled signal has one searchlight signal head, and is capable of displaying any one of three aspects, red, yellow or green. The absence of a number plate designates these signals as absolute stop signals, A.A.R. rule 292.

When a switch is reversed and the signal is cleared for a train to enter the passing track, the home and distant signal aspects are yellow. At the ends of double track where No. 20 turnouts are in service, such as at Bandini and DT Junction, when the signal is cleared for an approaching train to go from the single track to the normal right-hand track of the double track, and at Venta from the single track to the secondary main track, the aspect displayed is a flashing-yellow on both home and distant signals with blocks clear ahead. This indication authorizes a speed of 40 m.p.h. for passenger trains and 30 m.p.h. for freights, when making the diverging move over the turnout.

The A.A.R. stop-and-proceed rule 291 applies to the most restrictive aspect of the intermediate automatic block signals, and they are so designated by number plates. Ordinarily each of these intermediate signals has only a searchlight head, and displays the three aspects, red, yellow or green. However, where the second block ahead is shorter than train stopping distance, a lower unit, consisting of

a normally extinguished yellow lamp, is provided on the mast of an intermediate automatic signal. When the third block ahead is occupied, the lower unit is lighted to display yellow, in combination with a yellow in the searchlight unit above. This Medium-Speed aspect of yellow-over-yellow, indicates Proceed, approach next signal prepared to proceed at restricted speed.

Two C.T.C. Control Machines

One C.T.C. control machine, in the office at Fullerton, controls the territory from Bandini through Fullerton and south as far as El Toro. The purpose of including the Bandini-Fullerton section was to control the end-of-double track switches at Bandini and DT Junction, as well as to authorize train movements on the single track between these places. The switches, crossovers and signals in the junction layout at Fullerton were formerly included in an all-electric interlocking. When the track changes were made, the control of the switches and signals, as revised, were included in the C.T.C. machine, the old interlocking machine being removed. A second C.T.C. machine, in a new one-story fireproof concrete building at Oceanside, controls the territory between El Toro and San Diego.

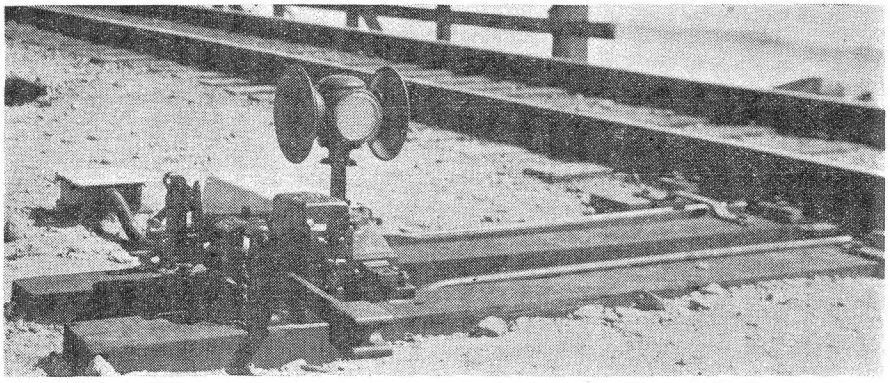
The illuminated track diagrams on these machines include a lamp to repeat the occupancy of: (1) Each OS switch detector section; (2) each passing track; (3) each section of main line opposite a passing track; and (4) each section of single-track main line between two passing tracks. The switch and signal levers, as well as the indication lamps above these levers, are of the conventional arrangements. Electric time locking is provided in connection with the signals at switches, i.e., if a proceed aspect is taken away by lever control, electric time locking by time-element relays at the field location is effective in preventing operation of the power switch, as well as the clearing of an opposing signal until a certain time has elapsed. So that the operator will know when the time-element relay is operating, the red (stop) indication light over the signal lever remains dark. Any attempt on the part of the operator to move a switch involved in the territory controlled by that signal will result in the loss of the code.

Below the levers, there are two rows of toggle type switches, one row of which controls the electric locks on the hand-throw main line switches and the other the maintainer's call lamps at each field location.

Above each portion of the diagram representing a section of main track between sidings there is a double-headed arrow with two lamps. When the machine controls are established to permit the clearing of a signal in a northward direction, the lamp to the left, which is green, is lighted. Or, when southward, the right-hand lamp, which is yellow, is lighted.

Each machine controls a code line extending in each direction and all independent of each other. At Fullerton, the north code line controls stations up to Bandini, and the south line down to but excluding the north end of El Toro. The northward code line at Oceanside controls all stations up to and including the north end of El Toro, and the south line down to San Diego.

At the north end of El Toro, the northward signals are dually controlled in such a manner that Oceanside cannot clear a signal for a northward movement unless the Fullerton operator codes a permission. In this manner there is no confliction on the part of each operator attempting to clear signals simultaneously into the single-track territory, with the result that the first signal cleared will reserve the route and hold the opposing signal at Stop. A telephone carrier is superimposed on another line for the exclusive conversation between the two men who are on duty in charge of the C.T.C. machines at Fullerton and Oceanside. The C.T.C. field stations are equipped with filters which permit the C.T.C. line to serve as a voice-frequency telephone line. The waystation phones which are connected to the C.T.C. line are used mainly by the maintenance personnel for conversation from point to point along the line and with the dispatcher. The C.T.C. code line circuits are on two No. 6 Copperweld wires with double-braid, weatherproof covering.

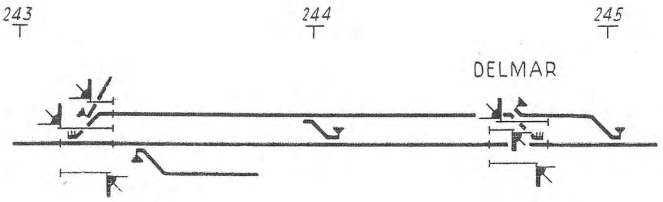


New T-21 hand-throw switch stand with electric lock

The general system is known as the Type L Form 506 Time Code Control System. The "Field Station Disconnect" equipment is installed, and permits a faulty station to be removed from the line, also it permits the exact location of the faulty station to be determined.

Electric Lock on Hand-Throw Switches

At the main-line switches which were not equipped with power switch machines, the old hand-throw stands were replaced with Style-T21 stands, including a switch-and-lock movement, lock rods and an electric lock which locks the hand-throw lever in the normal position. A target, mounted on and operated by the mechanism, normally displays a reflector-type green lens in each direction along the track, but when the switch is reversed, a red disk and red reflector lens is displayed in each direction.



Locations of electric locks on hand-throw switches in Delmar

In addition to main-line switches, some "inside" hand-throw switches are equipped with electric locks. As for example, at San Onofre the north end of the passing track is a crossover, a house track extending on north. The "inside" switch of the crossover is normally lined for the passing track turnout, and an electric lock was applied to this hand-

throw switch. At Delmar, for example, there is a hand-throw crossover between the main track and the passing track, and an electric lock was installed on the switch stand at the main line end of this crossover. On account of the numerous spurs and house tracks, 84 electric locks were installed on the territory between Fullerton and San Diego, and 4 between DT Junction and Bandini.

The Lock Lever Controlled

These electric locks are controlled by small toggle switches mounted in a row below the switch and signal levers on the C.T.C. machine. If two or more hand-throw switches with electric locks are located within the same block signal limits, these locks can all be controlled with one lever.

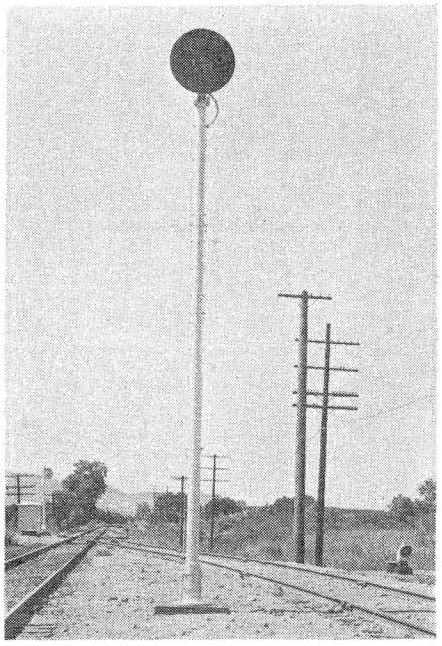
When a local train on an industry track is ready to depart, the conductor telephones to the man in charge of the C.T.C. machine, requesting an unlock. Operation of the corresponding toggle switch on the C.T.C. machine causes a code to go out on the line to the field station nearest the switch, if the switch is within a station area, and then energy goes out over a separate two-wire circuit to energize the lock coil if protecting signals are at stop and the track is clear. When the trainman removes the padlock from the switch lever, contacts are opened in the line circuits for automatic control of signals so that no signal leading toward the switch can be cleared until the switch is again placed normal and locked.

If an unlock is desired at a switch in intermediate territory (i.e. between two stations), where the two-wire either-direction circuit is used, the trainman telephones the office and requests an unlock. In this case, operation of the switch lock toggle and starting button sends codes to *both* adjacent stations in such a way as to apply battery to both ends of the reversible line circuit. Removal of the switch padlock then breaks the line circuit and places WATP and EATP relays across the line. Both of these relays pick up if the protecting home signals are at stop and all intervening track is clear, and the lock coil is energized over front contacts. The C.T.C. operator cancels an unlock by returning his toggle to normal and pressing the starting button.

When a local train on the main line is to move into a siding over a switch that is electrically locked, the operator at the code machine is not required to code an "unlock." This exit move is accomplished by removing the pad lock at the switch, and then, after a short time interval, a local "unlock" circuit permits the switch to be manually operated.

Changes in Automatic Controls

The previous automatic block signaling included d-c. neutral track circuits, and two two-wire polar line circuits, one such circuit being for the control of signals in each direction. These line circuits were arranged on the overlap principle. In the new arrangement, the automatic signals are controlled on the absolute permissive block scheme. As a part of the C.T.C. system, only one of two opposing station-leaving signals can be cleared at any one time, and, therefore, the intermediate signals need not be arranged to provide head-on protection. For this reason, the intermediate signals were entirely rearranged to provide protection for following moves and to serve as "distant" signals. As a result, the track circuit locations were changed in most instances, but the practice of using d-c. neutral track circuits was continued in the C.T.C. system. With 4-ohm relays, the maximum length of track circuits on main track is 3,500 ft. On passing tracks, the ballast may not be so clean and, therefore, the track circuits are limited to 3,000 ft.



Signal between tracks at 18-ft. centers

Two-Wire Either-Direction Line Circuit

In the new arrangement, a circuit with only two line wires is used for the automatic controls of signals for one direction or the other, depending on the direction for which traffic is established when the C.T.C. code control is sent out from the office to clear a signal. The two-wire either-direction circuit is, in effect, practically the same as was installed on the Louisville & Nashville, as was explained in detail with circuit diagrams on page 420 of the August, 1943, issue of *Railway Signaling*. An important difference between the reversible line circuit used on the Santa Fe and that described for the L. & N. is that the Santa Fe uses positively-controlled switching to determine whether "battery" or "relay" is to be connected to the circuit at a control point while the L. & N. scheme employs automatic methods. The positive control makes use of a C.T.C. function relay (polar-stick Style-KP) to provide the directional selection, which is determined by the interpanel wiring on the C.T.C. machine. Thus in clearing a home signal, codes are sent to both ends of the traffic block to properly select and set the direction of the two-wire circuit. Such a scheme permits the application of battery to both ends of the circuit to transmit a switch "unlock," as described above.

The reversible circuit was not used through the station areas; rather the conventional four-wire block-repeater arrangement was retained. The two line wires for this circuit, as installed on the Santa Fe, are No. 8 double-braid weatherproof galvanized iron. The track relays double-break this circuit.

Some of the intermediate signals display a fourth aspect, yellow-over-yellow, Medium Speed, as discussed previously, and in each such instance, a separate two-wire line control circuit using existing line wires was provided to control this fourth aspect.

In order to control the track-occupancy indications on the C.T.C. machine, as well as the motor car warning indicators at various locations along the track, there are two two-wire line circuits, one for northward and the other for southward. These circuits are separate from other circuits and are fed from separate batteries so that crosses or grounds will not cause failures on the signal control circuits.

Alternating-current power is distributed in both directions from various stations, the power circuit being on two No. 6 copper wires with weatherproof covering. The feeds are for various lengths and at 110-volts, 220-volts or 440-volts, depending on the available supply. The line transformers at the ends of sidings are rated at 250 volt-amperes, and those at intermediate signals are rated at 100 volt-amperes. The storage bat-

teries on floating charge are of the same type throughout; Exide DMGO-9 rated at 80 a.h. on an 8-hour rate. At a power switch location there is a set of 13 cells all of which is used to operate the switch machine, while 8 of these cells feed the line-code-storage equipment and 5 cells feed relays. Also there are two sets of 5 cells each which feed line circuits, and at each double intermediate location there are two 5-cell sets of battery. Each track circuit is fed by one cell of battery.

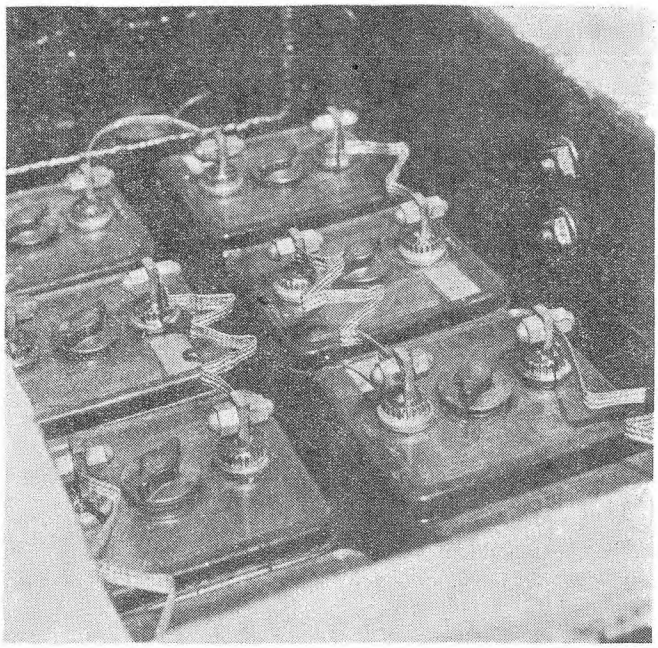
At the C.T.C. control offices, as for example at Oceanside, there are two sets of 8 cells each of EM 9 battery rated at 160 a.h., which are used to feed the office equipment. The code lines are fed by small batteries rated at 5 a.h., the line north is fed at 85 volts and the line south at 80.

At the power switch layouts, the relays, code equipment and rectifiers are located in small houses, which range from 6 ft. by 7 ft., to 6 ft. by 10 ft. On the territory north of San Juan Capistrano the houses are welded sheet-metal, but on account of the corrosive effects of the salt atmosphere along the ocean, concrete houses were used between Serra and San Diego. The batteries are located in concrete boxes which are set in the ground near the end of the house.

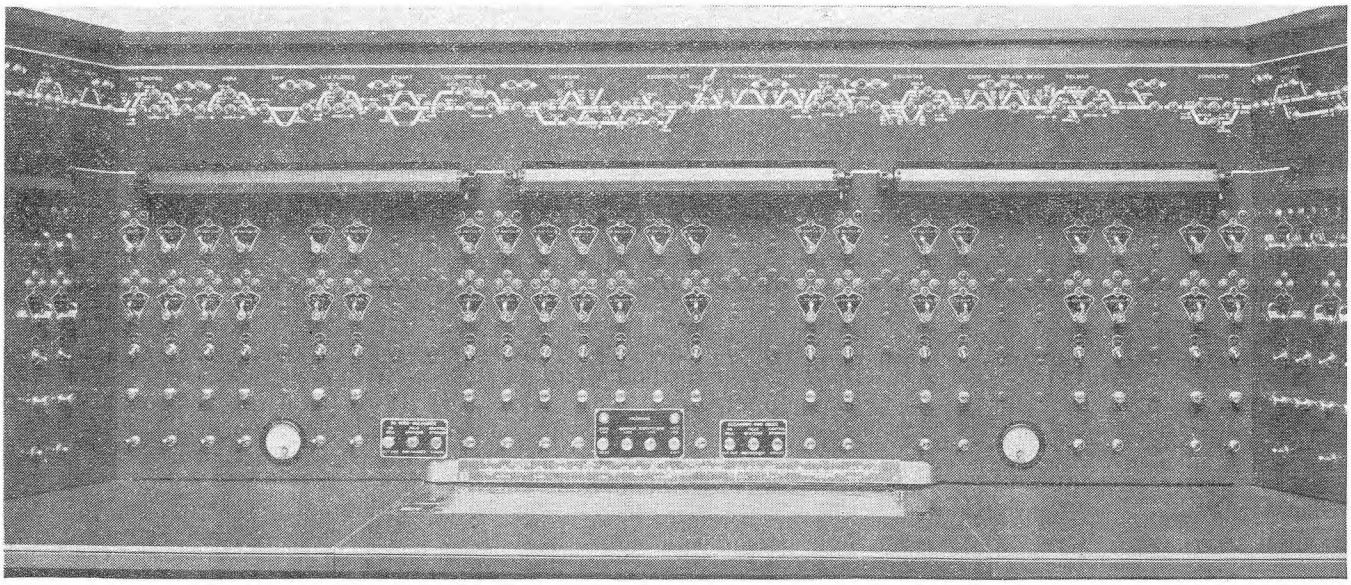
As mentioned previously, the line wire circuits used for the control of the track-occupancy indications on the C.T.C. machine, are used also to control motor car indicators. These indicators are of the semaphore type, similar to those formerly used on some roads as switch indicators. The indicators face the track so that men on motor cars can see them. The indicators are normally energized, but when a train enters the control limit, the blade is released to the O-deg. position. Information to show the extent of the control limits is printed on the indicator so that a man on a car, when he sees an indicator clear, may estimate how much time he has to travel beyond the hazardous zone or to the next indicator.

The improvement program, including the new sections of second track and longer sidings, as well as the centralized traffic control, have accomplished satisfactory results in saving train time and increasing the track capacity, so that trains can be kept moving without delay. On the average, the overall time of freight trains has been reduced about 2 hours or more, and in most instances the saving is from overtime. Of most importance is the fact that trains can now be moved out of Fullerton, San Diego, Oceanside and other places when they are ready to go, without losing time waiting for orders. Although the traffic has more than doubled since 1941, the trains are being moved promptly. Considerable time has been saved for the local freight trains and helper locomotives. For example, a helper can now make at least two helping moves in 8 hours, whereas previously one such move was all that could be made. Fewer locomotives and crews are, therefore, required for this service.

The track changes and centralized traffic control on this project were planned and constructed by the forces of the Atchison, Topeka & Santa Fe, the major items of the signaling equipment being furnished by the Union Switch & Signal Company.



The storage batteries are located in concrete boxes near the houses



Center panel and automatic train graph of C.T.C. machine at Oceanside, Cal.