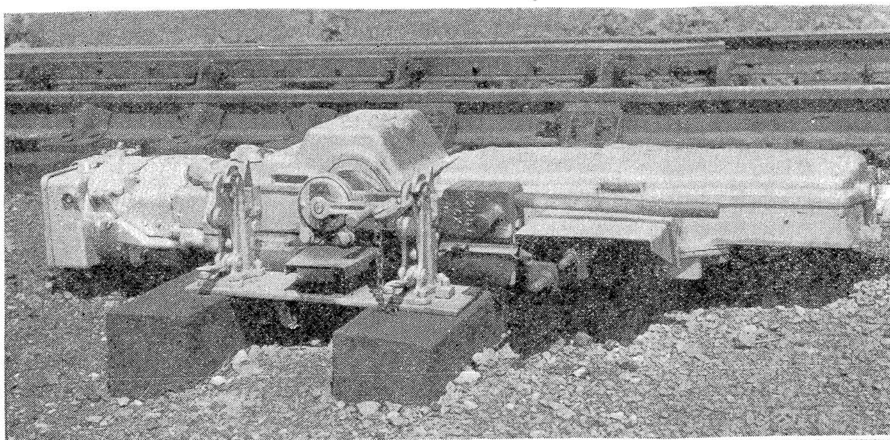
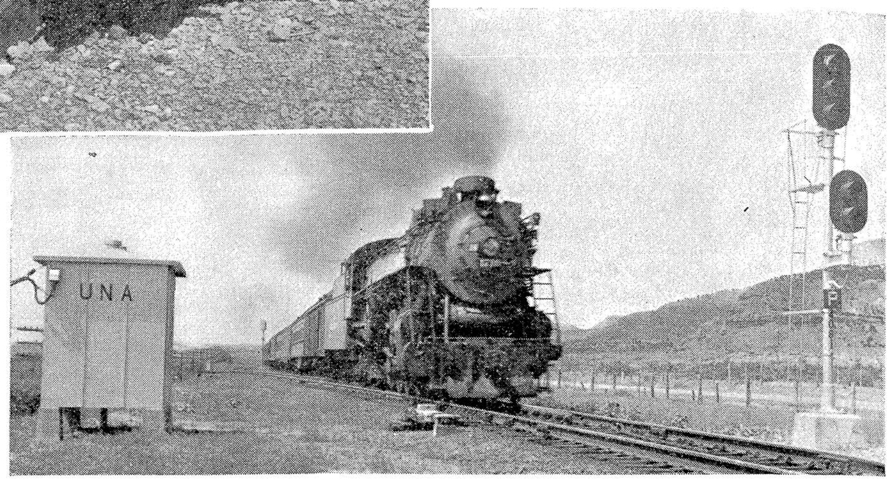
C.T.C. on





Above—Typical dual-control power switch machine. Right—The switch and the signal layout at Una siding

Train movements expedited on the bottle-neck section through canyon of the Colorado river

THE Denver & Rio Grande Western now has centralized traffic control on the entire 107 miles of single track between Dotsero, Colo., and Grand Junction, which previously was the bottle-neck section that limited the operating capacity of the through line as a whole.

One main line of the D. & R.G.W. extends from Denver south through Colorado Springs to Pueblo, then west through the Royal Gorge of the Arkansas river, then over the Continental Divide at Tennessee Pass and down the Eagle river canyon to Dotsero. A second route extends west from Denver, over the Continental Divide at the Moffat tunnel, and then down the Colorado river via Bond to Dotsero to connect with the Royal Gorge Route. Thus the traffic of both routes between Denver and Dotsero must be handled over one single-track line on the 107 miles between Dotsero and Grand Junction which is the division point.

Character of the Line

Between Dotsero and Funston, 19 miles, the railroad follows along the south side of the Colorado river through the Glenwood canyon. Three tunnels, one of which is 1,700 ft. long, are involved. The curves are numerous and range up to 12 deg., which require speed reductions to 18 m.p.h. for freight trains and 27 m.p.h. for passenger trains. The grade ascends from Funston to Dotsero, the average being 1 per cent and the maximum 1.4 per cent.

Between Funston and Grand Junction, 88.3 miles, the railroad runs down an open valley of the Colorado river. The line is at river grade which is 1 per cent for a large percentage of the mileage, and in no instance exceeds 1 per cent. The curvature is comparatively light, not exceeding 6 degrees; one stretch is tangent for 12 miles just east of Grand Junction.

In 1937, when making track changes and additions to facilitate shipments of fruit at Palisade, as well as to expedite train movements into and out of the Grand Junction yard, a section of C.T.C. was installed between Midwest and Grand Junction, 13 miles. In 1941, in order to relieve train congestion in the Glenwood canyon, C.T.C. was installed on 25.9 miles between Dotsero and Chacra, as well as on 8.1 miles between Midwest and Tunnel.

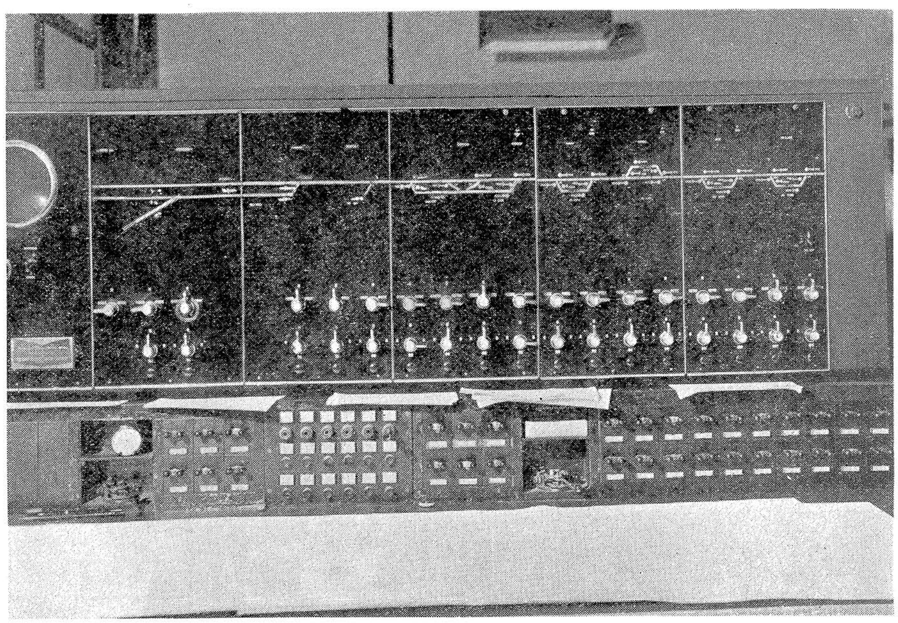
The C.T.C. in service on 21.9 miles on the west end, and on 25.9 miles on the east end, left 59.8 miles between Tunnel and Chacra to be operated by time tables and train orders. The result was that extreme congestion was experienced in this train order territory. The only logical procedure, therefore, was to install C.T.C. on the Tunnel-Chacra section, thus completing the entire 107 mile territory, the final section of C.T.C. being cut into service in October 1942.

Siding Changes and Improvements

When preparing for the installation of the centralized traffic control, various changes were made to eliminate as many main line switches as possible. A siding for loading sugar beets at Antlers was moved to connect it with the passing track rather than the main line. The stock pens and loading tracks at Silt and at Debeque were moved to connect these tracks with passing sidings rather than the main line. Three passing tracks, Gravel, Niger and Morris were eliminated.

Except in the few instances where it was impracticable to do so, the remainder of the passing tracks were lengthened to increase the car capacities as shown on the accompanying diagram. In order to save train time by increasing the speed at which trains can enter or depart from sidings, the old No. 10 turnouts were replaced with new No. 15 turnouts including 33-ft. curved points, which are good for speeds up to 37 m.p.h. In these switch layouts, the stock rails are 60 ft. long, thus eliminating rail joints in

107 Miles of Single-Track on the Rio Grande



Centralized traffic control machine in the office at Grand Junction

the switch area. The stock rails were milled, stocked and precurved at the factory to fit the Sampson switch points. Type M, Ramapo switch rods are used on all these new switch layouts, as a means for minimizing rolling of the points. Adjustable rail braces and 1-in. by 8-in. insulated gage plates are used on three ties. Dual-control electric switch machines were installed at the passing track switches, and electric locks were installed at the hand-throw main track switches leading to house tracks, such as at Debeque.

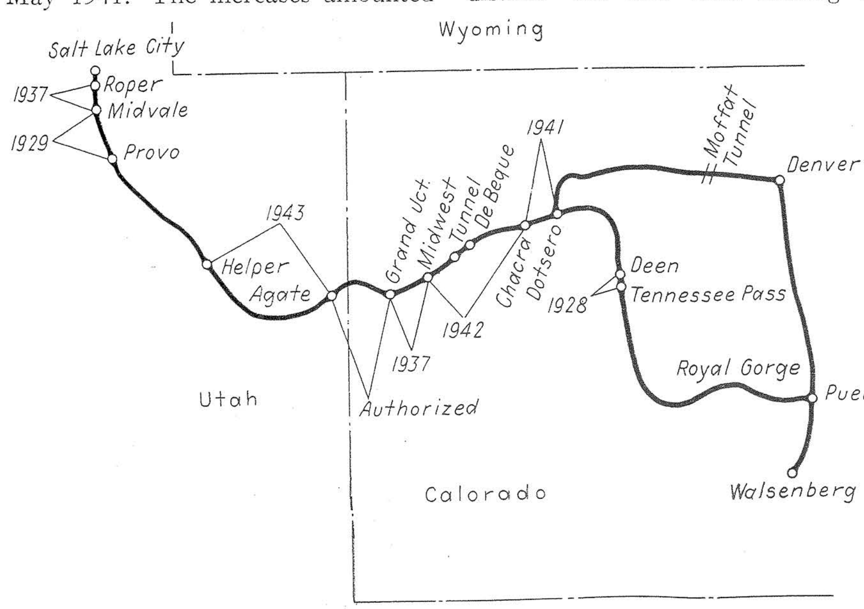
A C.T.C. control machine in the office at Grand Junction controls the 33 miles of territory between Grand Junction and Debeque, and a second C.T.C. machine in the office at Funston controls the 74 miles between Debeque and Dotsero. The switches and signals at Dotsero are controlled by a small machine in the office at that station.

Traffic Increases

Approximately twice as much traffic was handled between Dotsero and Grand Junction in May 1943 as in May 1941. The increases amounted to 97.3 per cent in freight gross ton miles and 103.5 per cent in passenger car miles.

In handling this heavily increased business, the Rio Grande was faced—not only with the problem of arranging meets and passes on a single track district—but also with making the best possible use of a limited supply of locomotives. This involved heavy loading of trains over this district—with smaller engines than had previously been used here. The result was that the average train speed over this district was materially reduced—but the efficiency in power utilization was at the same time improved. In spite of a 59 per cent increase in train miles per day (freight and passenger combined) the average productivity of freight locomotives on this district was increased by 16 per cent—as measured by gross ton miles produced per pound of tractive effort per hour between terminals.

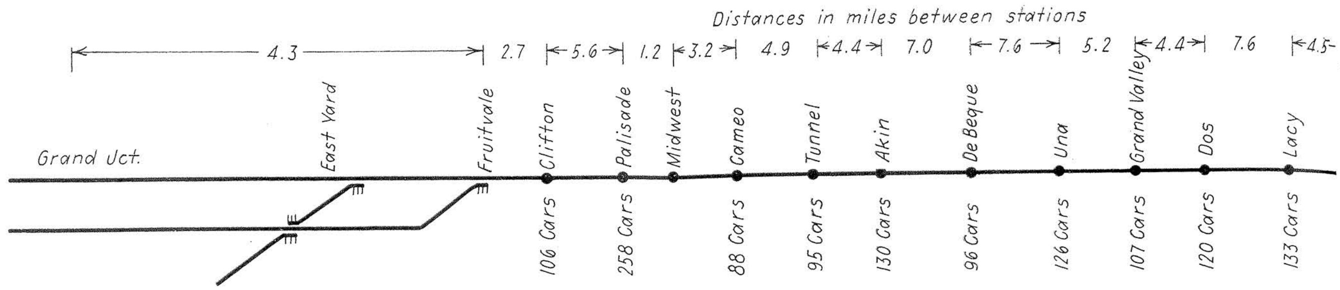
While this showing was aided to



Installations of C.T.C. on the D. & R. G. W.

Location	*Miles*	*Year*
Tennessee Pass—Deen	6.8	1928
Provo—Midvale	31.4	1929
Midvale—Roper	8.2	1937
Midwest—Grand Junction	13.1	1937
Dotsero—Chacra	26.7	1941
Tunnel—Midwest	8.8	1941
Debeque—Tunnel	11.4	1942
Chacra—Debeque	47.1	1942
Agate—Helper	127.8	1943

some extent by other factors, there is no doubt that without C.T.C. the result would have been very much poorer. Under war conditions, a major problem is to move the fruit and other agricultural products eastward, addition to 5 helper moves from Dotsero back to Funston. On June 12, there were 15 passenger trains and 22 freight trains, totaling 37 trains in addition to 4 light engine moves between Dotsero and Funston. The the switches and signals to advance trains for close meets. In view of the fact that power switches are in service and that the trains can make diverging moves over the new No. 15 turnout at speeds up to 37 m.p.h., a train can



General layout of stations between Grand Junction and Dotsero

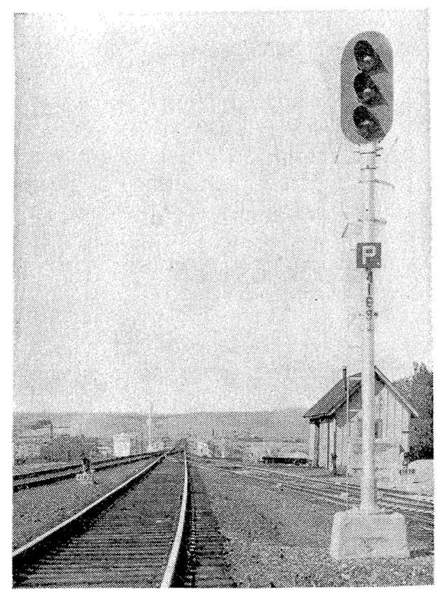
and at the same time move a preponderance of loaded cars of war commodities.

The number of trains operated daily depends on numerous variable factors, which result from a constant shifting of locomotive assignments. Because of the relief effected by the centralized traffic control, smaller locomotives are now used in this territory, the more powerful locomotives having been shifted to other districts. When the smaller locomotives are used on eastbound freight trains, helpers are required between Funston and Dotsero. On June 10, there were 14 passenger trains, and 20 freight trains, totaling 34 trains in addition to 7 light engine moves between Dotsero and Funston. On June 11 there were 15 passenger trains and 18 freight trains, totaling 33 trains in maximum daily movement to date was 16 passenger trains, 23 freight trains totaling 39 trains in addition to 8 light engines and 2 work trains.

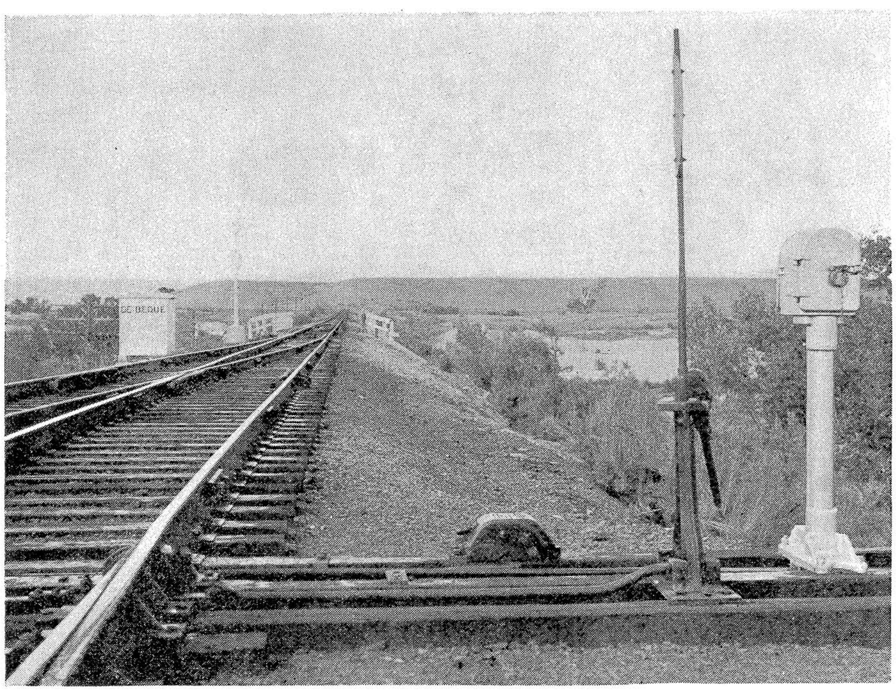
How the C.T.C. Helps

On numerous occasions the machine at Funston controlling 74 miles has successfully handled as many as 24 trains in one 8 hr. shift, and at times as many as 19 trains have been in territory at one time which somewhat taxed the capacity of the machine to promptly receive the changing indications.

The track-occupancy indications on the C.T.C. control machine show the locations of and progress being made by trains. Based on this minute-to-minute information, the men in charge of the control machines can control depart from a passing track, make a move over a section of main line and into another passing track in a period about 20 minutes shorter than if hand-throw switch stands were in service with No. 10 turnouts. The lengthened sidings, ranging from 100 to 154 car capacities, not only accommodate long trains when operated, but



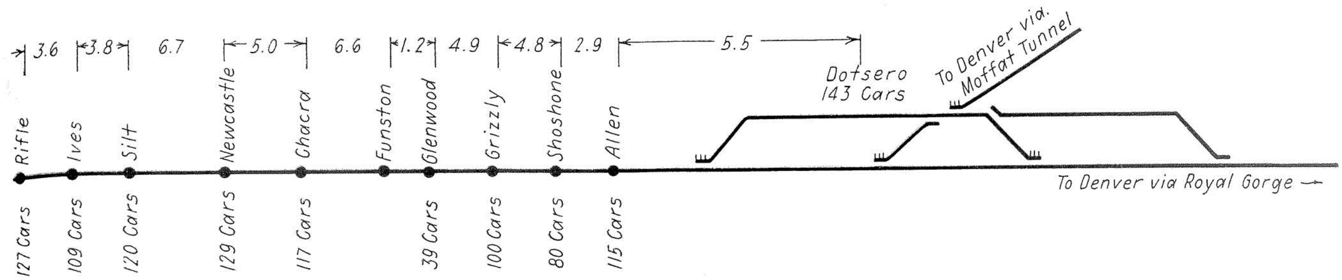
Westward signal at Debeque



Electric lock on hand-throw switch for the house track at Debeque

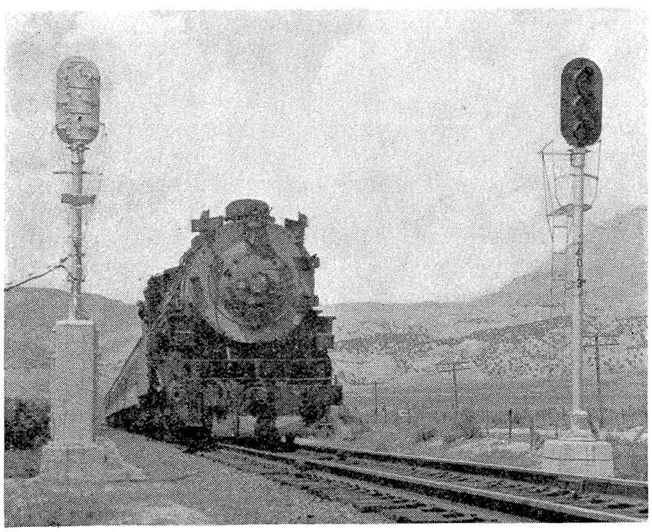
also with normal length trains of about 70 cars, these new sidings permit numerous non-stop meets to be made without either train stopping.

With the previous time-table and train order operation, meets and passes had to be set up ahead of time. In the meanwhile if some train did not make the progress anticipated, one or more other trains were delayed at the meeting points, simply because the dispatcher had no means for changing orders soon enough to take advantage of the changing conditions. On the other hand, with the C.T.C., the trains keep going, enter sidings, and depart from sidings according to the aspects displayed by the signals. As a result, a lot of time formerly wasted when waiting on sidings can now be used to keep trains moving. So many changes in locomotives, traffic, and operating conditions have



indicating the capacity of passing tracks in the C.T.C. territory

occurred since the first portion of this C.T.C. was placed in service, that it is impossible to determine how much train time is saved by the C.T.C. on



Typical intermediate signal layout

the 107 miles as a whole. A point of definite consideration is that this territory is handling 100 per cent more gross tons of freight traffic and about twice as many passenger trains as it was two years ago, and the average time of freight trains on the road between Grand Junction and Dotsero is at least two hours less than in 1941. As explained by the operating officers, if the passing tracks had not been improved and the centralized traffic control installed, the present volume of traffic could not be kept moving promptly on the territory between Grand Junction and Dotsero, and, therefore, as a result, the through line to Salt Lake City would be limited in its usefulness in the war program.

Signaling Changes

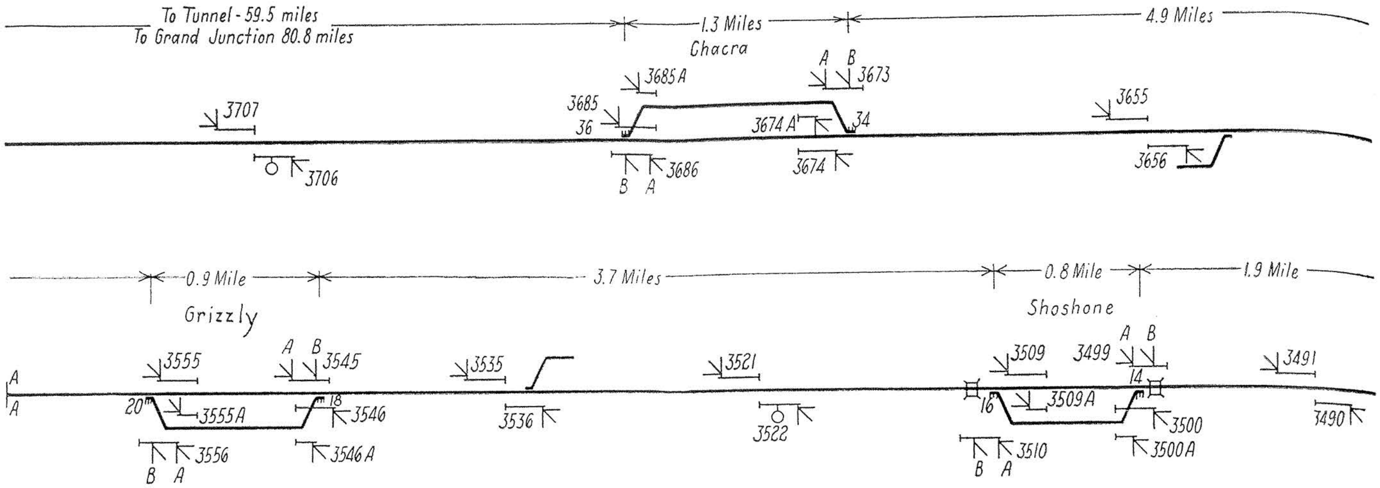
In 1927 this territory was equipped with color-light automatic block signaling using absolute permissive controls. In this arrangement, a double location including a signal for each direction was located near the switch at each end of a siding. When converting to centralized traffic control, several changes and additions were required at each end of every siding, the entering signal, i.e., the one in approach to the facing points, was

Power switch and instrument house at west end of Funston

left in its previous location and a lower, two-aspect "arm" was added to direct moves when the switch was reversed for trains to enter the siding. The departure signal was moved back to a new location at the right of the main track and opposite the clearance point on the turnout so that this signal would then be located properly to stop trains short of the switch or to direct trains to proceed to the next passing track. These signals were in all instances located immediately at the right of the main track, and, where necessary, the siding track was shifted to get 19-ft. centers, thus providing proper clearance for the signal between the main line and the siding.

On the siding and opposite the clearance point, a searchlight type color-light dwarf signal was installed. Such a signal displays three aspects, being red normally, and, when controlled by the operator, will display green if two or more automatic blocks are unoccupied, or yellow if only one block is unoccupied. This use of three-aspect dwarfs on the passing tracks as compared with two aspect signals displaying only yellow as a proceed aspect, facilitates moves because when a green aspect is displayed an engineman can pull his train out and accelerate to normal speed promptly, without the necessity of running at reduced speed until he sees the next signal displaying a green aspect.

The signals on masts, i.e., the station-entering and the station-departure signals, display three aspects: red



Detailed track and signal plan of that portion of the centralized

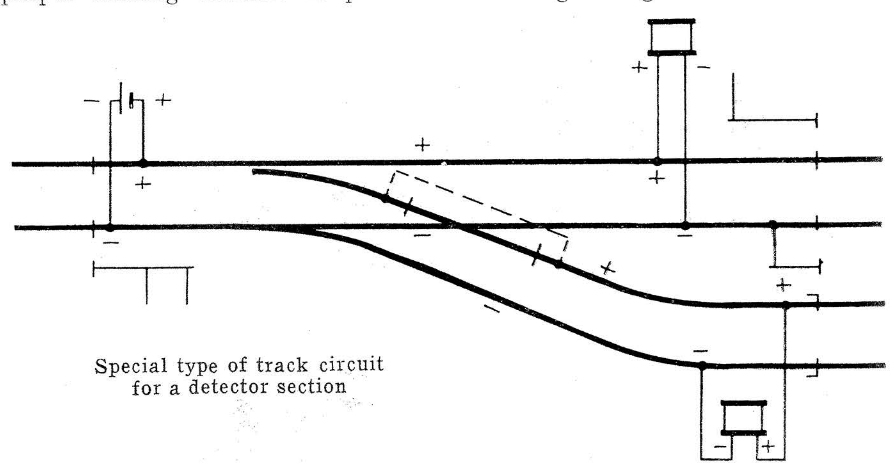
for stop, yellow for approach, and green for clear. The bottom signal of a station-entering signal displays red normally or yellow under a red to direct a train to enter a siding. All signals governing movements over power switches are designated by a reflectorized marker displaying the letter "P."

One "Call-On" Signal

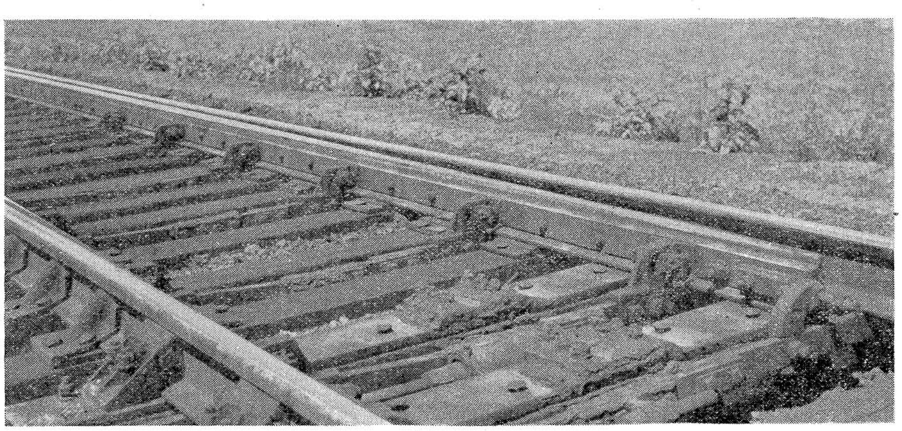
While an eastbound freight train is standing on the main line at Funston, the locomotive is sometimes cut off, run up ahead of the switches and back into the yard, to pick up or set out cars. Also for some of the heavier trains a helper locomotive is coupled ahead of the regular locomotive. When making such moves, the main line is occupied and the top or second signal of 3605 cannot be cleared for back-up moves against an occupied block. In order to authorize such moves, therefore, a third "arm" was provided, the normal aspect being red. With both switches normal, a yellow call-on aspect can be displayed for a locomotive to back down on a train. Incidentally, this is the only call-on non-track circuit controlled signal on the D. & R.G.W.

Intermediate Automatic Signals Changed

In a C.T.C. project such as installed on the D. & R.G.W., the positive signals normally display the Stop aspect, and, furthermore, only one of two opposing station-leaving signals can display a Proceed aspect at one time. As a consequence, the spacing of intermediate automatic signals for proper braking distance to provide head-on protection, was not necessary, as was previously the case with the former automatic block signals, all of which normally displayed the Clear aspect. When installing the C.T.C., therefore, the intermediate automatic block signals were relocated as necessary to provide better view, and some were removed, the purpose being to provide the most efficient spacing for following train movements and at the same time have a minimum block spacing of 6,500 ft., on the basis of level tangent track, with variations according with grades and curvature.



Special type of track circuit for a detector section

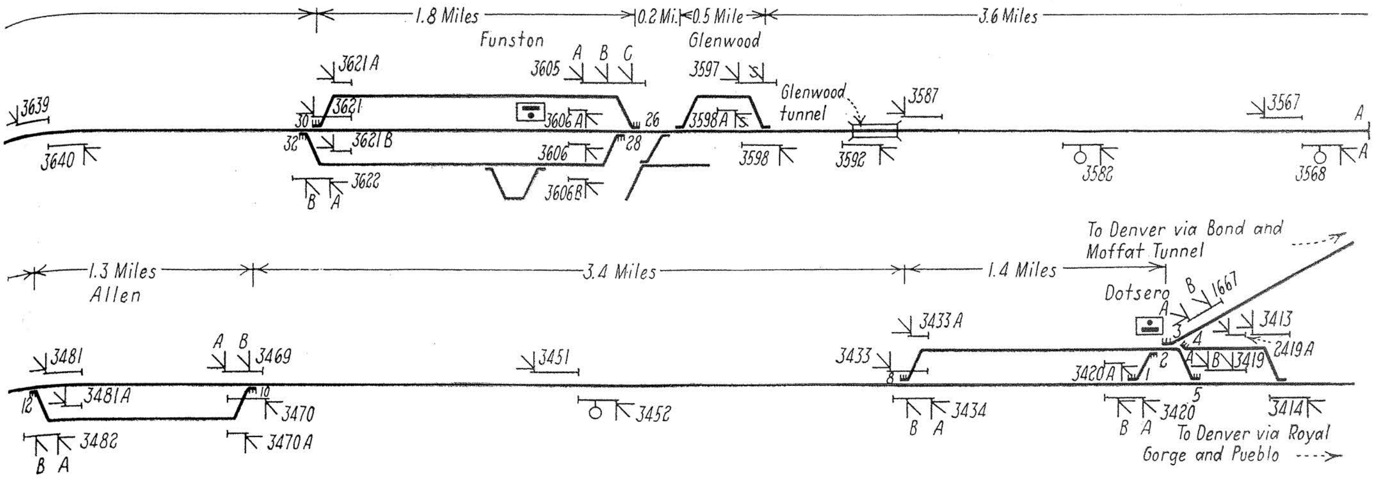


Typical power switch showing the insulated gage plates and the special tie rods

The original automatic signaling included conventional d-c. neutral track relays, with polarized line circuits using a line wire for each direction in connection with a common line wire. When changing over to C.T.C. the line wire circuits were retained but numerous changes were made in the track circuits.

Special Detector Track Circuits

The revision of the locations of signals at each end of every siding, as required for direction of train movements by signal indication, resulted



traffic control territory between Chacra and Dotsero

in the introduction of a new detector circuit at each switch. In each of these layouts, battery is fed to the rails at the signal in approach to the facing points of the switch, the insulated joints and jumpers through the turnout being as shown in the accompanying sketch. The battery feeds two track relays, of which one is connected to the rails at the station-departure signal on the main line and the other connected to the rails at the dwarf signal on the turnout. These track relays are quick acting and equipped with only two contacts. They are rated at 4 ohms with a 20-ohm resistance in series with the coil, and the normal current is 125 m.a. A 500-ohm d-c. neutral slow pickup repeater relay, in the instrument house, is controlled through these track relays, with a double-wire double-break and double-shunt feature. This arrangement provides good shunting characteristics, prevents picking up the repeater relay in instances of momentary loss of shunt, and provides maximum broken-rail protection.

Coded Track Circuits

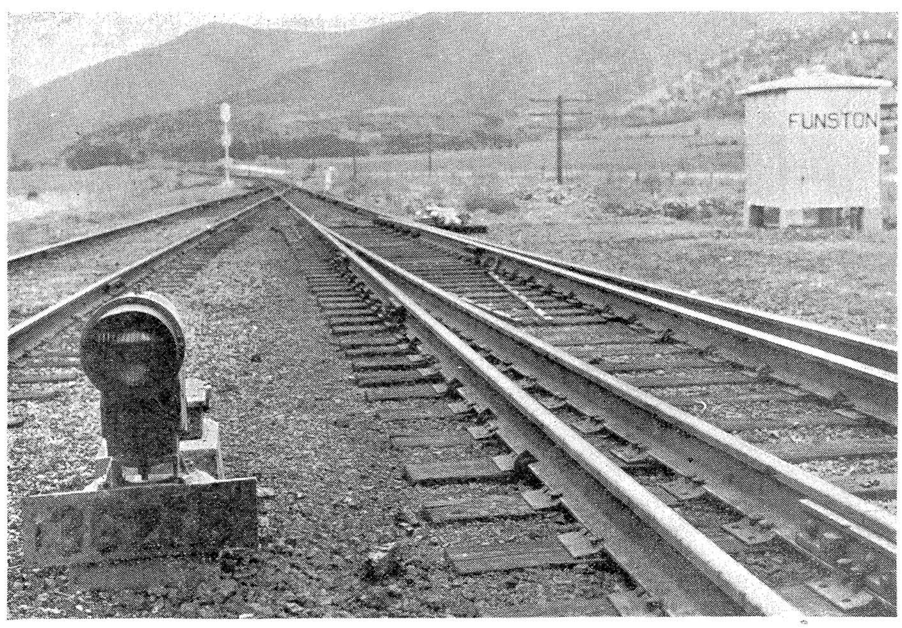
In the previous automatic signaling, the main line throughout the length of a passing track was two track circuits, using conventional d-c. neutral relays. As a part of the improvements, these two conventional track circuits were replaced with one d-c. coded track circuit. A code transmitter, rated at 5.5 ohms, 2.0 volts is driven constantly at the rate of 75 times each minute, from a storage cell which also feeds the coded energy to the rails. This low voltage transmitter is considered to be a new feature.

On the sections between sidings, new coded track circuits operating at 75 code, were installed wherever one such track circuit could be used to replace two or more conventional d-c. track circuits thus eliminating cut sections.

Automatic Sectionalizing of Code Line

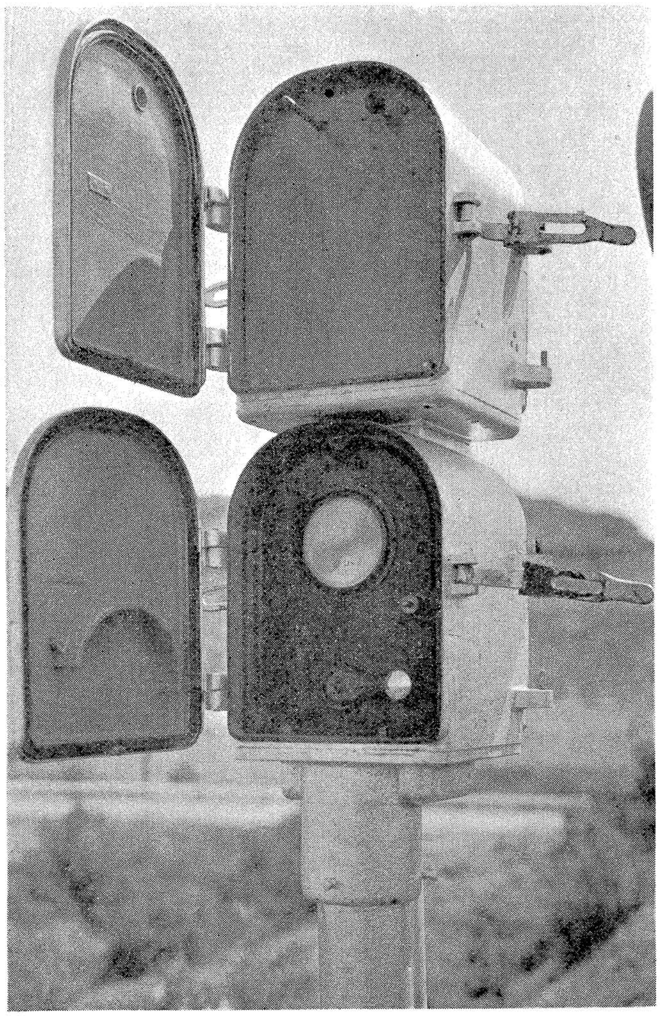
The power switches and signals at the field locations are controlled by code sent out from the office, and likewise indications on the control machine to repeat the operations of the switches and signals as well as track occupancy are sent into the office by codes. These codes are transmitted over three line wires using the General Railway Signal Company's Type-F Class-M coding system, by means of which control codes and indication codes can be transmitted simultaneously. The coding equipment on this installation is what is known as the 8-step size, and can control as many as 32 single switch field locations or their equivalent, with 4 controls and 11 indications each.

In this system, a 48-ohm relay at each field station, i.e., each end of every passing track, is connected in series with the control line circuit. In previous installations of this character, if the control wire or the common wire of the code system is broken, the coding system as a whole is inoperative until the wire is repaired or until the maintainer manually sectionalizes the line at a field station closer to the office than the break. In order to automatically maintain operation of the

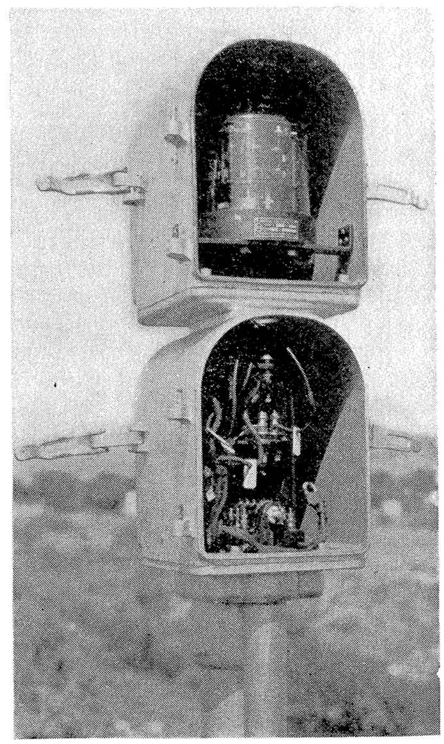


Dwarf signal on the end of the passing track at Funston

C.T.C. system on the sections between the office and a line wire break, a new arrangement of automatic sectionalizing was included in this new D. & R.G.W. project. At certain selected field stations, a 2,400-ohm neutral relay with its series resister is connected in multiple across the control line circuit. Under normal operation this relay is not energized. In case a line wire is broken beyond one of these field stations, however, the 2,400-ohm relay is picked up, and, after a delay period of a few seconds, an automatic sectionalizing relay is picked up to terminate the C.T.C. line circuits at that point and return to service the sections between that station and the control office. This automatic sectionalizing is indicated by lamps on the control machine, so that the opetrator is informed of the circumstances and so that he can call the maintainer to repair the broken line circuit. In addition to handling the control and indication codes of the C.T.C., a telephone circuit is superimposed on the common return and indication line wires, for a distance of 19 miles, in the balance of the territory a message phone circuit was erected. Telephones connected to these circuits and the dispatcher's circuit are located in the instrument houses at the switches for use by signal forces, or train crews when communicating with each other or the operator in charge of the control machine. In case the telephone train dispatching circuit is out of order, this superimposed line circuit can be used also by members of train crews when communicating with the operator. This telephone line is normally terminated at the end of the territory controlled by each C.T.C. machine; however facilities were provided to cut the line through by code selection from either control machine, thus providing two telephone circuits over the entire C.T.C. territory.



Trainman's side of the electric lock on a hand-throw switch with a clockwork time release in the top



Rear of electric lock cases with doors removed

Control of Electric Locks on Hand-Throw Switches

The operation of the numerous slide detector fences in the territory is indicated by the illumination of the track occupancy lights.

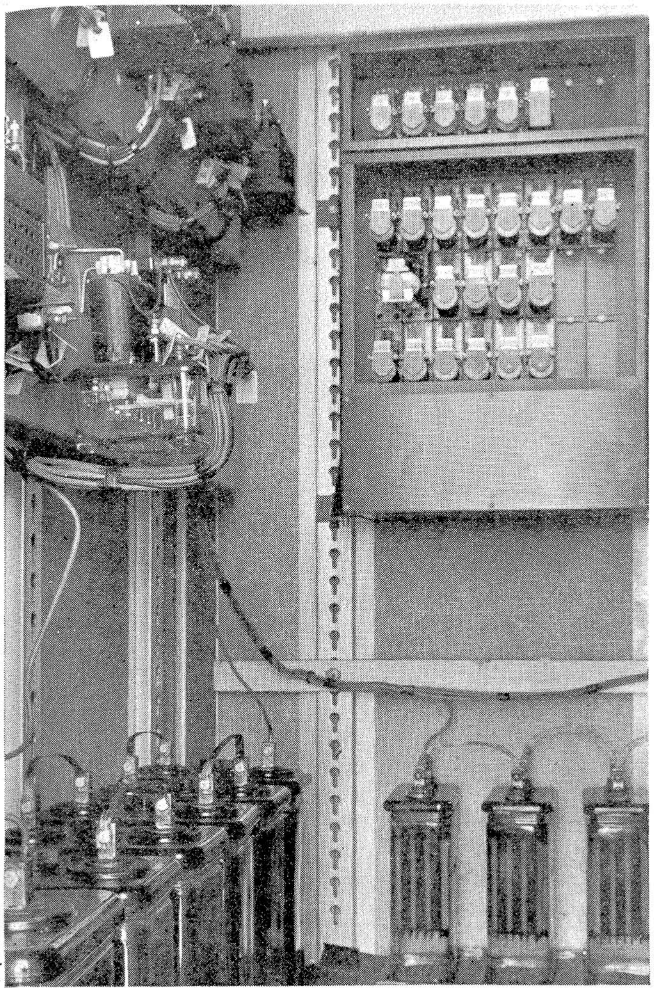
The electric locks on the hand-throw main line switches at house tracks, such as at Debeque, are controlled automatically. A special releasing track circuit, about 78 ft. long is located in approach to the facing point of each switch. When a train is to make a move into this house track, the train or a portion of it must be stopped in this releasing track circuit, and when so done the release is direct. Releasing the track circuit gives immediate release of the lock when a train is to enter the spur track.

Departure Move

When a train on the house track is to enter the main track, the conductor telephones to the dispatcher for written authority; after receiving authority the dispatcher protects the intended move. The conductor then goes to the electric lock, and opens the door. This action does two things. First, the signals approach from each direction are set at their most restrictive aspects, and second, the release of a 3-min. clock-work time release is started. At the end of three minutes the electric lock is released. The coils of the electric lock is rated at 16 ohms, and it is fed from 1 cell of 72-a.h. lead storage battery.

Power Supply System

In this installation, the signals, switch machines, relays, track circuits, etc., are of the d-c. type which are fed from storage battery charged by rectifiers supplied from an a-c. power distribution circuit. The batteries are of the Exide lead type, various capacities being used for different purposes. At each field location, the switch machine is operated from a set of 15 cells of three-plate battery rated at 38 a.h. on a 72-hr. rate. Twelve of these cells are used also to feed the line stepper of the line coding system. A set of four cells provides the local and line circuits, a set of five cells provides standby for light circuits and is rated at 174 a.h. Each of the cells used to operate a track code transmitter and feed the coded energy to the rails is rated at 290 a.h. Each of the conventional d-c. neutral track circuits is fed by an 87 a.h. storage cell.



Interior view of sheet metal house showing the line coding equipment

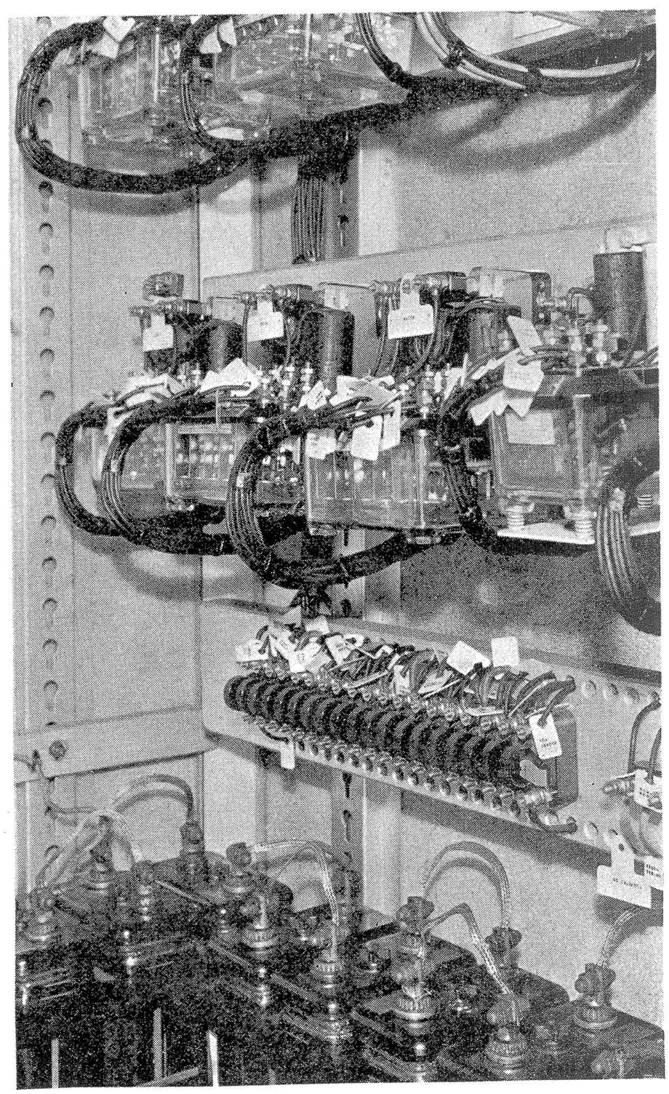
Instrument Houses

At each power switch location the relays, rectifiers, batteries, line code apparatus, etc. are located in a 6-ft. by 8-ft. sheet-metal house. These houses were shipped in knocked down panel sections to field headquarters, where they were assembled and then all the wiring and instruments were installed. Instead of using one terminal board at one end of the house for all wires, separate boards are used on each side, thus reducing the insulated wire required. The complete wiring for such a house requires 1,975 ft. of No. 14 flexible, for controls and 200 ft. of No. 10 for switch operating and lamp feed circuits. After the houses are complete, a Burro crane operating on the track is used to load the houses on cars as well as to set them on foundations at their field locations.

New underground cables of 3, 5, 7 and 19 conductors were installed as required. The track circuit connections are in single-conductor No. 9 cable from the house to a Raco bootleg from which two-stranded bronze connections extend and are attached to the rail with Cadwell welded bonds. All underground cable has mummy finish with no metal coverings. The insulated wires and cables were furnished by the Kerite Insulated Wire & Cable Company. All line wire connections as well as line drop connections from line wires to cables were made with Nicro grip sleeves, thus avoiding the use of any solder in the field.

Construction by Railroad

This centralized traffic control was planned and installed by signal forces of the Denver & Rio Grande Western under the direction of B. W. Molis, signal engineer, the major items of equipment being furnished by the General Railway Signal Company.



Interior view of the sheet metal house showing the relays, arresters and storage batteries