C. T. C. Saves Train Time on a Section of the Southern Pacific

New project relieves congestion on a 17-mile bottleneck thus expediting operations on a division

IN ORDER to relieve congestion on a 17-mile single-track section of heavy grades and curvature, the Southern Pacific made an installation of centralized traffic control which was completed August 13. In brief, the new signaling facilities have reduced the overall time of trains in this section, thereby increasing the track capacity of this bottle-neck to the extent that operations of the division as a whole have been facilitated.

Between West and East, the two ends of the new centralized traffic control section, the line passes over a ridge, the crest of the grade being in a tunnel 3,600 ft. long. From West to the crest, 4 miles, the grade ascending eastward varies, most of it being about 2.2 per cent. Of a total of ten curves, three are 10 deg., three are 7 deg., one is 4 deg. 30 min. and three are 3 deg. From East to the crest, 12.5 miles, the grade ascending varies, with a large proportion of it between 2 per cent and 2.2 per cent. In this 12.5 miles there are 42 curves, of which 26 are 10 deg. In addition to the tunnel through the crest, there are three other tunnels totaling about 2,150 ft. in length. On account of the curvature and grades, the speeds are limited to 30 m.p.h. for passenger trains and 18 m.p.h. for freight trains in both directions, except that the limit for passenger trains is 35 m.p.h. on 4.1 miles between Siding No. 4 and East. All freight trains and most of the passenger trains require helper locomotives up the grades.

Track Layout and Train Movements

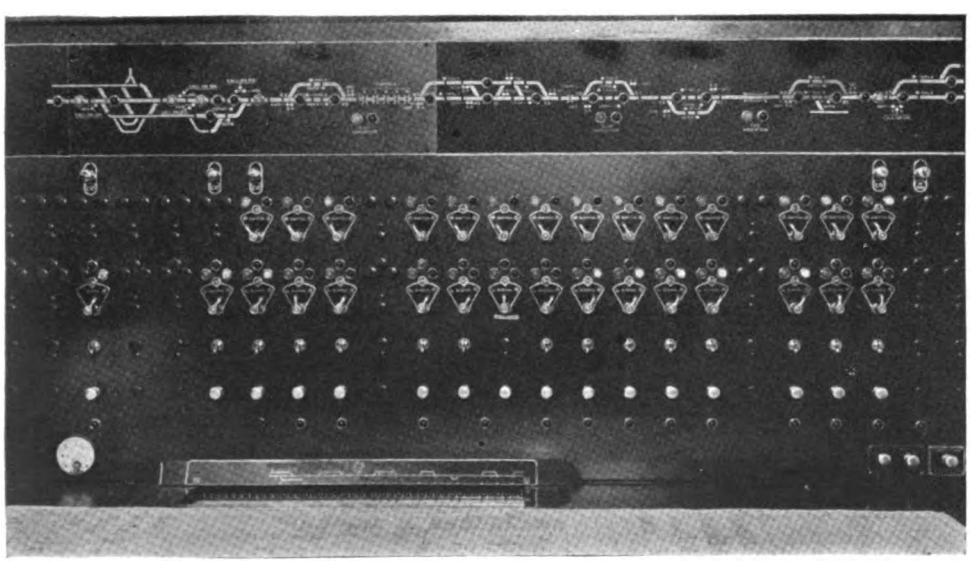
East is a sub-division point where all freight trains enter and depart from a yard. Helper locomotives are coupled to the freight trains in the yard. Westbound passenger trains hold the main line, and a helper is coupled to the head end. At West a special siding and crossovers are provided to permit helpers to cut in or cut off of trains when on the main track or on the passing track.

Between West and East, there are five passing tracks with car capacities as shown on the diagram. At Siding 2, a set of crossovers is provided between the main line and the passing track so that the two portions of this siding can be used separately to hold opposing train while a third passes.

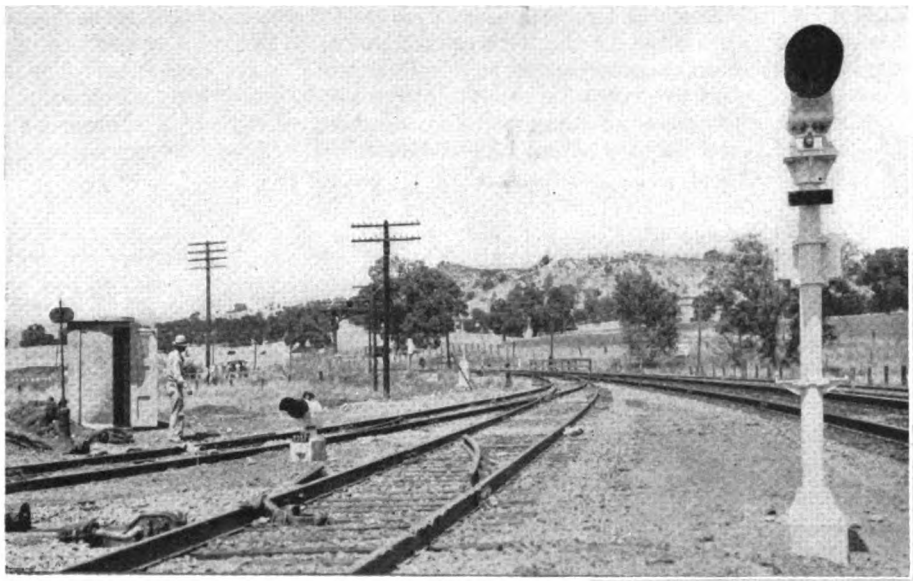
Number of Movements

The Southern Pacific routes much of the freight and some of the passenger business over a different line, the section between West and East is a part of a route used primarily for passenger trains, fast merchandise freight trains and other freight trains required in local service for stations on this line. Five passenger trains are operated in each direction daily. Prior to several months ago, four more passenger trains were operated daily, four trains having been removed from the schedule to conserve equipment and locomotives for emergency service. From one to as many as four extra sections of certain overnight trains are operated on various nights, the peak being on week end nights. Other movements require as many as ten or more additional extra passenger trains in a 24-hour period.

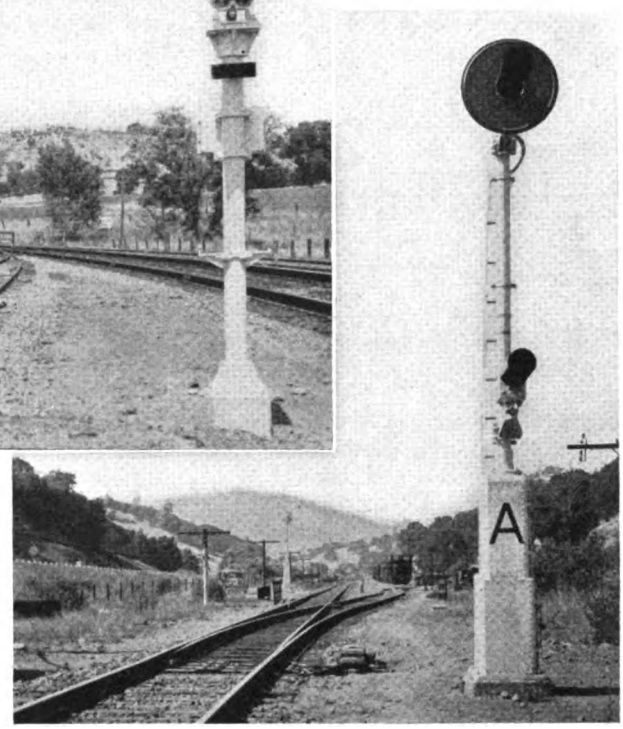
One merchandise freight train in each direction is operated on passenger train schedule. Three other



The C.T.C. control machine included the illuminated track diagram, 14 levers for switches, 16 levers for signals, and an automatic train recording graph



Below—A typical power switch machine and station-entering signal



Above—High dwarf and hand-throw derail on a turn-out where the mainline switch is operated by switch stand

freight trains are scheduled westbound and two eastbound. On heavy traffic days, from three to four extra sections of each scheduled freight trains are required.

Thus the total number of train movements daily over this territory averages from 33 to 36. As a general rule, the helper locomotives operate through from East to West or vise versa. As long as the number of trains in each direction are about equal and properly distributed, no light movements of helpers are required. For example, on a typical day there were only five occasions in which a helper was run light between the two ends of the territory.

Reasons for Congestion

For many years this 17-mile section of mountain grade has been the bottle neck which limited the capacity of the entire division. Trains of the same name are scheduled to leave each of two terminals at the same time. On the basis of train time, the territory between East and West is midway between terminals so that paired trains of opposing direction meet in this section. On account of the heavy curvature and grades, the speeds are limited to the extent that the best possible running time eastbound between West and East is 34 minutes, and westbound 37 minutes. These periods are so long that train schedules cannot be set back or advanced to allow the meets to be made off of this territory. As a result, in this 17-mile section, six of the passenger trains have one meet, two have two meets and two have three meets. Each of the two merchandise freight trains have three meets.

The three-hour peak is between 12:35 a.m. and 3:13 a.m., during which time four scheduled passenger trains and the two merchandise trains are handled. On some nights, the freight requires one extra section, and one of the passenger trains may run in as many as four sections in each direction, thus increasing the number of meets and congestion of trains.

For many years this section of line has been protected by automatic block signaling, the passing track switches being operated by hand-throw stands, and train movements were authorized by time-table and train orders. On account of the mountainous character of the terrain and the tunnels, the addition of a second main track, as a means for increasing track capacity, or the reconstruction of the single-track line to reduce the curvature and grade as a means for increasing the speed of trains when in motion would be so expensive as to be beyond reason. The only logical solution, therefore, was to install centralized traffic control by means of which a considerable proportion of the train time previously lost in delays could be saved, thus not only reducing the total time for each train, but also getting each train off the terriory more quickly, thereby permitting other trains to enter. Thus the capacity of the existing line could be increased.

Because of the numerous meets between trains, the power switches, included in the new centralized traffic control system, accomplish a considerable proportion of the total saving in train time. The turnouts are No. 14 so that trains can make diverging moves to or from the main track at speeds up to 25 m.p.h.; therefore, the trains can now enter or depart from passing tracks at normal speed and without stopping to permit the operation of hand-throw stands. Circumstances vary depending on the grades, curvature and the length, as well as the direction of trains, but, on the average, the power switch machines save about 4 to 6 minutes when a train is entering a passing track and about 6 to 10 minutes when departing. The signaling is arranged so that an engineman is informed whether a passing track is unoccupied, when he is heading in. Also, when departing, he is informed whether one, two or more automatic blocks ahead have been cleared by a preceding train.

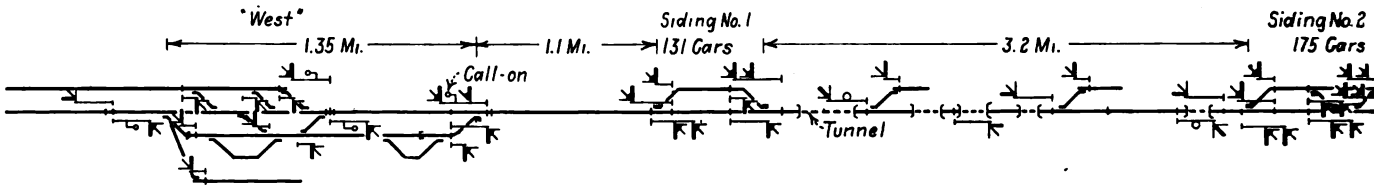
For these reasons, a train can make a move out of one passing track, then over the main line to the next passing track, and get into the clear in approximately 17 minutes less time than such a move could be made previously when hand-throw switches were in service.

Closer Meets

Another source of time saving with the centralized traffic control is that by means of the O.S. indication lamps

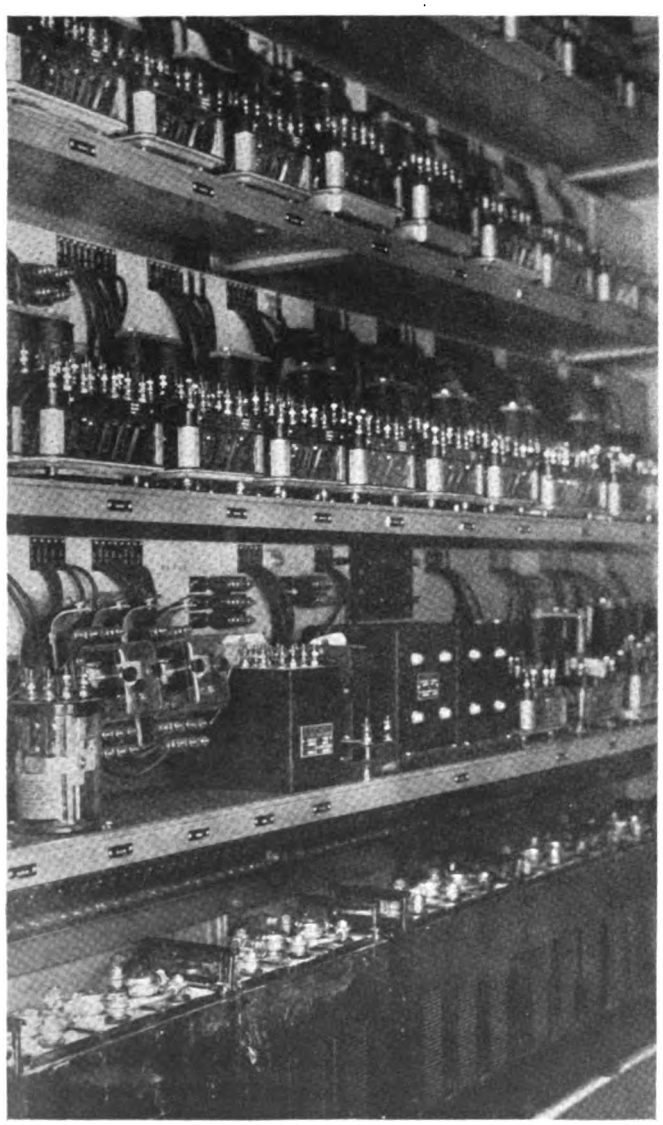
and the automatic train graph on the control machine, the dispatcher knows of the progress being made by each train, so that he can advance trains for meets at close timing. With one exception, the passing tracks will hold from 103 to 175 cars. Thus, trains can be run through sidings without losing much time. On account of the length of the sidings, non-stop meets are numerous. For example, on August 12, two passenger trains, No. 8 eastbound and No. 9 westbound, made a non-stop meeting at Siding No. 4, where the capacity of the siding is only 43 cars. The head end of No. 9 passed the east switch at 1:03 p.m. and was in the clear on the passing track at 1:04 p.m. The head end of No. 8 passed the west switch at 1:05 p.m. and the east switch at 1:06 p.m. In the meantime, No. 9 passed through the siding without stopping, and departed from the west switch at 1:06½ p.m. On August 13, these two trains met at siding No. 2, the head ends of the trains passing their respective "first" switches at practically the same time, No. 9 going through the passing track, and the meet was made without either train stopping.

The trains No. 8 and No. 9 are scheduled to meet at Siding No. 5 at 2:44 p.m. In the instance on August 12 as explained above, No. 8 was late, and if No. 9 had been held at Siding No. 5 for the meet instead of advancing it to Siding No. 4, it would have lost 15 minutes or more. On August 13, No. 8 was late and No. 9 was advanced to Siding No. 3, otherwise it would have been held at Siding No. 4 because time would not have been available under the previous method to change train orders to take advantage of changing conditions.



Plan showing the locations of the tracks, switches and signals

Instances similar to those discussed occur numerous times each day, so that, in brief, the centralized traffic control has accomplished the objective for which it was installed; i.e., the track capacity has been increased to the extent that all trains offered can now be accepted promptly without delay at either end and the trains can be moved over the section without incurring delays out of proportion to the mileage and physical conditions involved.



Interior of typical sheet-metal house at a switch location on the new C.T.C. project

Changes in Flagging Rule 99

Field observations showed that much valuable train time and track occupancy was consumed when providing flag protection when trains stopped, because in most instances the flagman was required to go back around curves, and the time consumed in returning long distances was excessive. Numerous such stops are at stations when taking water or when cutting in or cutting out helper locomotives. In view of the fact that the centralized traffic control includes complete automatic block signal protection, a decision was made to modify compliance with the flagging Rule 99, in that flagging protection is not required when a train makes a stop between head blocks at a controlled siding, except for trains carrying passengers. Flagging is required, however, if a train makes an unusual stop at points between stations. On the average this change in the application of Rule 99 saves from 5 to 10 minutes for each stop by a freight.

Special Signaling at Passing Tracks Saves Train Time

The turnouts at the ends of passing tracks, which are equipped with power machines, are No. 14 with

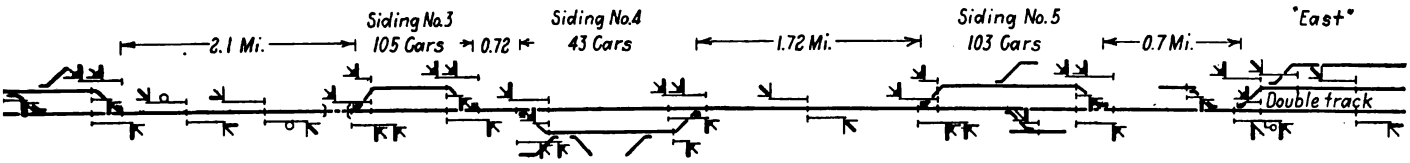
24-ft. points so that diverging moves to or from the main line can be made at speeds up to 25 m.p.h. which in general is near the maximum train speed on the main line in much of this territory. On account of the numerous curves and mountains, the engineman of an approaching train which is to take siding cannot see whether the siding is occupied. When the switch is reversed for a train to take siding, it is necessary to provide a signal to govern movements over the switch in the reverse position. In addition to indicating that the power-operated switch is locked in the reverse position and the track section over the switch is not occupied, this signal also indicates whether the siding is unoccupied or occupied by a preceding train. Referring to Fig. 2, if the switch is reversed for a train to enter the passing track, and that track is unoccupied, the lower unit of station-entering signal 5 displays a green aspect under a red in the top unit, which authorizes the train to head in and stop in the clear on the siding. Advance information is given by the display of a yellow aspect on the distant signal 7. If any part of the siding is occupied by a preceding train, and a second train is to be headed in, the lower arm of signal 5 displays yellow, under a red in the top unit. This aspect warns that a train is to head in at slow speed, prepared to stop short of the train already on the siding. If the siding is occupied by an opposing train, or the signal at the other end of the siding has been cleared for a movement into the siding, signal 5 cannot be cleared and displays its most restrictive aspect, red over red.

If the sighting distance in approach to the station-entering signal 5 is adequate, advance information for either of the two circumstances explained above is given by a yellow aspect on the distant signal 7. If local conditions are such that the sighting distance to signal 5 is short, when signal 5 displays an aspect of green under red for a diverging move into an unoccupied passing track, then distant signal 7 displays a yellow over green aspect, but if signal 5 displays an aspect of yellow under red for a diverging move into an occupied passing track, then distant signal 7 displays an aspect of yellow only. Thus if the passing track is not occupied, a freight train can proceed prepared to head in on the passing track rather than reducing speed prepared to stop short of signal 5. The extra lower units on the distant signals are of the HC-33 type with yellow glass and equipped with Phankill units. The lamp in the HC-33 unit is normally extinguished, being lighted only under the circumstances explained above.

The previous semaphore automatic block signals were removed, and the new installation includes searchlight-type signals for the semi-automatic signals at the passing tracks as well as the intermediate signals. All of the relays as well as line control circuits were installed new as a part of the C.T.C. project.

Three Aspect Leave-Siding Signals and Special Overlaps

Referring to Fig. 2, the leave-siding signals such as No. 3 and No. 4 are capable of displaying three aspects. For a following train movement, if a train has passed signal 8 and is occupying that block, and if a control is sent out to cause a Proceed aspect to be displayed on leave-siding signal 4, with a preceding train occupying the block of automatic signal No. 8, then signal 4 will display an Approach aspect, yellow. On the other hand, if the preceding train is beyond automatic signal 10, then signal 4 would display the Clear aspect, green. The use of the three aspects, red, yellow and green, as compared with the practice of only red or yellow, affords the advantage that when a green aspect is displayed the engineman knows that two or more blocks ahead are unoccupied and that he can pull out and accelerate to normal speed assured that he will not need to approach signal No. 8 prepared to stop.



on the new centralized traffic control territory

No Red With a Green

A special practice on the Southern Pacific is that on a two-unit signal, such as station-entering signal 5, if the line up is for a through move on the main line with a green aspect in the top unit, then the lamp in the lower unit is not lighted, this being different from the conventional practice of a red light also in the lower unit. The thought on the Southern Pacific is that a clear aspect should not include a red light because an engineman might see this red light before he saw the green and thus cause confusion in his mind. Thus on the Southern Pacific, the lamp in the lower unit is lighted in combination with that in the top unit only when a diverging route is set up, or as a red under a red for the absolute stop aspect.

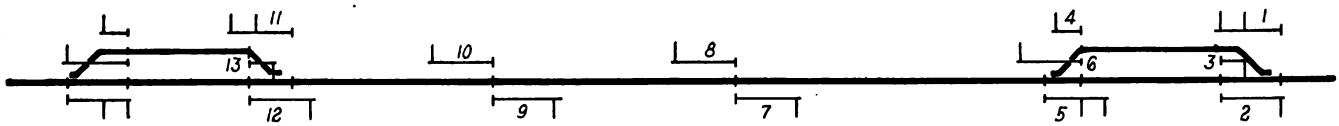


Fig. 2—Typical signaling arrangement

Call-On Signal Aspects

At some of the stations such as East where a helper locomotive must pass an absolute signal displaying a Stop aspect in order to be coupled to a standing train, a special C.T.C. controlled call-on signal is provided for authorizing the helper to move into the occupied block. This aspect is given by a third lamp unit mounted on the mast below the other two units. Normally the lamp is extinguished, but, when a couple-up move is to be made, control is sent out from the office and the helper locomotive is moved onto a short track circuit about 50 ft. long in approach to the signal,

at which time the signal displays red in each of the two upper units and a flashing yellow in the special bottom unit. The reason for making the track circuit short is to force the helper locomotive to come to a stop or reduce to very low speed before the flashing yellow call-on aspect will appear. An additional feature is that the train must have occupied the station-limit track circuit for more than a minute and a half, which checks that that train must be stopped before the call-on aspect can be displayed for the helper locomotive.

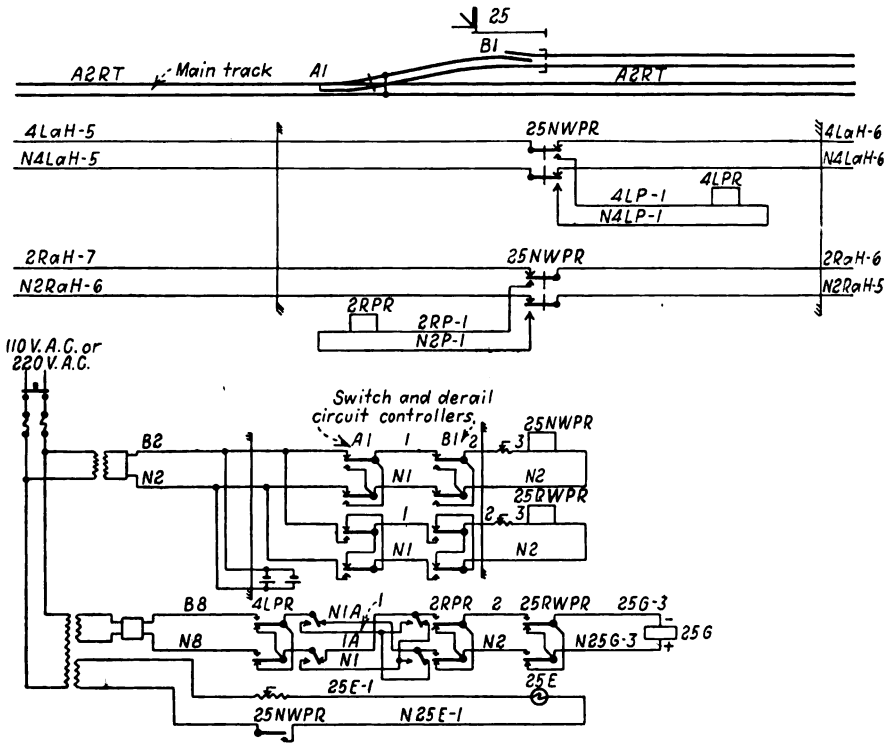


Fig. 3—Circuit for control of leaving signal on turnout with hand-throw switch

Signal Protection at Hand-Throw Turnouts

At the main-line turnouts which are not equipped with power switch machines, but which are operated by hand-throw stands, a high-dwarf signal is located opposite the clearance point to govern moves to the main line. A telephone is provided at each of these locations so that the conductor of a train on the siding can secure information from the dispatcher to know that movement of the train to the main line will not interfere with other trains.

Providing the dispatcher has not sent out controls to clear either of the semi-automatic signals admitting trains to the section including the hand-throw switch, the two two-wire line control circuits between passing tracks are energized, as explained later. Under these circumstances, when the trainman operates the stand to remove the derail from the track on the turnout, and operates the hand-throw stand to reverse the main-line switch, the signal will display a Proceed aspect to authorize the train to occupy the main track.

Referring now to Fig. 3, when the derail is removed from the track, the circuit controller connected thereto operates contacts which causes relay 25 NWPR to be released. The front contacts in this relay operates contacts in the line control circuits so that no signal leading to the location of the said switch from either direction can be cleared. Furthermore, the back points in relay 25 NWPR connect the line circuit feeding from the left to relay 4 LPR, and other back contacts connect the line circuit feeding from the right to relay 2RPR. If neither station-leaving semi-automatic signal has been cleared and no approaching train is occupying any of the track circuits in the station-to-station block as a whole, then relays 4LPR and 2RPR will be energized, which will control the signal 25 on the turnout to display a green or yellow aspect.

If the train on the turnout had been waiting for a train on the main line to pass, the signal on the turnout can be cleared to display the yellow aspect after the through train has passed beyond the first automatic signal, or to display the green aspect after the receding train has passed beyond the second automatic signal. In this instance, the feed back over the line circuit is made complete by the A.P.B. direction stick features so that the signal on the turnout can be cleared when a "receding" train is occupying the station-to-station block.

Normally the signal operating coil as well as the lamp are de-energized. When the derail is thrown off the track, the lamp is lighted to display a red aspect, and when the switch is thrown, and if the other controls are complete, the signal coil is energized to position the spectacle in the searchlight unit to display either the yellow or the green aspect, as previously explained. If the hand-throw switch is at the end of a siding where regular train movements may be made, there is an approach track circuit provided, which, when occupied, causes the lamp in the signal to be illuminated.

Thus a fact which may well be emphasized is that by using a separate two-wire signal line control circuit for each direction, these same line wires serve also for approach lock circuits as well as for controls of signals governing moves from hand-throw turnouts to the main line.

Special Detector Protection

On one bridge, which has open deck construction, and in one tunnel, fire detectors are provided which include a circuit with fused connections. At one location where rocks from a mountain side might roll on to the track, a slide-detector fence was provided, a total of 400 ft. of such fence being in service on this territory.

In brief, if any of the special protection mentioned above is operated, the signals in approach to the point of hazard from each direction are set to display their most restrictive aspect. Each such signal is designated by a special plate in the form of a triangle which displays the letter "P" in addition to the signal number. The instructions in the divisional timetable explain the form of protection included in the controls of each of the signals with the "P" markers, so that if a train is stopped at such a signal the crew knows what to look for.

An additional feature is that when a detector device is operated, an indication is sent over the C.T.C. system to the control office so that the dispatcher can at once call out the track forces and signal maintainer to clear the track or extinguish the fire, and, when proper to do so, restore the controls to the normal condition.

Track Circuits and Signal Line Controls

The track circuits are the d-c. type using neutral relays rated at 4 ohms except that 2-ohm relays are used in

tunnels as a means for securing better shunting characteristics with adverse damp ballast conditions. Each track circuit is fed by three cells of Edison 500-a.h. primary battery connected in multiple. The length of each section of main track opposite a passing track is cut into two track circuits. Likewise, the length of the passing track is cut into two track circuits. On these sections of main line, as well as on the passing tracks, the track relays are on the ends of the circuits toward the switches. The purpose for this track circuit arrangement is to provide a "two-track-circuit" release of the locking. A train must occupy the OS switch detector track circuit, then occupy the next track circuit, before the locking is released. The switch is, of course, always locked when the OS track section is occupied. This procedure prevents operation of the switch if the OS circuit should be inadvertently shunted and a switch control sent out which under some other methods of control may release the locking with a train approaching and permit the switch to be operated.

On each turnout, a series connected fouling circuit is used so that a check is made for broken rail or open bonding. The connections are such that if any of the four insulated joints in the turnout fail, the battery will be shorted, thus causing the relay to be released.

The local signal control relays are the Type DP-14 polar rated at 250 ohms. A separate two-wire normally-energized line circuit is used for the controls of signals for each direction. Each line circuit checks through contacts of the track circuts in its respective automatic block. The conventional arrangement of absolute permissive block stick relays provide for the clearing of intermediate signals for a following train. These A.P.B. circuits also include the absolute control of opposing station-leaving signals for a station-to-station block between passing tracks. If a station-leaving signal is cleared, energy is cut off of the line circuits for all opposing intermediate signals as well as the opposing station-leaving semi-automatic signal. Thus if one station-leaving semi-automatic signal has been cleared, the opposing station-leaving semi-automatic signal cannot be cleared, regardless of whether a control code is sent out from the office. Thus the established route and traffic direction is automatically retained. Furthermore, the line controls of opposing station-leaving signals are taken through relays controlled by the approach locking so that if a Proceed aspect of a station-leaving signal is "taken away," the line control circuit of the opposing station-leaving signal is not closed until the expiration of the time release period. Thus, with the two two-wire signal line control circuits, the route and direction are retained and, furthermore, compliance with Item 412 of the I.C.C. Rules, Standards and Instructions is accomplished automatically, without interconnections and extra relays in the control machine.

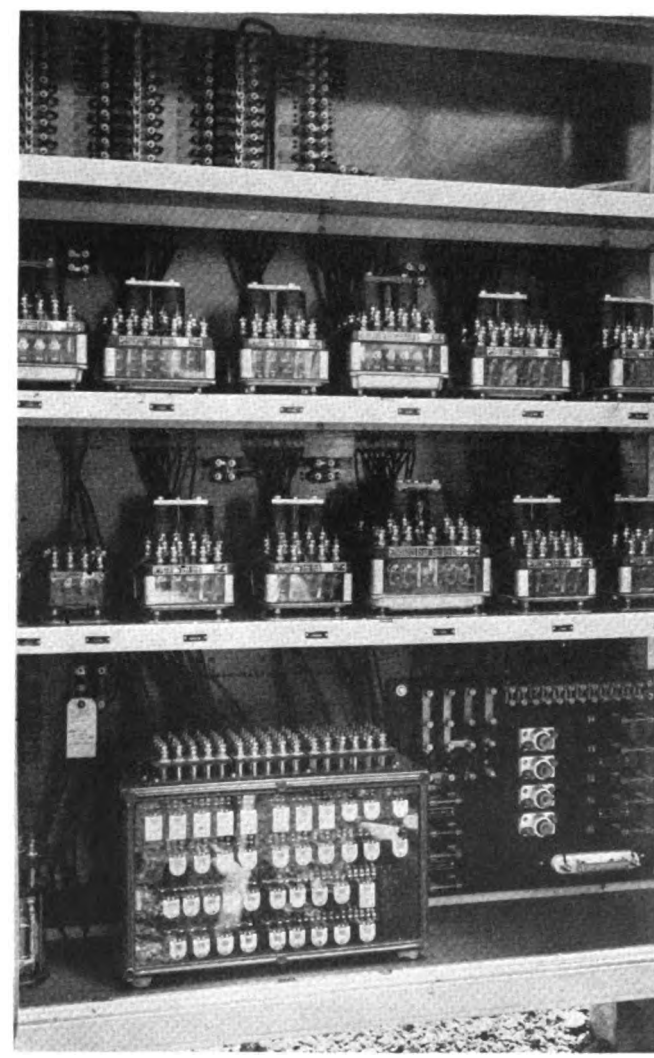
Signal Line Circuits Used in the Approach Locking Controls

Automatic approach locking is provided, the control of which is extending through contacts of the H relay of the signal for the reverse direction, and the control of this relay, for an opposing train movement extends from one passing track to the next. Thus the signal line control serves also in the approach locking without extra line circuits for the locking. If a signal at the next siding has been cleared, or if that signal has been accepted and passed by a train, the signal or switch, if the signal has been cleared at the given passing track, cannot be changed or operated until a delay period has expired, this period being determined by the operation of a DT-10 time relay.

C.T.C. Machine is Portable

The office building in which the C.T.C. control machine is located is of one-story frame construction. In consideration of the fire hazard, the C.T.C. control machine is mounted on large-sized casters 6 in. in diameter, so that in case of fire it can easily be pulled out of the building, a set of double doors being provided for this purpose. A detachable plug connection for incoming wires is provided on the machine as a quick disconnect feature. All of the C.T.C. apparatus, other than that in the machine, is contained in fire-proof housings remote from the station building, and a multiple emergency cable with plug-in connectors is available so that after the machine is out of the station, this cable can be connected and the system cut in service.

The C.T.C. controls are sent out to the field stations and the indications are returned by the multiple time code system, using two line wires. The



Interior of case at one of the outlying C.T.C. controlled stations

504-B scheme of circuits and apparatus is used, the control office equipment having capacity to handle 35 field stations over the two code line wires. The outgoing code chain provides for seven controls at each field station, including switch normal, switch reversed, signal right, signal left, maintainers' call, and two special controls such as for a call-on signal and stick-non-stick signals. The incoming indications include switch normal, switch reversed, signal right, signal left, OS track occupancy, power-off and an extra indication for a special track circuit. This provides for power-off at each end of every passing track and the extra indication step is available for fire protection or approach indication, etc.

All signal controls are stick; i.e., to clear a signal for a second train, a new control code must be sent. After a train accepts and passes a signal, no code need be sent to set the control apparatus normal at the field station. In addition to the conventional arrangement of levers for the control of switches and semi-automatic signals, the machine includes toggle levers for the control of maintainers' call lamps at the field stations which are mounted below the signal levers. The call-on signals are controlled by special buttons mounted above the switch levers. The locations of trains are shown on the automatic train-graph sheet, and, in addition, the lamps in the track diagram repeat train occupancy of the OS section at the switch locations.

As long as each fire-protection and slide-detector installation is normal, a corresponding lamp on the track diagram displays a green indication, but, when the protective device operates in the field, a code is sent automatically to the office to extinguish the green lamp and illuminate a red lamp corresponding to the field location. The dispatcher can then hold trains and call the track forces as well as the maintainer. Details of the construction and operation of fire-protection and slide-detector fences, as used on the Southern Pacific, are explained in an article in the March, 1939, issue of *Railway Signaling*.

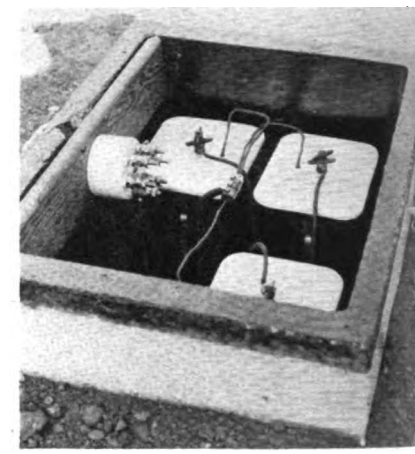
Indicators for Users of Motor Cars

On account of the numerous train movements and the short sighting distances, indicators, which show whether a train is approaching, were installed at numerous points on this territory so that track forces, maintainers and others using motor cars can know when they can proceed with safety. These indicators are similar in construction and appearance to those ordinarily used as switch indicators on some roads. The locations and the spacings of the indicators are based on the practice that having seen an indicator displaying clear, a man on a motor car has time to proceed at about 15 m.p.h. to the next indicator and set his car off the track before any train traveling at normal speed might arrive. When the track within the limits of control is not occupied, the corresponding indicator is normally energized to display Clear. Thus the operator of a motor car is not required to stop to push a button before gaining the information.

In view of the fact that new No. 9 gal. iron wire with weatherproof covering was installed for all signal control circuits as a part of the new C.T.C. project, the old bare iron wire, previously used for the line controls of the old semaphore signaling, was available for the controls of the track car indicators. The line controls for the indicators are extended through front contacts of the relays of track circuits. One line wire is used as common, and the number of control line wires, at a given place on the pole line, depends on the distance over which the controls of various indicators must extend. Except for special conditions, a total of not more than four line wires are required. An important point is that this indicator system is separate and distinct from the automatic block or C.T.C. systems, separate batteries being used to feed the indicator line circuits so that line crosses or grounds cannot affect signaling circuits.

Power Switches Well Constructed

Previously the main-track switches in this territory were operated by hand-throw stands, with the exception that spring mechanisms with mechanical facing-point locks were in service at the end of double track, as well as at the north switch at Siding 4 and at both of the switches at the passing track at Siding 2. As a part of the C.T.C. project, Type-M22A dual-control low-voltage d-c. electric switch machines were installed at the passing tracks, at the two crossovers at Siding 2 and at the end of double track.



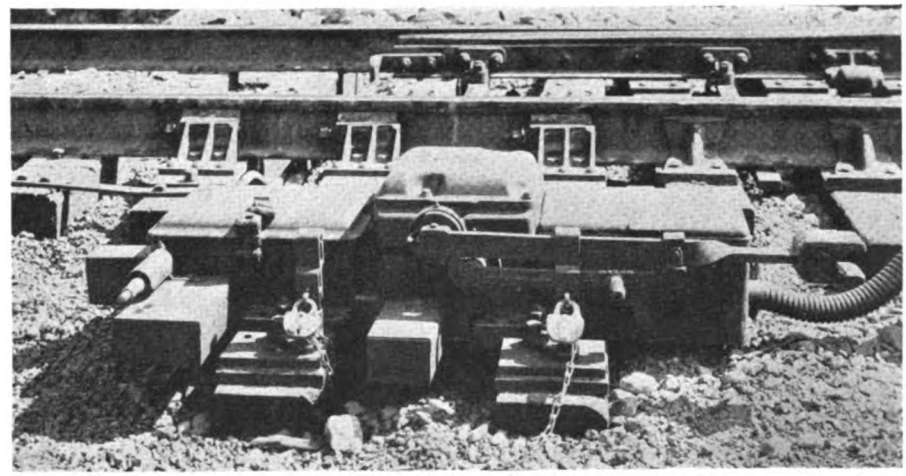
Typical track battery location

At each power switch, three 1-in. by 9-in. insulated gage plates were installed with Racor adjustable rail braces. Two of these plates extend out under the switch machine which fits snugly between toe plates, thus lost motion between the rails and the machine is prevented. The toe plates and the riser plates at the rails are welded in place.

The turnouts are No. 14 with 24-ft. points. In order to facilitate operation by minimizing friction, each set of switch points is equipped with a set of roller bearings which normally support the points free of the slide plates. The weight of a car or locomotive works against spring action to push the points down on to the slide plates.

The previously existing signal de-

The leave-siding dwarfs are mounted on pipe masts



Each power switch is operated by a dual-control, low-voltage d-c. switch machine

partment pole line in this territory was reconstructed as necessary to put it in first-class condition and provide for the new line circuits. Approximately 40 per cent of the poles were replaced, using fir poles pressure creosoted full length.

The code circuit is superimposed upon the existing No. 9 bare copper dispatcher's circuit, which is part of the communication circuits, suspended on Western Union Telegraph Company poles. With this type of circuit, all field stations are connected to the line in multiple, with a filter between each field station and the line in order to quiet the line to permit conversation while a control code or indication code is taking place. The old line wire which was reused for indicator controls is No. 9 bare. Power is taken from commercial sources at several locations and distributed on two No. 6 AWG hard-drawn bare copper line wires, with no interconnections between power sources.

Power Supply

At the various switch and signal locations the 110 or 220-volt a-c. circuit is extended to a W-10 transformer and an ANL-30 power-off unit in the instrument housing. At each power switch, a set of 18 cells of Edison B4H storage battery is provided. Six of these cells, charged by an RT42 rectifier are used for feeding signal lighting and control circuits and as reserve for signal lighting, and the other 12 cells feed code equipment. The 18 cells in series supply energy to operate the power switch machines.

At each intermediate signal location, a set of 6 cells of the B4H type are used to feed control circuits and reserve for lamps. Each track circuit is fed by three cells of Edison 500-a.h. primary battery, connected in multiple. At the control station the code line is fed by a set of 60 cells of Edison N2 Type battery, and a set of 12 cells of Edison A4H Type battery feed the coding equipment. This battery also provides standby service for the model board lamps in the event of a power outage. Standby service is also provided for the Telechron motor operating the train graph, which normally is connected to the commercial power supply. In the event of a power outage, a DN-11P relay, connected to the low voltage side of a transformer, is de-energized, which, through drop contacts, closes the circuit for a tuned alternator. This alternator is similar to equipment used for standby service in coded track circuits, operates from 16-volts d-c. and delivers 110-volts a-c. to the train-graph motor.

Insulated Wires and Cables

The drops from the line poles to the instrument housings are in multiple-conductor No. 14 aerial cable ranging up to 37-conductor. The insulated wiring in the instrument housings is either No. 14 or No. 16. The underground cable is No. 14 for controls, No. 9 for signal lamp circuits, No. 6 for switch feeds and No. 10 for track circuit connections to the track. The switch control relays are located in the sheet metal houses so that a six-conductor No. 6 cable as well as a 10 conductor No. 14 cable extends to each switch machine. The underground cables have non-metallic mummy-type protective coverings and were furnished by the Kerite Insulated Wire & Cable Company.

Lightning Protection

Thyrite type arresters made by the General Electric Company are used on the code line and on the signal line circuits, one set of these arresters being located in the instrument housing and another set in a box on the pole under the crossarm. The special purpose of the arresters on the pole is to drain off static and provide protection to the drop cables from lightning surges. With this arrangement, lightning coming in on the rails from either direction is influenced to pass through the location and be dissipated on the rail beyond, rather than affecting the track relays. Experience on the Southern Pacific has proved that this arrangement is effective. General Electric Company pellet-type arresters are used on the 220-volt a-c. power distribution circuit.

Ground connection for the arresters in the instrument houses is obtained by connecting to one of the track leads. Normally there are four-track leads, entering the instrument house; three of these leads are also connected to Thyrite lightning arresters, and the fourth lead is connected to the ground post of all lightning arresters, including the three for track leads.

By providing lightning arresters at all track cuts and always using the track lead that connects to a certain rail and extending in the same direction, the rail actually becomes a condenser of large capacity, since a charge will continue to dissipate through several track circuits by discharging through a lightning arrester at each consecutive track cut.

Two Copperweld ground rods, 5/8-in. by 6-ft., are driven at the line pole and one such rod is driven at the instrument housing at each C.T.C. code location. The rod at each code location is used to ground the lightning arresters on the combination code line and dispatcher's line, since it was considered desirable to avoid connecting the ground for the dispatcher's phone circuit to the rail ground connection used for the other circuits. A 9/32-in. hole is drilled through the rod, 1 in. from the top, the ground wire being connected to the rod by driving a channel pin in this hole.

This installation of centralized traffic control was planned and installed by the signal forces of the Southern Pacific under the direction of R. D. Moore, signal engineer. The major items of signaling equipment were furnished by the Union Switch & Signal Company.