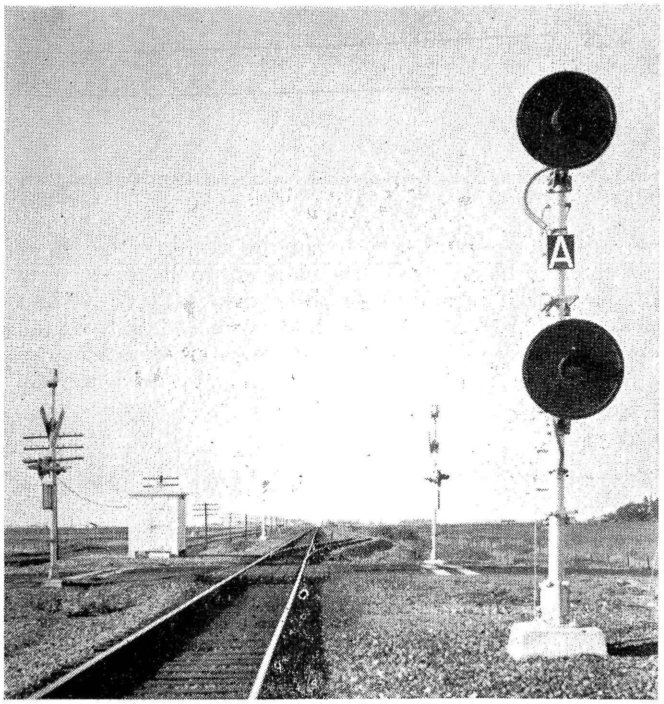
Modern Signaling On Western



A power switch and signals at end of siding in CTC section

Train operation by signal indication on 438 mi. of single track between San Francisco, Cal., and Gerlach, Nev., demonstrates benefits under different volumes of traffic, and physical characteristic of line

THE Western Pacific will soon complete an installation of centralized traffic control on 117 mi. between Portola, Cal., and Gerlach, Nev., which in connection with similar projects previously in service, makes a total of 438 mi. from San Francisco eastward to Gerlach, on the 928-mi. route to Salt Lake City, Utah. Prior to 1944, the Western Pacific, on single track main line, had no automatic block except as protection at tunnels, and, on the entire railroad, train movements were authorized by timetable and train orders.

Thus, this railroad, starting with practically no block signaling on single track, had its choice of installing conventional automatic block or centralized traffic control to include train operation by signal indication. Of interest is the fact that the later system was chosen, and has been modified as necessary, to adapt it economically to the requirements of traffic and physical characteristics of different sub-divisions. Therefore, before discussing the signal installations, an explanation of the train movements, volume of traffic, grades and curves will now follow.

Freight Traffic Centers at Stockton

The Western Pacific runs two passenger trains each way daily. In connection with other roads the new fast schedule "California Zephyr" is operated between San Francisco and Chicago, and the "Royal Gorge" between San Francisco and St. Louis. The freight traffic and number of freight trains vary on the different sub-divisions. At Stockton, 92 mi. from San Francisco, the Western Pacific has a large freight yard at which eastbound freight is assembled into through trains, and in this yard, westbound through freight trains are broken up for distriibution over W.P. rails to the San Francisco Bay area, and throughout certain portions of the Sacramento and San Joaquin valleys. Also at Stockton, the W.P. exchanges considerable traffic with the Santa Fe, and in less volume with the Tidewater Southern and the Southern Pacific.

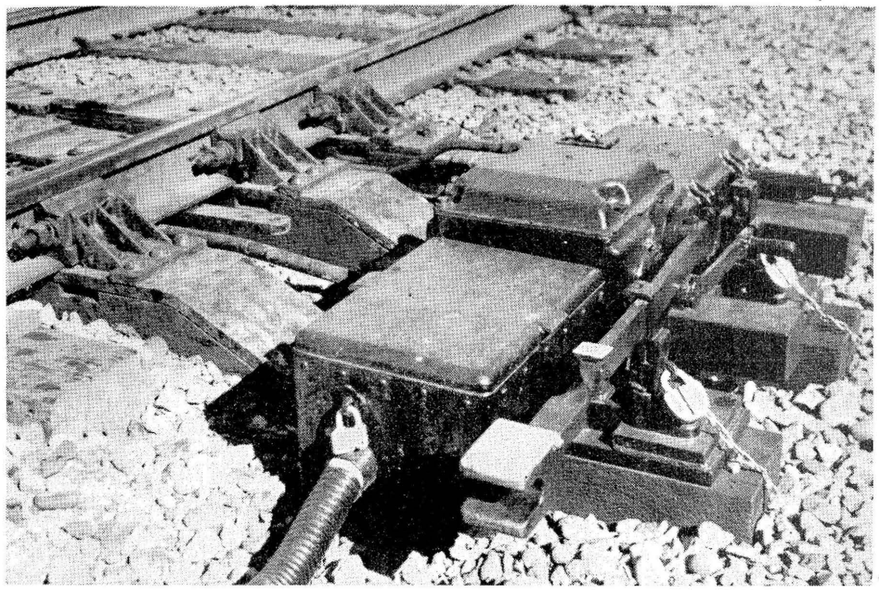
The Western Pacific through freight traffic on the east-and-west route between Stockton and Salt Lake City ordinarily requires about four to six through trains each way daily. This does not include local freight trains or turn-around runs to pick up fruit, vegetables or sugar beets. In addition to hauling freight on the east-and-west route between San Francisco and Salt Lake City, a portion of the Western Pacific forms a part of a north-and-south route between points in California and Oregon and Washington. This route breaks off at Keddie, Cal., in the Feather River Canyon, 189 mi. east (and north) of Stockton, where there is a junction with a main line extending 112 mi. north to Bieber, Cal., where it connects with a line of the Great Northern extending north to an east-and-west line of the G.N.

Thus, these lines, including portions of the W.P., form a north-and-south route between Seattle-Portland-Spokane on the north, and San Francisco on the south. And, with interchange with the Santa Fe at Stockton, this north-and-south route is extended to Los Angeles and other points in Southern California. On the average, the W.P. handles two through trains daily on the north-south route between Stockton and Bieber via Keddie. About 15 per cent of this traffic goes to and comes from the San Francisco Bay area, and the remainder is interchanged with the Santa Fe at Stockton. Including the four passenger trains daily and the freight trains on the lines to Salt Lake City and to Seattle, a total of 16 to 18 through trains are operated daily on the section between Stockton and Keddie.

Operating Problems In the Canyon

Referring to the accompanying map, the main line of the Western Pacific is in the Feather River

Systems Pacific



Ties are daped so throw rod is straight

Canyon for 116 mi. between Oroville, Cal., and Portola, this being a low-grade route over the Sierra Nevada mountains. For the first 14 mi. east of Oroville, the grade is 0.4 per cent ascending, and, from there on, the ascending grade eastward is 1 per cent, practically all the way to Portola. On account of the consistently uniform grades, not to exceed 1 per cent, the locomotives can handle heavy trains; for example the Class M-80 are rated at 2,200 tons and the M-137 at 4,000 tons. Because the grade descends all the way westward, there is no tonnage limit, the train length being limited by the car capacities of the sidings, ranging from 85 to 95 cars.

Throughout this Feather River Canyon, there are numerous curves, one right after another. Most of the curves range up to 6 deg., but a considerable number range between 8 deg. and 10 deg., the maximum being 10 deg. except that at a few locations where the spirals have been extended, the central curvature slightly exceeds 10 deg. From a practical standpoint, therefore, the train speeds are limited by curvature more than by grades. For 45 mi. between Bloomer and Grays Flat, the maximum 40 m.p.h. for the California Zephyr and 35 m.p.h. for other passenger trains using conventional cars, and the limit is 25 m.p.h. for freight trains. As a result, the freight trains average about 20 m.p.h. and the passenger trains up to 35 m.p.h. Therefore, on account of the larger volume of traffic and the slow speeds of trains due to curves and grades, the Western Pacific decided in 1944 that the first portion of the road to be signaled would be that in the Feather River Canyon. This entire project is complete centralized traffic control with power switch machines at sidings, and these machines, as well as signals at these locations, for authorizing train movements, are controlled by the dispatcher. This C.T.C. installation was described in detail in an article in the Railway Age for June 23, 1945 and in Railway Signaling for June, 1945.

West of Oroville

From Oroville, the Western Pacific extends westward through the broad level Sacramento River valley and the San Joaquin valley to Stockton. Throughout this 113 mi., the line is practically level, and is tangent for long distances, the few curves being light. For these reasons there was no urgent need, in 1945, to install signaling on this subdivision. However, after finishing the C.T.C. between Oroville and Portola in 1945, the Western Pacific was faced with a need for signaling on the first subdivision, i.e., between Stockton yard and Clinton (Oakland), 84.3 mi. In this territiory the railroad passes over a range of hills with maximum elevaton of 750 ft. at Altamont. From Stockton the grade is generally ascending up to 0.6 per cent westward for 23.3 mi., then at 1 per cent for 12 mi. to Altamont, from which point the grade is descending at 0.8 per cent for 26.5 mi. down through the Niles Canyon to Niles. From there to Oakland, 22.5 mi., the line is practically level. The decision with reference to types of signaling to be installed on this subdivision was based on the reduced volume of freight traffic as compared with other subdivisions.

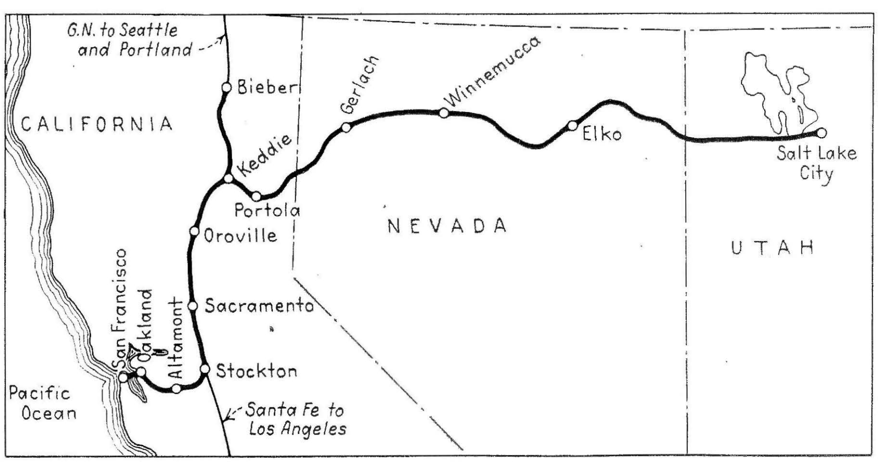
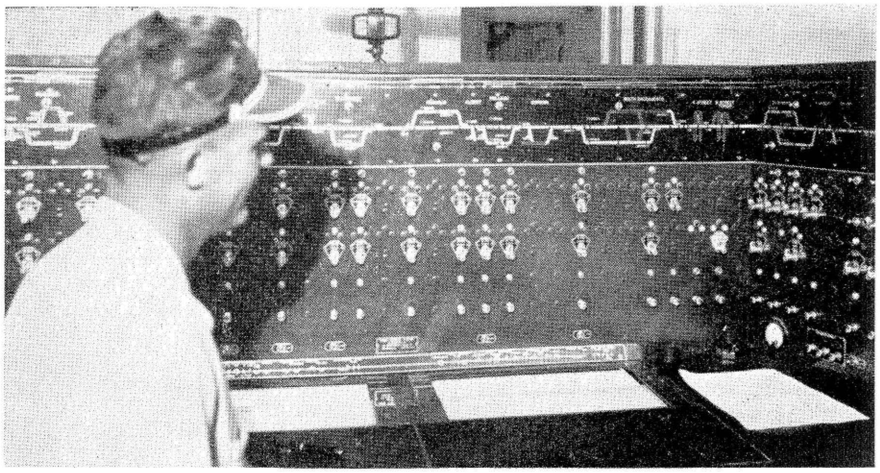


Fig. 1—Map of Western Pacific showing signal territories

An earlier portion of this article explains how eastbound and northbound freight from various points is assembled in the yard at Stockton, and likewise how westbound and southbound freight is distributed from this yard. The westbound traffic on the first subdivision, i.e., between Stockton and the San Francisco Bay area ranges between 150 to 175 cars or more daily. In a corresponding manner about 175 cars are moved eastward daily over this first subdivision be-



One of the three control machines in dispatchers' offices at Sacramento

tween San Francisco Bay area and Stockton yard. This is roughly about one third of the volume of traffic handled on the territory east, i.e., between Stockton and Keddie. Thus, the scheduled trains on the first subdivision of 93.8 between Oakland and Stockton include the four passenger trains, and about four through freight trains. A local freight train is operated each way daily except Sunday, and in certain seasons, a switch run is operated from Stockton out to Carbona and down a branch to Kerlinger, and return to Stockton.

Because fewer trains were operated on the first subdivision, the primary consideration at that time was to provide complete track-circuit-controlled signaling as a safety protection. Based on the benefits of authorizing train movements by signal indication on the Oroville-Portola C.T.C. territory, the Western Pacific wanted these benefits also for the Stockton-Oakland subdivision. However, as explained by G. W. Curtis, division superintendent of the Western division, the cost for C.T.C.—over and above that for conventional automatic block—did not, at that time, seem to be justified by the number of trains. Therefore, a committee was sent to investigate a signaling installation on a single-track line of the Wabash in which the siding switches were operated by hand-throw stands and the signals at these switches, under the control of the dispatcher, displayed aspects to authorize train movements. As stated by Mr. Curtis, "We adopted the Wabash system for our first subdivision and thereby we derived the benefits of train operation by signal indication. Our first costs were not a whole lot more than for straight automatic block."

In this Western Pacific installation on 84.3 mi. of the first subdivision between Oakland and Stockton, the siding switches are operated by hand-throw stands and the dispatcher-controlled signals authorize trains to: (1) Proceed from one siding layout to the next. (2) To enter a siding. (3) To depart from a siding and proceed to the next siding. (4) Stop.

The signals are the searchlight type. On each station-entering signal and on each leave-siding signal, there is a second "unit" which consists of a normally-dark lamp which when lighted displays a black letter "S" on a circular white background 8⅜ in. in diameter.

At the end of each siding, the main track station-leaving signal and the leave-siding signal are in line, opposite the clearance point on the siding, as is customary practice, (See Fig. 2.) Also, at each siding the station-entering signal, such as No. 2 at Midway, is located opposite the fouling point in the same line with signals No. 1 and No. 3. This practice allows an eastbound train, for example, to stop short of the switch and pull into the siding without the confusing procedure of being required to pass a signal indicating Stop. Also, incidentally, the location of signal No. 2, as explained, permits the elimination of a short track circuit through each switch. As shown in Fig. 2, one track circuit extends from signal No. 1 to approach signal No. 4.

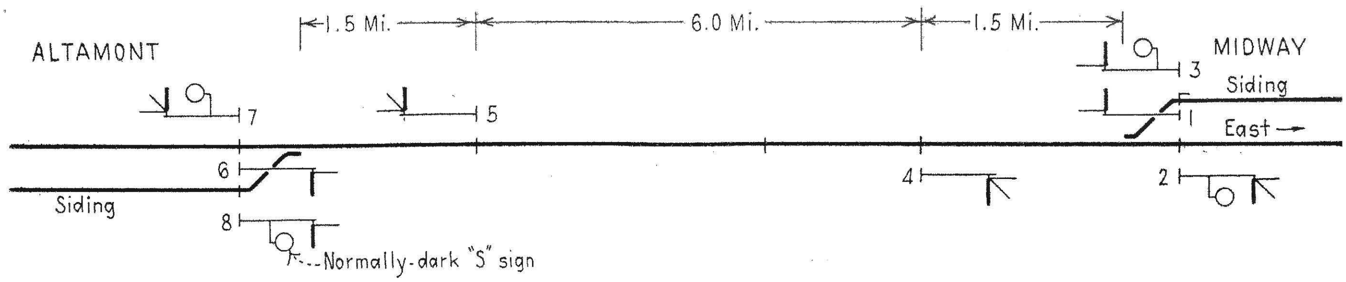
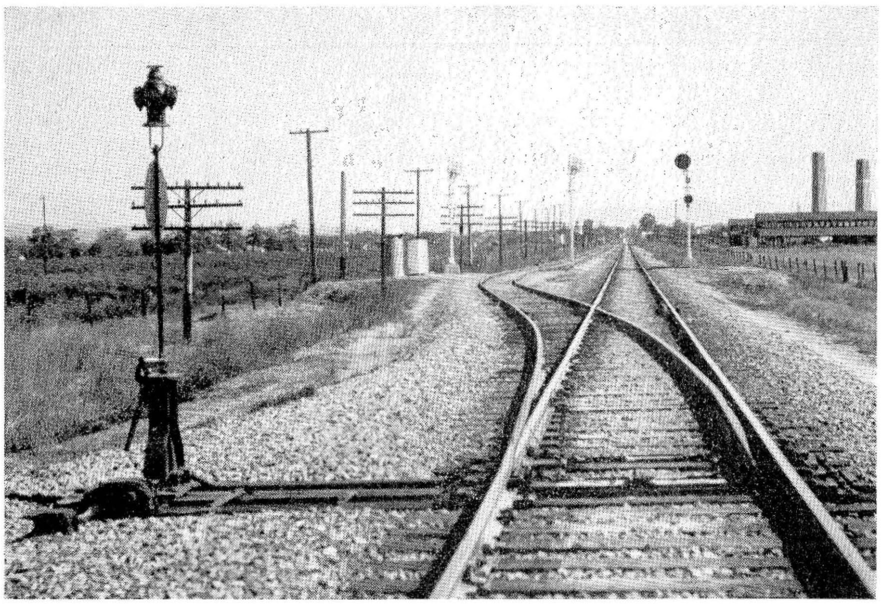


Fig. 2—Layout with dispatcher-controlled signals and hand-throw siding switches

Referring to Midway in Fig. 2, the main-track westward station-leaving signal No. 1 normally displays the red aspect which indicates Stop. If there is no train between signal No. 1 and signal No. 7 at Altamont, and if the dispatcher sends out a proper control, signal No. 1 operates to display the green aspect, thus authorizing a train on the main track to proceed to signal No. 7 at Altamont.

If there is a westbound train on the siding at Midway, and the dispatcher is ready for it to depart, he sends out a control which causes the leave-siding signal No. 3 to display red over an illuminated "S". Then the head brakeman throws the switch, after which the aspect of signal No. 3 changes to green, which authorizes the train to pull out on the main track and proceed to Altamont, the switch at Midway being placed normal by the rear brakeman before the train departs. As a train proceeds westward, the westward approach signal No. 5 will display yellow if the station-entering signal No. 7 at Altamont is displaying red, or the approach signal No. 5 will display green if the signals at Altamont have been cleared for the train to proceed on the main track at normal speed through Altamont and on to the next station west.

On the other hand, if the westbound train is to be directed to stop and enter the siding at Altamont, the dispatcher sends out a control which causes the station-entering signal No. 7 at Altamont to display red in the top unit over an illuminated letter "S" in the lower "unit," and the approach signal No. 5 displays yellow as advance information. Accordingly, the train is stopped short of the east switch at Altamont. After the head brakeman reverses the switch, the train enters the siding and the switch is placed normal. If the dispatcher wants a train to stop and wait at a certain station-entering or station-leaving signal, he simply does not clear that signal until he is ready for the train to proceed. Telephones connected to the dispatcher's circuit are located at all switches and if the dispatcher wants to talk to a member of the crew of a train that has been stopped, he sends out a control that lights a "call" lamp on the track side of the relay housing at that switch.



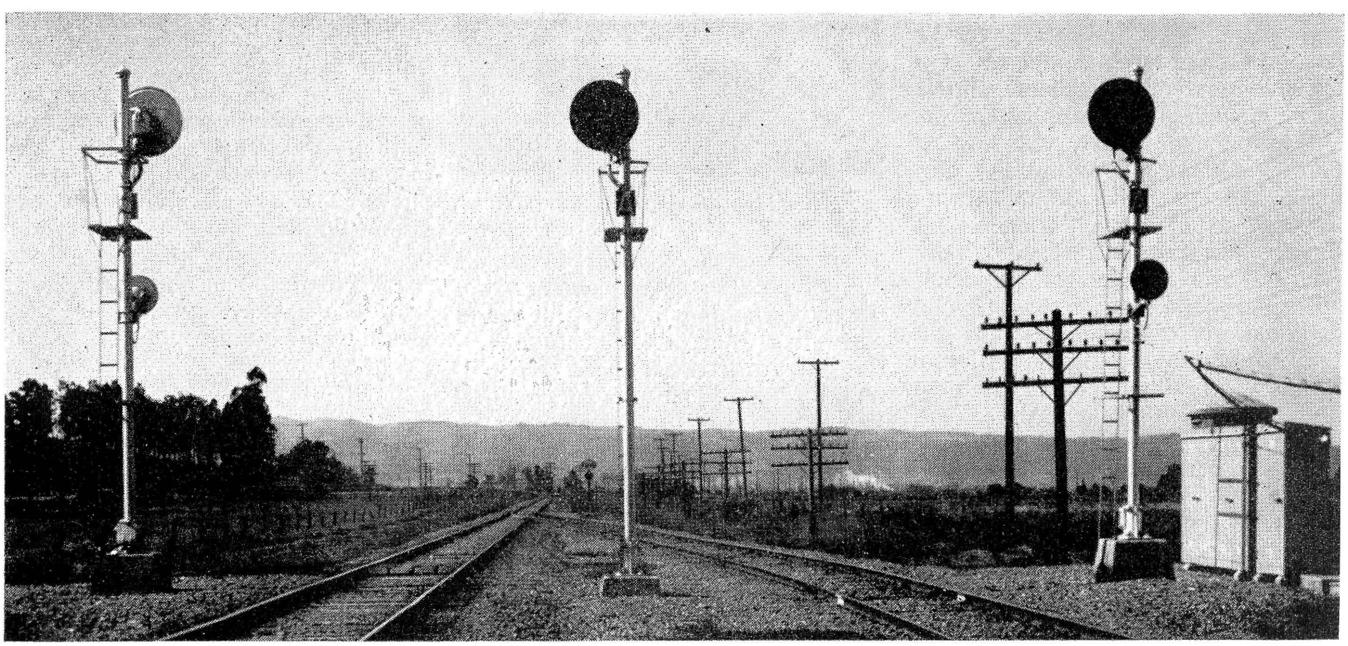
Switch and signals at end of siding on first sub-division between Oakland and Stockton

Second Subdivision in 1948

Based on a policy of general improvements to the railroad as a whole, and especially to promote safety and expedite train movements, the Western Pacific, in 1948, decided to install signaling on the second subdivision, 113 mi. between Stockton and Oroville. As explained previously, this portion of the railroad passes through important agricultural territory where large volumes of fruit and vegetables are grown. Also there is considerable traffic into and out of Sacramento, a city of approximately 120,000 population. About 40 to 50 cars are handled locally in and out of Sacramento daily. For about 60 days during the sugar beet harvest, the W.P. operates a turn-around run out of Stockton to Sacramento and return to Stockton that picks up 50 to 60 cars of beets daily. At several points the W.P. connects with its subsidiary, the Sacramento Northern, which extends throughout much of the Sacramento valley and on through industrial areas on the northern end of San Francisco Bay. The W.P. interchanges about 60 to 70 cars daily to Sacramento with the S.P. and the S.N. Also at Marysville the W.P. interchanges about 20 to 25 cars daily with the S.N.

This 113-mi. second subdivision is in the broad level valleys where the track is practically level and tangent for long distances. However, because this subdivision is part of not only the east-and-west, but also the north-and-south route, more trains are operated. The daily traffic on this second subdivision includes 4 passenger trains and 12 to 18 through freight trains, and also the local freight trains and turn-around pick-up trains as required. Therefore, on account of this heavier traffic, the signaling adopted for this subdivision is centralized traffic control, including power switch machines at sidings.

The signals at the sidings, which are controlled by the dispatcher,



The three signals are in line with fouling point on siding

are located in accordance with conventional practice, as shown in Fig. 3. With certain exceptions the station-leaving signals, such as signal 11 at station East, are two-aspect signals, which authorize a westbound train to move to station West, there being no provision for a following train to enter an occupied station-to-station block. In this arrangement, there are no intermediate signals other than the approach signals No. 14 and No. 15. In these respects, the signaling is similar to that on the first district, Oakland to Stockton. The station-to-station as a single block was considered to be practicable for nearly all the blocks on the Stockton-Oroville territory because of the level tangent track which permits comparatively quick acceleration and sustained high speeds. On a few of the station-to-station blocks, more than 10 mi. long, intermediate automatic signals were installed so that a following train movement can be made.

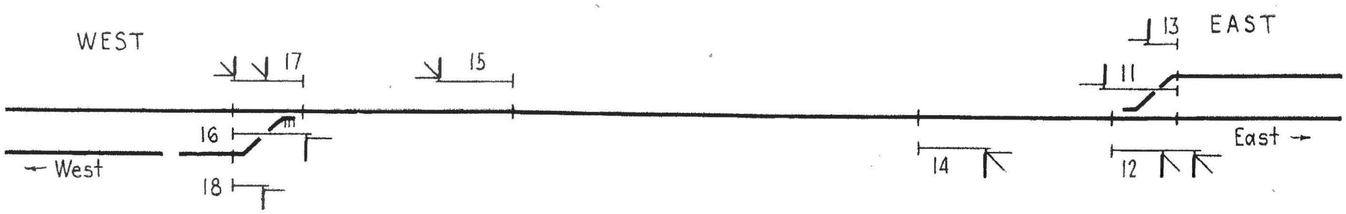


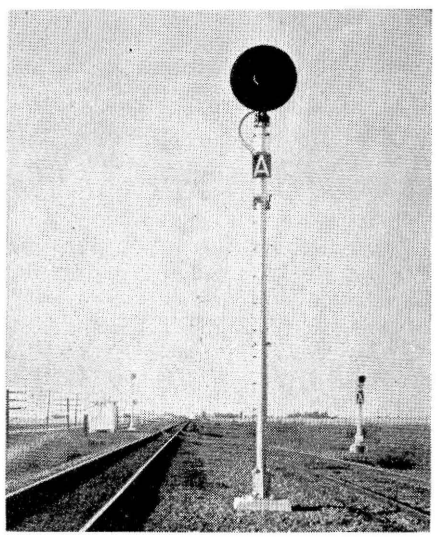
Fig. 3—Power switch and signal layout in C.T.C. territory, Stockton to Oroville

Normally-Dark Control Panel

In setting up the preliminary specifications for the control machine to be used on the Oakland-Stockton installation, the Western Pacific called for: (1) all indication lamps to be normally dark, and (2) the signal-clear indication to be carried on the track model adjacent to the involved switch as shown on the etching. The opinion of the Western Pacific is that the important advantage gained by the normally-dark panel is the ability to notice a changed condition as indicated on the control panel more readily. The reaction of the operators has been most gratifying. An explanation of the indications for the Stockton-Oroville installation follows herewith. This system of indication was arranged by Western Pacific engineers, and is patterned in part after the system used on the Oakland-Stockton machine designed by the Union Switch & Signal Company.

Above the track diagram and between each location of controlled signals, there is a blue lamp which is lighted when westbound traffic is established in the corresponding block by the clearing of the westbound signal, and this lamp continues to burn steady until the train movement has cleared the block. If the signal is placed to Stop by lever control, the blue lamp continues to burn until the time locking at the field station has expired, and a corresponding indication has been transmitted to the control machine. A second blue lamp, located on the panel below each "block", operates in a manner similar to that described above, for eastward traffic.

On the track diagram the three signals at each power switch layout are each represented by a symbol including a green lamp. When a signal on the ground is cleared for a main-track movement in either direction or for a movement from the siding, the lamp on the panel which corresponds in location with the signal that has been cleared, will be lighted and burn steadily. If the lineup is for a train to take siding, this signal indication lamp flashes.



High leave-siding dwarf in CTC

Above each switch lever, there are three lamps, a green one to the left above the normal position, an amber one to the right above the reverse position, and a white one in the center. The white lamp above the center of the lever is lighted only when the switch in the field is out of correspondence with the lever. The green normal lamp or the amber reverse lamp is lighted only after a signal is cleared over the switch or the OS track section is occupied.

Above each signal lever there is only one white lamp, which is normally dark. When a signal, which has been cleared, is taken away, the lamp above the signal lever is lighted until the time locking interval has expired. This exact notice of the expiraton of the time period permits the dispatcher to make other lineups at once.

The track-occupancy lamps on the track diagram are red and are normally dark. One lamp represents each OS section at a power switch, and such a lamp is lighted steady when the corresponding switch detector track circuit is occupied, or when the dual-control switch machine lever is in the hand-throw position. One track-occupancy lamp is used for each section of the diagram which represents the main track between controlled switches of a siding. In addition, one lamp is used for each section of the diagram which represents the main track between two sidings.

A white lamp, with black letter "C," above each code-sending push button is lighted when code is going out, or when code is being received from the corresponding field station. A circuit network in the machine prevents code from going out to clear a signal that is not consistent with the position of a switch or is in conflict with a signal already cleared. The objective of this feature is to prevent setting up time locking unnecessarily.

Coded Track Circuits

Except for switch-detector sections, short releasing sections for outlying electric locks and the yard area at Oroville and Portola, coded track was used exclusively on the Oroville-Portola installation, completed in 1945.

The successful operation of long track circuits (some are over 11,000 ft.), the improved broken-rail protection, and the facility of block signal operation without the use of line wires have been the factors which influenced the W.P. to use coded track on all subsequent installations. Where highway crossing protection or interlockings are present in a coded-track controlled block, the W.P. uses the conventional coded line jumper method of getting around the conventional track circuited section.

As the signal program progressed, the W.P. worked with the engineers of the Union Switch & Signal Company to apply new ideas of coded track circuits to later operational systems. Some affect the overall operation, others are more in the nature of innovations. One of the most important of these changes has been to provide a means of returning the direction of feed for the steady current normally energizing the track circuit to a given direction (westward on the W.P.).

In the station-to-station blocks on the Oroville-Portola installation, steady energy is fed into the block behind the train, regardless of direction; therefore, the circuits in a block were left feeding eastward or westward, depending on the previous movement. With this arrangement, the discharge on the track cells shifting from "no-load", when the circuit was feeding from the opposing end, to over 1.2 amp. when actually feeding the track. As a consequence, the regulation of the charge on the track cells was a real problem. No trouble was experienced in maintaining the proper battery condition in the siding areas where steady energy fed normally in one direction only; and a conclusion was that on future installations the station - to - station block should be arranged in a similar manner. The Union Switch & Signal Company developed a scheme which has been used on the W.P.

Referring to the block between east-end Altamont and west-end Midway, the following description gives the basic principals of this scheme. (See Fig. 2). Normally, steady energy is fed to the track at the east end of the block over the traffic relay RFSR and the signal control relay LHSR for westward movement into that block. Both of these relays are controlled by the dispatcher from the control machine. The steady energy is received at the west end of the block and holds the track relay 561TR continuously energized.

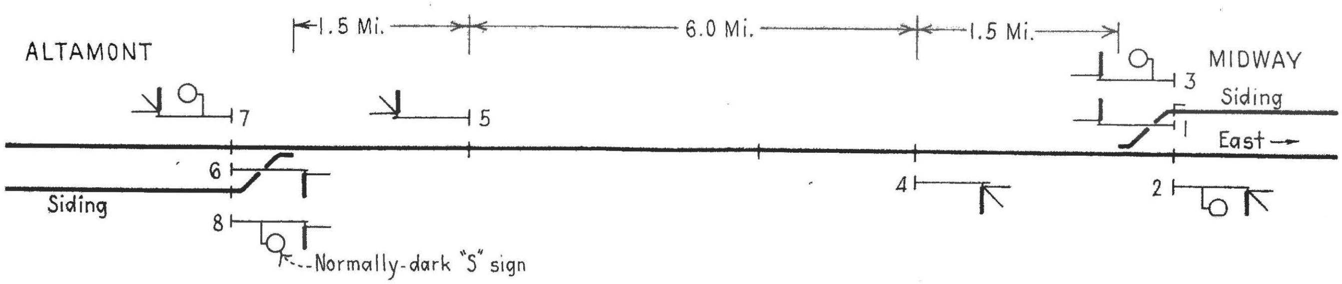
If the control machine operator wishes to clear signal 6 for an eastward move into the block, control codes are sent first to the west end to position the signal control relay RHSR and then to the east end to reverse the traffic relay RFSR. This latter action changes the steady energy feed to coded energy; and upon receipt of this coded energy at the west end of the block, the signal 6 will clear.

As the train moves through the block, the track behind it is not energized. As soon as the rear of the train moves clear of the block, code is again fed westward as though to clear signal 6 for a following train. The clearing of this signal will occur, providing the control machine operator has recoded the signal relay RHSR for such a move.

If no following move is required, the receipt of coded energy at the west end of the block will energize a clear-out relay, FPR, which, once picked up, is held so for several seconds by use of a condenser unit. During the period this relay is picked up, steady energy is applied to the west end of the block in an easterly direction. This eastbound steady energy overrides the code feeding westward in the block and energizes the track relay TR at the east end of the block. This action resets the traffic relay RFSR to normal, thereby removing the coded energy and restoring the normal steady energy feed at the east end.

In the meantime, the current in the condenser, which is holding the clearout relay FPR at the west end of the block is dissipated, and that relay releases, permitting the track relay 581TR to resume its normal steadily energized condition.

For a westward move into the block, the signal relay LHSR at the east end is reversed and the steady energy is thereby removed from the track. As the track relay 5TR releases at the west end of the block, a traffic relay LFSR is energized and held up by a stick circuit over a contact made in the de-energized position of track relay 5TR. Coded energy is fed eastward over the traffic relay LSFR and causes the signal 1 to clear for the westbound train. As it moves into the block, normal steady energy is fed into the track to the rear of the train. The track relay 5TR at the west end of the block is energized by this normal steady energy as the rear of the train clears the block and the traffic relay LFSR is released, thereby restoring the block circuits to normal.



Coded track circuits for controls, with normal steady energy feeding west

Directional Stick

In general, on both the first and the second subdivisions, the lever-controlled station-leaving signals are the two-aspect type, and govern from station to station, as one block. However, in some instances in the second subdivision, the distances between sidings were so long that conventional intermediate signals were installed to permit the operation of a following train in station-to-station blocks. These intermediate permissive signals are in coded track circuit territory and a new stick circuit was designed which operates in a manner similar to that used in line-controlled territory, and in the opinion of Western Pacific engineers, this new stick circuit is preferred to the one used previously.

In the initial considerations, thought was given to providing short neutral track circuits adjacent to the permissive location. However, after considerable study, a circuit was designed, using series approach track relays, to accom-

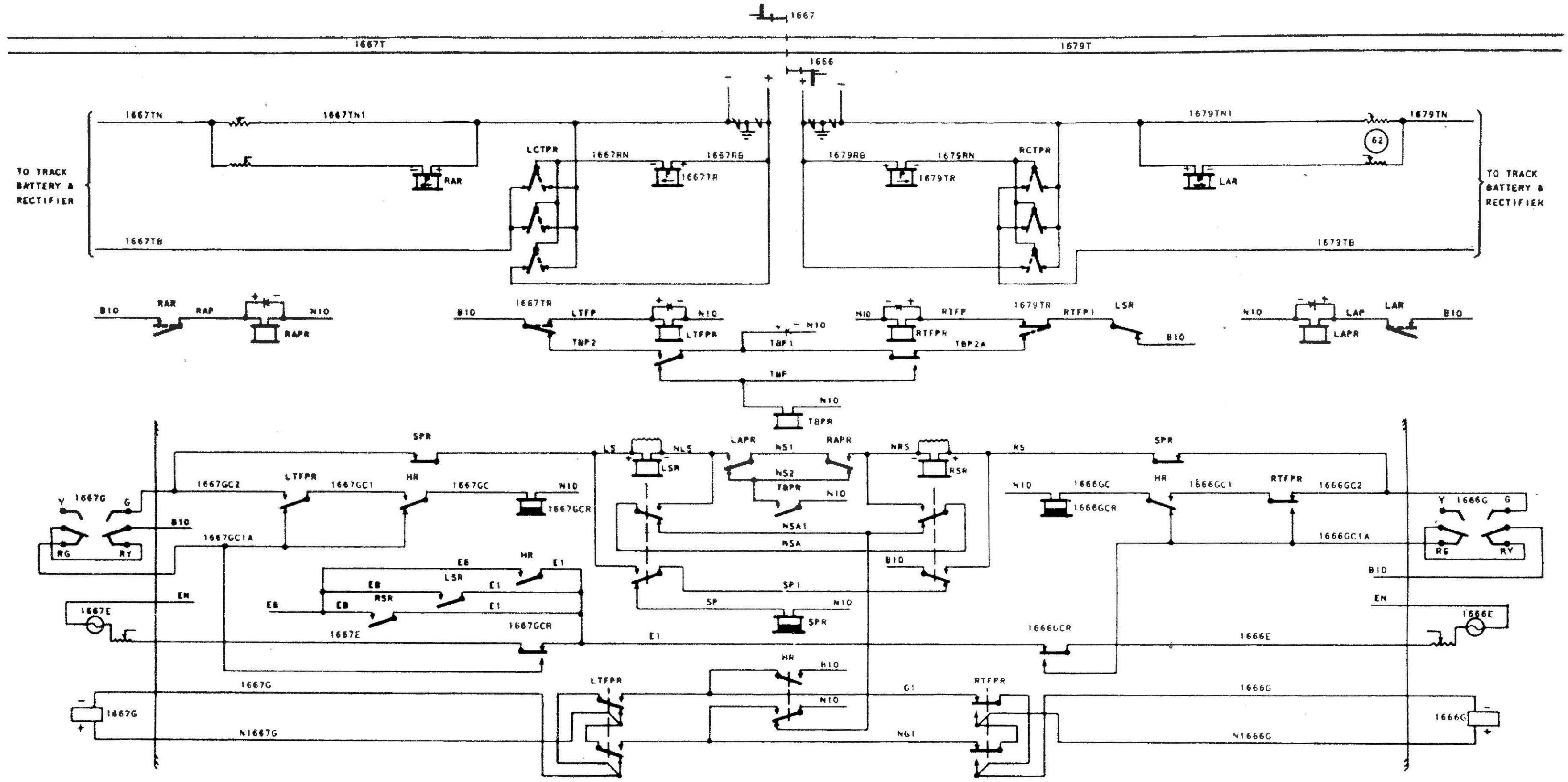


Fig. 5 — Diagram of typical circuits in centralized traffic control with steady energy normally feeding westward, and when control is established by dispatcher, coded energy in the rail feeds in direction opposite to train movement, and directional stick is controlled by approach track relays.

plish the results which are outlined in the following description. Referring to Signal 1666, which is an eastbound signal, assume that the block has been set up previously and that an eastbound train is approaching, but has not yet moved close enough to cause the series approach relay RAR to follow code. At the moment, 1679TR is following code from the east. RTFPR, TBPR and HR are all picked up, energizing 1666G, the signal mechanism.

Relay 1666GR is now energized over the green position of the signal and the HR picked up. The same battery is being fed to relay RSR over the front contact of SPR but the return circuit is open at the front contact in relay RAPR, the repeater of the approach track relay RAR. As the train moves to a point approximately 1,000 ft. west of Signal 1666, the relay RAR begins to follow code from the local track feed, the positive side of which is being carried to the rail over the front contact of relay LCTPR. Relay RAPR picks up and closes the pick-up circuit for relay RSR.

Assume for a moment that the train stops without having passed Signal 1666. With the pick-up of the RSR, a stick circuit is closed direct to B10 and relay SPR is released. However, the return circuit to N10 remains dependent upon the original pick-up circuit, since the stick circuit to N10 is open at relay HR, which is energized to clear Signal 1666.

If the train recedes without having passed the Signal 1666, relay RAR will stop following code as soon as the train has moved beyond the point of approach 1,000 ft. west of the signal. The RAPR will be released and RSR will drop out. If instead, the train passes Signal 1666, relay HR will drop out and close the RSR stick circuit to N10 before the release of relay TBPR.

Now assume that the train has passed Signal 1666 and stops east of that signal but without moving clear of the block. The RSR relay is, at the moment, energized over the stick circuit and is dependent upon the pick-up of relay HR for its eventual release. The release of RSR will occur in this manner if the train proceeds and clears the east end of the block in the normal way, unless of course, a following train has entered the 1,000 ft. approach section in the meantime. During the switching operations a train may, instead, back into the block west of signal 1666 and continue westward to a point beyond the 1,000-ft. approach section. In doing so, the RSR will also be released, since both the pickup and stick circuit will be open, providing the circuit east of the location is clear of cars. The adjustment for the pickup of the series approach relay is not critical in this instance, since the approach relay is used for the sole purpose of providing the pick-up circuit for the stick relays.

Referring to Signals 1666 and 1667, it will be noted that the GCR relays normally check the signal mechanism in position to display RED and relay HR de-energized. When relay HR is energized, one signal mechanism or the other assumes the GREEN position. The selection is made over track front repeater relays RTFPR and LTFPR and the control circuit for the GCR relay involved is transferred so as to check the newly assumed green position.

Correspondance Relay

It is apparent, therefore, that should an occasion arise where the condition of the control circuit and the position of the corresponding signal mechanism failed to agree, the GCR or mechanism-correspondance relay would release. This action opens the code transmitter repeater circuit controlling the coded track current leaving the signal, thus causing the signal in the rear to display RED.

Originally, the circuit design made no further use of the GCR relay, since the function of providing a restrictive approach to the improperly displayed signal, seemed to be as far as the circuit designers could go. This feeling was based on this premise, that, since the failing signal mechanism provided the aspect to the engineman, that aspect would persist, regardless, since the signal mechanism was the final apparatus in the system.

Lamp Extinguished

In those remote instances, where the mechanism may fail so as to improperly display a non-restrictive aspect, it would be highly desirable to extinguish the light, since the Western Pacific operating rules provide that when a light fails in a color-light signal, the signal must be regarded as displaying its most restrictive indication. The GCR relay presented a ready made means to accomplish this end, by using a front contact in the light control circuits. However, this meant that the light would also be extinguished with the signal mechanism improperly displaying a restrictive indication. As a result of further study, the circuit indicated on plan for Signal 1666-1667, was adopted. Using Signal 1666 as an example, and assuming an out-of-correspondence between the mechanism and the control relays, the relay 1666GCR will be de-energized.

In the Red Position

If the mechanism is in the normal or RED position, B10 over the RY and RG signal mechanism contacts will be fed to the 1666E light over the 1666GCR down. The EN return circuit for the light is both NX10 and N10. In the above instance, the light will burn and the signal will be displaying a RED or STOP aspect. If, however, the signal mechanism is set to display GREEN, the light circuit just described will be open at the RG mechanism contact and the light will not be burning.

By this scheme, the light burns under all normal circuit conditions and under abnormal circuit conditions so long as no unsafe operating condition results. When circuit conditions are such that the aspect displayed would create an unsafe operating condition, the signal is dark, thereby removing the aspect. As a further precaution, the Western Pacific expects in the near future to test the use of a reflecting type of paint on the number plates for a group of these signals, in an attempt to overcome as much as possible all chances of passing a dark signal without observing it.

Locks on Hand-Throw Switches

Outlying main track switches on the Stockton-Oroville installations are equipped with hand-operated switch-and-lock movements and electric switch locks, which are controlled by the dispatcher for movement to the main track. Pipe-connected derails operated by the switch-and-lock movements are located at the clearance points. (See Fig. 4).

Trains on the main track may use the switch by occupying a short neutral track section ahead of the switch points, and securing permission from the train dispatcher to make the move. Referring to the plan for electric lock 24A, the removal of the padlock closes a contact connecting B10 to a circuit over a contact in relay 24CTR for the releasing section de-energized, to the WLSR over STPR, the switch time repeater relay, de-energized and the time-element, TE, check contact. The pickup of relay WLSR which remains stuck over its own contact, operates the thermal relay TE and causes STPR to pick up and stick, releasing the lock. Once picked up, the lock armature contact sticks the release circuit until the padlock is returned to the electric lock stand.

To the Main Track

For movement to the main track, permission is secured from the dispatcher to remove the padlock. If signals have been cleared into the block or if a train is already occupying the block, such permission is withheld. Should the padlock be removed in error under these conditions, no action will take place at the lock and the signals will not be affected.

Assuming that the station-to-station block is normal, steady energy is feeding westward to the lock location. Removal of the padlock closes a contact in a circuit, which at the end of the operation of the time-element relay, cuts off the steady energy feeding on west to the next siding. As previously explained, this causes coded energy to feed back east to the lock at the switch. In the meantime, the dispatcher positions the lock toggle lever on his panel which causes a control to go to the east end of the station-to-station block. This control cuts off the steady energy feeding west in the track circuit and sends coded energy west in the track circuits to the lock location. With coded track circuit energy thus feeding from both ends of the

(Continued on page 295)

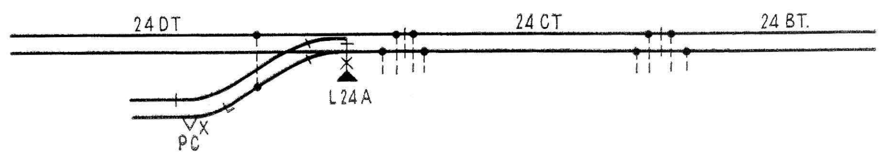


Fig. 4—Track circuits at spur switch equipped with electric lock

Movable-point-frog No. 24A at Bailey interlocking

are one or more batteries consisting of six cells of 80-ah. lead type on floating charge, for operation of low-voltage circuits and signal lighting. Track circuits are of the conventional a.c. type. Line circuits are protected by Raco Clearview lightning arresters.

The rail through the plant is bonded with Cadweld rail-head type bonds. Frog and switches are bonded with American Steel & Wire Company stranded duplex bonds with $\frac{3}{8}$-in. plugs.

To facilitate placing the plant in service, the power switch machines were temporarily operated from the mechanical interlocking machine. After the signals, relays and other equipment were wired and ready for service, the change over was performed one group at a time under traffic with no delay to trains.

This project was carried out by the regular signal construction forces of the B. & O., under the direction of A. S. Hunt, chief engineer-communications and signals, and under the immediate jurisdiction of W. W. Welsh, signal engineer. The major items of interlocking and signaling equipment were furnished by the General Railway Signal Company.

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(Continued from page 289)

station - to - station block to the switch, with the padlock out and with the time-element elapsed, the lock is released.

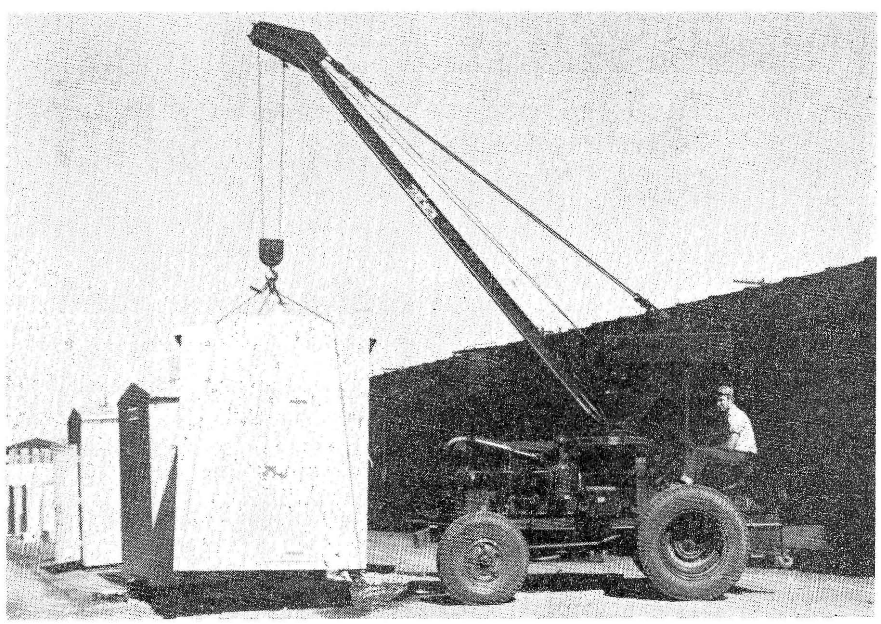
The use of time delay in the release of the lock was necessary to insure that an unauthorized release could not take place during the clear-out period after an eastward train movement in the block, when steady energy would be projected eastward in the block for the purpose of restoring the RFSR relay to normal. The time delay for moving from the main track to the spur track is 18 seconds and from spur track to the main track is approximately 1 minute under normal conditions. Conventional d.c. track circuits are used in the approach control section for highway crossing protection. The coded track circuits are taken around these approach sections on two No. 9 copper wires on the pole line. The maximum allowable resistance for such a line jump is 30 ohms.

Control Machine Circuits

An interesting development in connection with the use of reversible coded track is the use of additional circuiting in the control machine. In the foregoing, reference was made to sending code to the west end of the block to position the eastbound signal control relay at that point, and then sending code to the east end of that block to reverse the traffic relay for the purpose of changing steady energy to coded energy in the block. A link circuit was required to cause code to be sent to both ends of the block in this instance, since only one end of the block would normally be associated with given panel. Transmitting a control code to the east end of the block by the operation of the control start button for the west end of the block was necessary for the single step involved to reverse the traffic relay, but was neither required nor desired for any other function at the east station in connection with this operation.

Lever-Repeater Relays

Of particular importance was the possibility of an unintentional change in the condition of a signal at the east station due to a lever being out of position at the time the joint control codes went out. To overcome this condition, signal-lever-repeater relays were installed in the control machine. The pickup of this relay is necessary before a code can be transmitted to the field



A portable power crane mounted on a tractor which has rubber tires is used to handle switch machines, instrument houses and other heavy materials to clear the signal involved, and it must be released before the signal can be set to Stop from the control machine.

The pick-up of the relay checks the following conditions:

(1) Signal lever in proper position.

(2) Position of the switch lever (for entrance signals only), thereby providing selection main or side track entering signal.

(3) If switch lever is set up for main track, all opposing signal lever repeating relays, both local and at opposite end of block, de-energized.

(4) Opposing signals, both local and at opposite end of block, at stop and not in time on ground.

(5) Opposing traffic not set up.

(6) If electric lock in a block, lock releases lever-repeating relay in normal position.

(7) Start button must be operated for panel on which lever is located.

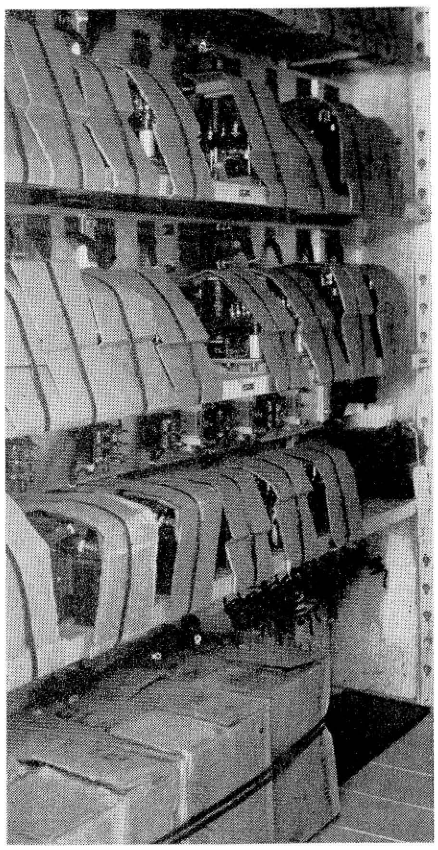
The relay is stuck up over the normal position of the start button for that panel, and/or the controlling position of the lever, thus, even if the lever is returned to normal there will be no release of this relay unless the start button for the panel is actually operated. Since the code character circuit for the signal control step is determined by the position of this relay, the results are obvious.

The link where it is required between stations is not established until this relay is energized and the code character for the traffic relay step at the oppositie end of the block is subject to the position of it. Once a train accepts the signal in the field and indicates occupancy of the OS section, the control for the signal lever relay is opened long enough to cause it to release. It can be re-energized by again operating the start button to store a signal for a following move. In making use of these machine circuits, none of the conventional safety checks in field circuits were sacrificed, and the Western Pacific found that the machine checks provide excellent added protection and assist materially in simplifying the machine manipulation by preventing the transmission of conflicting control codes.

Carrier on C.T.C. Code

The uses of carrier equipment on the C.T.C. code line circuits made it possible to locate the three separate C.T.C. control machines, for all three sub-divisions in the division offices at Sacramento. At each location, the carrier equipment is in duplicate. If the set in service fails, the standby set can be brought into service by sending controls from the office. In case the line relay at the involved field station is released due to an open line or other cause, the standby apparatus is automatically placed in service. Since the standby units are adjusted, so as to receive at lower power level, and transmit at a higher power level, ordinary losses to the carrier circuits are automatically compensated.

In addition to the carrier for control and indication codes, other carrier equipment, known as individual carrier is used for special purposes. (1) To transmit indications at 23 kc. from a rock-slide fence at M.P. 260.94 to Rich Bar; (2) To transmit controls at 41 kc. from Sacramento to release an electric lock on a hand-throw switch at the Campbell Soup spur; (3) To transmit at 27 kc. drawbridge indications from San Joaquin River bridge to Lathrop field station; and (4) To transmit OS indications at 41.0 kc. and 27 kc. from Radum interlocking to the field station at East End of Livermore.



Inside of house to be shipped

The C.T.C. conventional d.c. codes and the carrier frequencies are on one two-wire line circuit. West from Sacramento, this circuit is on No. 8 copper wire with plastic weatherproof covering. East from Sacramento to Oroville, this circuit is on No. 6 insulated copper wire; and from Oroville to Portola the circuit is No. 8 bare Copperweld wire.

Special Control of Crossing Signals

At some locations, important highways cross the single-track main line of the Western Pacific within 100 ft. of power-operated C.T.C. controlled siding switches. The control circuits for the flashing-light signals at such a crossing are arranged so that the crossing signals do not start to operate until a signal has been cleared for a train movement over the crossing. If a locomotive with cars makes a move to pull over the crossing and then back again, the flashing-light signals will operate because the receding stick relay is knocked down when the signal for the back-up move is cleared.

By Railroad Forces

The entire installation covering the three projects herein discussed has been handled by railroad forces except the wiring of the control machines and the wayside relay housings.

For the project east of Portola, Calif. to Gerlach, Nev., the signaling materials have been shipped to a warehouse at Sacramento, Cal., where wiring, relays, etc. are installed in the instrument housings in accordance with plans prepared by the railroad's own signal engineering department. Each relay is then covered with corrugated paper board packing and tied down by a metal strap. The cases and houses are then placed in box cars or gondolas to be hauled to and set at their final location in the field.

In the warehouse and in the surrounding yard area, the cases, houses, switch machines and other heavy materials are picked up and carried about by a portable power crane, mounted on a tractor which has large-sized pneumatic rubber tires. This machine, as shown in one of the pictures herewith, is known as a roustabout crane, made by the Hughes Kennan Co., Delaware, Ohio.

The control machine for the Portola-Gerlach project was wired by the signal company using plans furnished by the railroad's signal engineering department. The major items of signaling equipment, for all these projects discussed above, were furnished by the Union Switch & Signal Company.