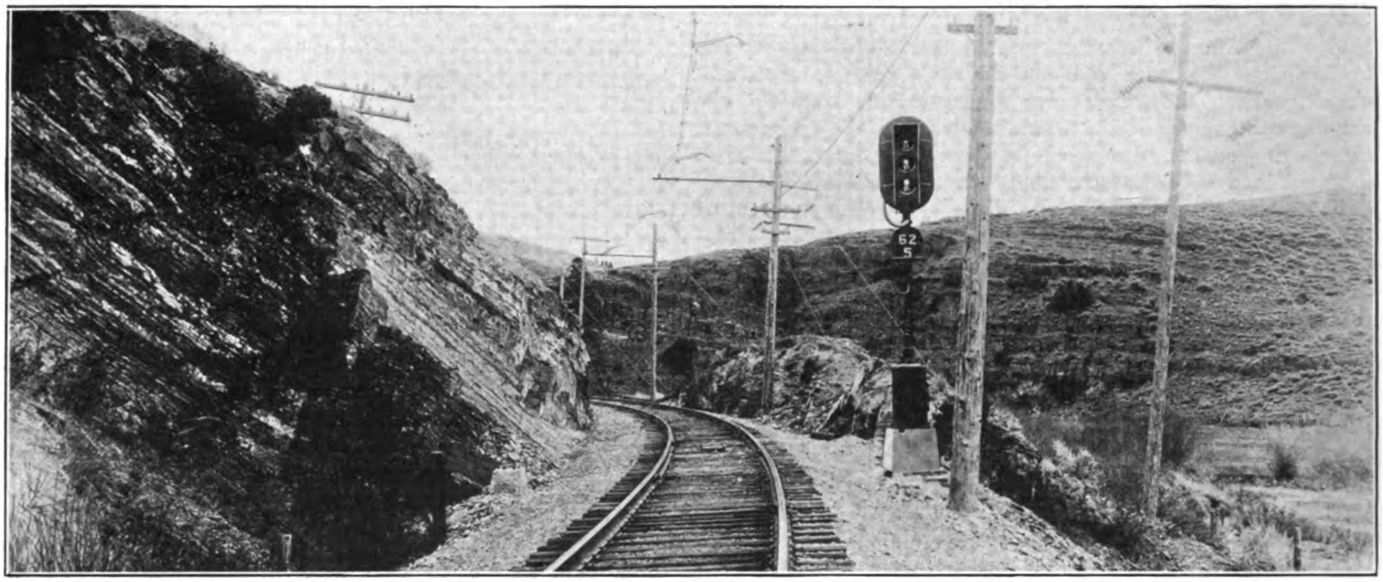


The Line Has Many Sharp Curves

Signaling the Milwaukee's Electric Zone

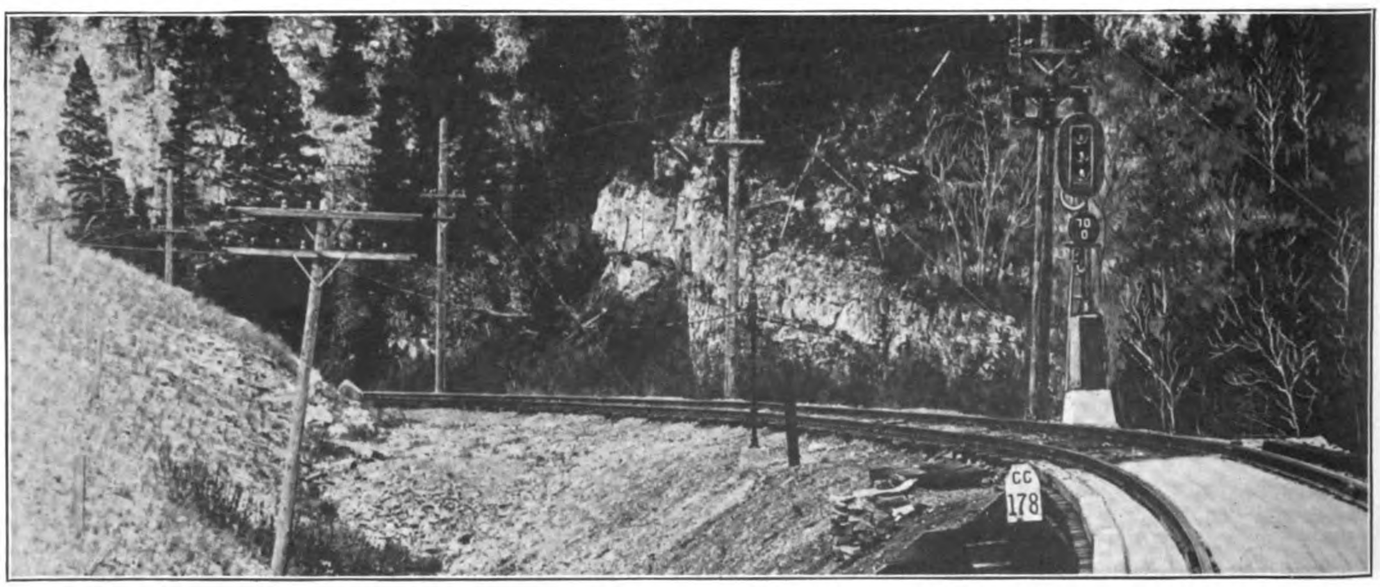
A. C. Light Signals Being Used for 440 Miles of Main Line Between Harlowton, Mont., and Avery, Idaho

The electrification of 440 miles of main line on the Chicago, Milwaukee & St. Paul in Montana has attracted a great deal of attention both from railway men and the public on account of the length of the installation, the possibility of effecting important operating economies which prompted its inception, and the advanced practice adopted in a number of respects in the application of the new power. It is the first extensive application of the 3,000-volt d. c. propulsion system and the longest single installation of light signals ever made.

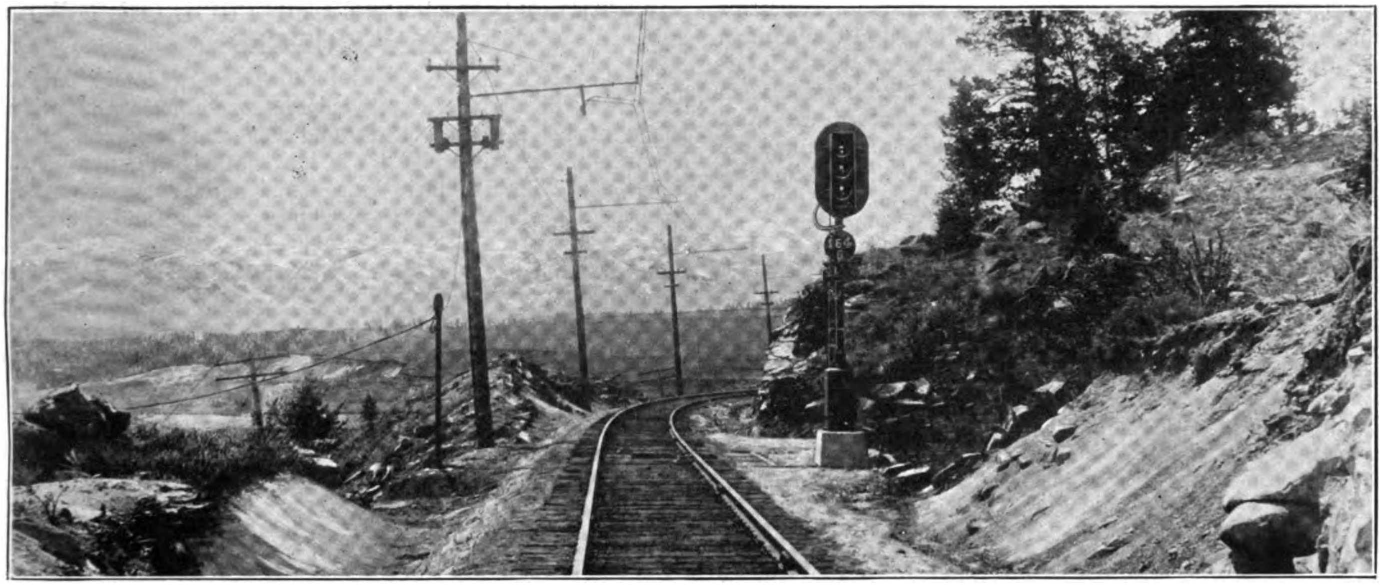
GENERAL

The electric zone extends from Harlowton, Mont., to Avery, Idaho, crossing the Big Belt, Rocky and Bitter Root mountain ranges and including four engine districts. The line is single-track, with maximum grades of 2 per cent, heavy curvature with a maxiumm of 10 deg., and 36 tunnels, the longest of which is 8,751 ft. in length. The traffic consists of two heavy transcontinental passenger trains, with a third local passenger train between Harlowton and Butte, and an average of four tonnage freight trains each way daily, with a local freight every second day.

Work on the electrification proper had progressed sufficiently in the early part of 1915 for a decision to be reached as to the signaling required. It was obvious that the d. c. signals then in service would have to be replaced by a. c. equipment, and in order to rearrange the signals for more satisfactory operation and to eliminate the obstruction to the view of semaphore signals by the electrification pole line it was decided to adopt light signals. The material for 130 miles of the new signaling covering the two existing installations and an extension of 16 miles on one of them was ordered from the Union Switch & Signal Company, and about the time the first of these signals were going in service, early in 1916, the authority was granted for



Typical Three-Light Signal With Line Transformer on Pole in Background.



One of the Signal Locations on the Piedmont-Finlen Section.

an additional 250 miles and for the reinstallation on sections farther west of the d. c. equipment removed.

At present, a total of 134 miles of the electrified line has been signaled, comprising two stretches between Lennep and Three Forks, and between Piedmont and Finlen, crossing respectively the Big Belt and the Rocky mountain summits. Work is under way on the remainder of the installation which will cover the entire electric zone, with the exception of a 38-mile stretch in the Bitter Roots, where the staff system now in service for the protection of numerous tunnels will be retained. The completion of this work will provide continuous block signal protection from Harlowton to Seattle and Tacoma, a distance of 877 miles.

POWER

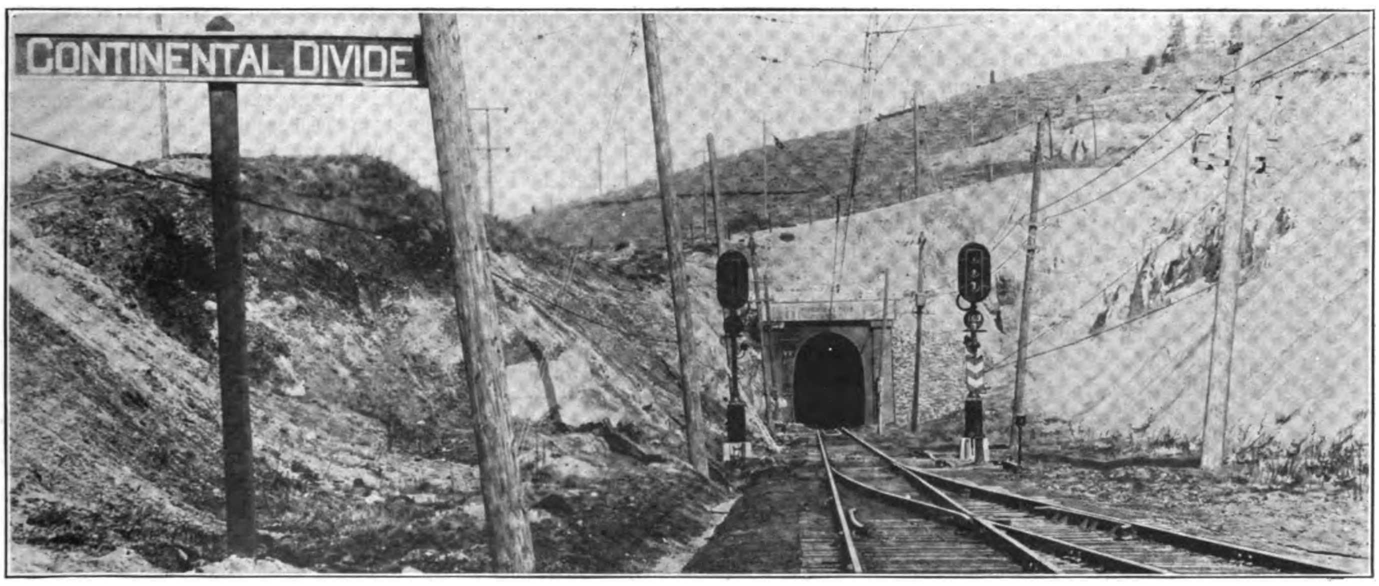
All power used on the electric zone is purchased from the Montana Power Company, which operates important water-power development projects in this vicinity. It is delivered to the right-of-way at 100,000 volts, three-phase, 60-cycle a. c. Fourteen sub-stations are provided, located on an average of 33 miles apart. The power required for the signaling system is transmitted at 4,400 volts, 60 cycles, on a line consisting of No. 4 solid copper wires. Oil sectionalizing switches are provided at each passing siding, which are approximately seven miles apart, so that in case of line trouble power may be supplied up to each side of the trouble from the adjacent sub-stations. Normally one sub-station will handle the entire load between it and the next one. Under this condition the maximum line drop will be between 3 and 4 per cent.

The line transformers at each signal location are 4,400-110 volt General Electric type H, with a capacity of 0.6 or 1.0 kv. a., depending on whether one or two track circuits are fed from the particular location. The line transformers are protected by graded shunt lightning arresters and expulsion fuse cut-outs are used on the high tension side of the transformer. Plug cut-outs with copper wires in place of the usual fuses are used as disconnecting switches to isolate both the transformer and the lightning arresters from the line when necessary.

The 110-volt line circuits use either No. 10 B. & S. G. copper clad or No. 9 B. W. G. galvanized iron wire. The leads from the track transformers and track relays to the track are No. 8 B. & S. G. copper wire. The 110-volt line wires and track leads are protected by vacuum tube type lightning arresters.

TRACK CIRCUITS

There are usually five track circuits between sidings, the average length of these circuits being 6,000 ft. They are fed from 0.5-kv. a. U. S. & S. track transformers having a primary



Double Location at Portal of Tunnel on the Summit of the Rockies.

of 110 volts, and a secondary of 18 volts with taps. A reactor is used in the transformer leads to track. Model 15 two-position vane track relays are used, the normal voltage on the track element of the relay being about 1 volt, thus allowing a margin for wet weather conditions. The local element of the track relay is wound for 110 volts. The track rails are 90-lb. and are bonded to capacity. The impedance bond for the propulsion current has a capacity of 1,500 amperes per rail on the 2 per cent grades. On the lesser grades, impedance bonds having a capacity of 500 amperes per rail are used. The ballast is disintegrated granite, which resembles gravel in character. The ballast is free from the rails and well drained with a few exceptions in yards, making very favorable track circuit conditions.

A supplementary negative feeder is connected to the neutral points of the impedance bonds, usually at every other track circuit, although at shorter intervals in some cases. This negative feeder offers a path for the return of propulsion current when it becomes necessary to remove rails. This cross bonding to the negative feeder is so laid out that broken-rail protection will still be provided by the track circuits.

The line relays are either three-position model 15 vane or two-position single-element vane. The single-element vane and both elements of the model 15 vane line relays are wound for 110-volt operation.

LIGHT SIGNALS

There are usually eight signals between sidings. The circuits are so arranged that a permissive feature is obtained, allowing a shorter overlap for following than for opposing moves. The light signals in service are the three-light model 14 type, having white, green and red indications. Four typical locations are shown in the accompanying illustrations. Each lens is illuminated by a main lamp and a pilot lamp burned at a lower voltage, which gives an indication in case the main lamp burns out. The signal is also provided with a small red marker lamp which is staggered with regard to the main lenses. This marker serves to locate the signal at night if for any reason the indication should not be displayed. The range of the light signal in daytime is 3,000 ft. on tangent track under normal conditions and 2,000 ft. under the most unfavorable conditions with the sun shining directly into the face of the lens, notwithstanding the intense sunlight experienced in the clear atmosphere of this territory.

For use on curves the lenses are provided with special deflecting prisms which give the light beam a wider spread and allow the indication to be observed for a much greater distance around the curve than would otherwise be possible. Some of these signals were in service last winter and it was noted that the indication could be seen during a driving snow storm in the daytime several times farther than it would have been possible to have seen a semaphore blade.

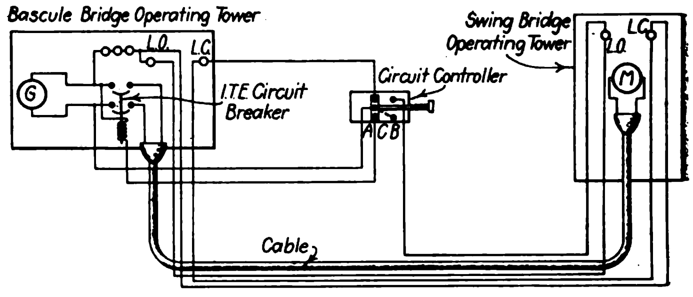
Provision was made for dimming the light signals at night, but it was found that the day indication, while very bright at night, was not too glaring to be uncomfortable or confusing to the enginemen, and so it was decided not to dim the lights at night. The reports from the trainmen with regard to the light signals have been very favorable, it being stated that it is possible to pick up the indication at a greater distance and with less effort than was possible with the semaphore signals previously used in this territory.

The signals, relays, track transformers and reactors are of the Union Switch & Signal Company's manufacture. The mechanism cases were wired complete at Swissvale, so that when installed by the railroad company's forces it was only necessary to place the relays in the cases and connect them to the proper wires. A more detailed description of the construction features of this installation will be published in an early issue.

THE BOSTON & ALBANY has ordered the necessary material to at once comply with the recommendations of the recent grade crossing conference in relation to signs at highway crossings.

INTERLOCKING THE CONTROL OF TWO DRAW-BRIDGES

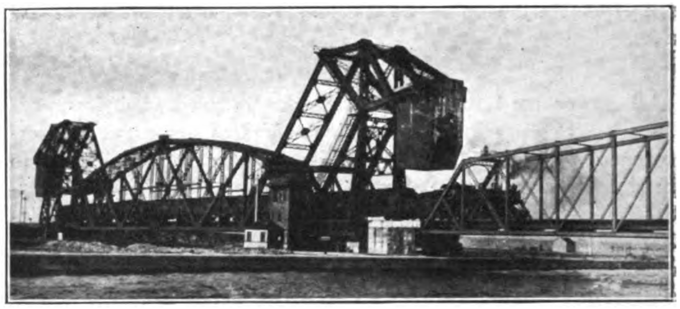
The Canadian Pacific just east of Sault Ste. Marie, Mich., crosses two drawbridges closely adjacent, one a horizontal swing bridge of 398 ft. span over the old ship canal, and the other a double-leaf bascule bridge 433 ft. long, spanning the new U. S. Ship Canal. Both of these spans stand normally open on account of the comparatively small number of trains and the large number of vessels which pass in both canals. There are no signals governing the approach of trains to the bridges, all trains



Operating Circuits for Controlling Two Adjacent Drawbridges.

being required to sound one long blast on the whistle when approaching to indicate a desire to cross. When the canal is clear the draws are closed, and the train is then answered from the bascule bridge operator's tower by two long and four short blasts given by a powerful diaphone horn located on the roof of the tower, which is operated by compressed air.

The bridges are both electrically operated, the movement of each being controlled from its respective operating tower, located on the bridge. As the signals for trains to proceed are given



Train Crossing the Bascule Span and Entering the Swing Span.

by the operator of the bascule span, it was not considered safe to allow the swing span to be operated independent of control from the bascule span operator, since without control of this kind the swing bridge might be opened after a signal to proceed had been given to a train from the bascule bridge.

This problem was solved by an arrangement of the control circuit devised by local officers and illustrated in the accompanying drawing. The power for the operation of the swing bridge is supplied from a motor-generator set installed on the second floor of the tower on the bascule bridge and is fed through a double set of submarine cables under the old canal. A special I-T-E circuit breaker, constructed without overload trip, but with a special shunt tripping device and time limit relay, was connected in these feeder cables near the generator panel in the operator's tower on the bascule bridge. The tripping coil of the special circuit breaker is operated by a circuit controller located in the tracks on the pier between the two bridges and adjacent to the end of the swing bridge. This circuit controller, in turn, is operated by the motion of one of the end rail locks of the swing bridge when the rail lock comes into position with the bridge properly closed. A contact block, C, indicated in the diagram, is mounted on a horizontal plunger, which is held in position to