

Track relays are of the U. S. & S. Co.'s model 12 Polyphase type, with 110-volt local. Normal voltage on track winding is .06 volt.

Track circuits are end fed. Track transformers are of the reactive type, with 110-volt primary and secondary taps, giving a range of from 2.7 to 16 volts.

High signals are the U. S. & S. Co.'s style "S" and style "T<sub>2</sub>," giving indications in three positions of the upper left hand quadrant. Style "S" signals are equipped with slot contacts. Dwarf signals are of the slot arm type. Lighting of signals is by alternating current, a 110 to 12-volt lightning transformer being provided at each signal location. Electric lamps are 18-volt 18-c.p. Tungsten filament, operating at 11 to 12 volts.

Approach and route locking is provided at each plant. Rear home signals have two arms and are arranged to give four indications, namely: green over red, proceed at high speed; yellow over green, proceed prepared to pass next signal at restricted speed; yellow over red, proceed prepared to stop at next signal; red over red, stop. "S. S." relays and signal repeating relays are three-position radial polyphase with 110-volt local and 110-volt line windings. In the normal position of signal repeating relays contacts are closed that control energy to back locks on the signal levers and to detector locks on the switch levers. In the reverse position of these relays contacts are closed that supply energy to the signal lever lights. An illuminated track model is provided for each plant.

#### REPORT OF SUBCOMMITTEE "P."

Mr. H. K. Lowry, Chairman.

Subjects Presented on A.C. Signaling.

Chicago, Milwaukee & St. Paul Ry.  
 Ringling and Three Forks, Mont.  
 Piedmont and Fenlon, Mont.  
 Rock Island Lines.  
 Chicago Terminal Division.

CHICAGO, MILWAUKEE AND ST. PAUL RAILWAY.

*Ringling and Three Forks—Piedmont and Fenlen.*

The electrification of a 440-mile single track territory between Harlowton, Montana, and Avery, Idaho, was practically completed during January, 1917. Propulsion is by direct current fed from 3000-volt trolley system. Trolley is supported by brackets attached to cedar poles wherever this type of support is practicable. Span construction is used on sharp curves and through passing track and yard limits.

*Railway Signal Association.*

## Committee VIII.—Electric Railway and A.C. Signaling.

Authority has been given to protect 402 miles of this territory with a.c. signals, the remainder having previously been protected by installation of the staff system, which will not be changed. During 1916 the installation was completed between Ringling and Three Forks and between Piedmont and Fenlen. All of these points are within Montana and total mileage now in service is 108.7. Signals are U. S. & S. Co.'s model 14 color light type, equipped for three indications.

Sub-stations are located approximately thirty-five miles apart. Power is supplied at 100,000 volts from Montana Power Company, which has fourteen hydroelectric plants throughout the State, most of which are tied together by high tension lines. A private one hundred thousand-volt power line parallels the railroad through the greater part of this distance with frequent taps to Power Company's system. Thus continuity is quite well assured. The signal system is fed from a separate 4400-volt single-phase circuit, which is supported by crossarm on trolley poles. This power is obtained through a step-up transformer from the 2300-volt side of power transformers feeding the motor generators.

The sub-stations are so arranged that a 2300-volt, three-phase bus is provided at the main switchboard. This bus is fed from the secondary of the power transformers and in order that the circuit may not, under normal conditions, be interfered with because of a damaged transformer or switching equipment, provision was made whereby the connections could quickly and easily be transferred to either one of two transformers. This is accomplished by means of so called selector switches (see Fig. 1). The tap for each power transformer is connected through so that when it is desired to transfer the 2300-volt bus feed from one transformer to the other, the open switch is thrown in and the switch originally closed tripped out. In this way the signal circuit is not interrupted at the time of transfer.

The step-up transformer used for obtaining the 4400 volts is a 25-k.v.a. single-phase, 60-cycle, 2300/4400-volt transformer. It's 4400-volt winding is connected to a bus, which feeds the signal circuits on each side of the station. Each signal circuit is controlled by a separate automatic K-5 200-ampere 4500-volt oil switch. The signal circuits being separate from each other precludes the possibility of trouble on one line interfering with the other. The primary of the 25-k.v.a. transformer is connected through a set of LG-6 disconnecting switches which permits the transformer to be entirely isolated from the 2300-volt bus. Also on the line side of the K-5 switches is another set of LG-6 disconnecting switches, which permits the 4400-volt side of the transformer to be isolated from the line.

The meter equipment consists of a recording voltmeter, ground detector, and an ammeter on each circuit. The voltmeter is a Bristol type with 24 hour chart connected across the secondary of a BQ-4 potential transformer of 40/1 ratio. The ground detector is of the electrostatic vane type. This meter indicates a ground on either circuit and the extent of the ground. The ammeters are of 5-ampere capacity, and are connected to the secondary of type "W-2" current transformers of 1/1 ratio.

As protection against an overload on the power transformer due to a short circuit in the 2300-volt bus connections, inverse time limit relays are provided, the coils of which are connected to type "W-2" current transformers, of 3/1 ratio. One of these relays is provided for each circuit, the coils of which are connected to the same current transformers, as the ammeters. In case of an overload on the equipment, the relay in the circuit affected closes the trip coil circuit and trips out the switch on the affected line. If for any reason this relay fails to operate, the inverse time limit relay will trip the switches on the 2300-volt circuit, providing the overload is heavy enough.

In order to reduce to a minimum the delays to train operation incident to an automatically opened switch, auxiliary switches are attached to each automatic switch which control a bell alarm and pilot light circuit. When the switch is tripped, the bell circuit is closed. This rings a bell and lights a pilot light, the latter being mounted on the panel and above the switch opened. The bell is large enough to be heard from any part of the station and the pilot light enables the operator to tell at a glance the circuit which has been interrupted.

Each sub-station, which is in or near signal territory, is provided with complete equipment as outlined above. Fig. 1 is a wiring diagram showing complete sub-station equipment for signal power circuits.

Oil break sectionalizing switches are provided at practically every passing siding or approximately five miles apart. The circuit is normally fed from one sub-station through to the next adjacent one and the system is so designed that it can be fed from either end without any adjustment of equipment. The sub-stations are supposed to be in synchronism, which will permit keeping the signals working with one break in the power circuit, provided a serious ground does not exist at the same time.

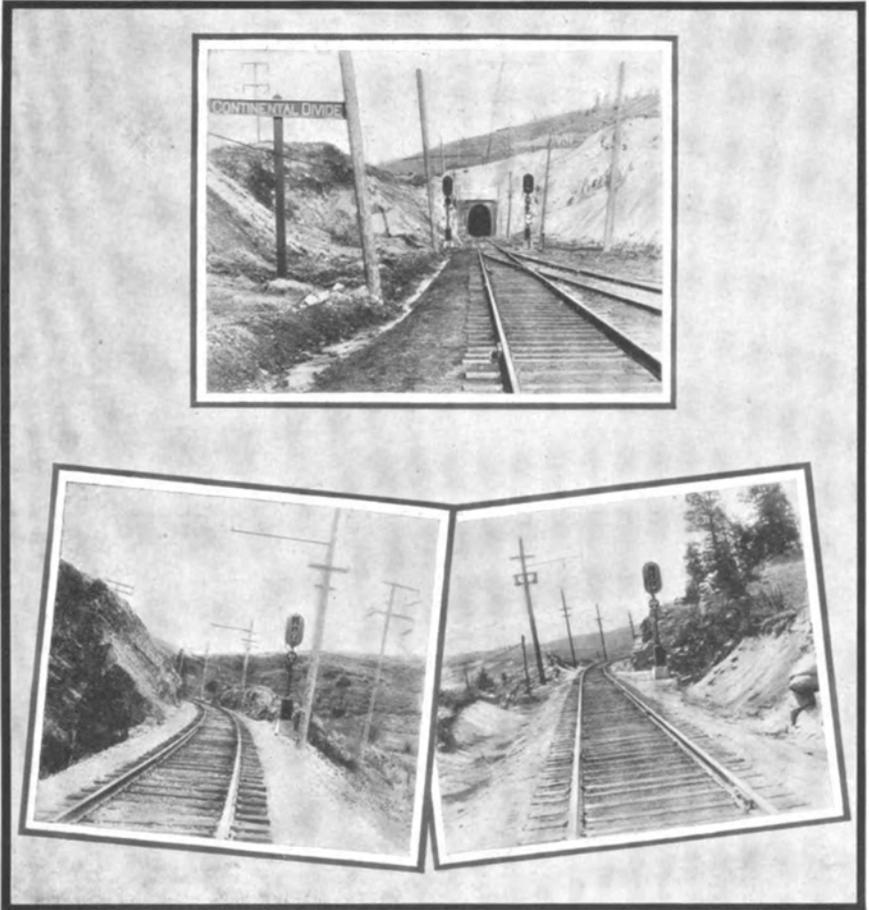
Line transformers are G. E. Co.'s type "H," 4400-volt primary, 110-volt secondary, 60-cycle, single-phase with four primary leads. Two capacities have been provided to satisfy the various load conditions, *i.e.*, 1-k.v.a. and .6-k.v.a.

Track transformers are of type shown by Fig. 38-B, U. S. & S. Co.'s drawing C-8921, sheet 6, specification 754, with 110-volt primary, one

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**CHICAGO, MILWAUKEE & ST. PAUL RAILWAY.**

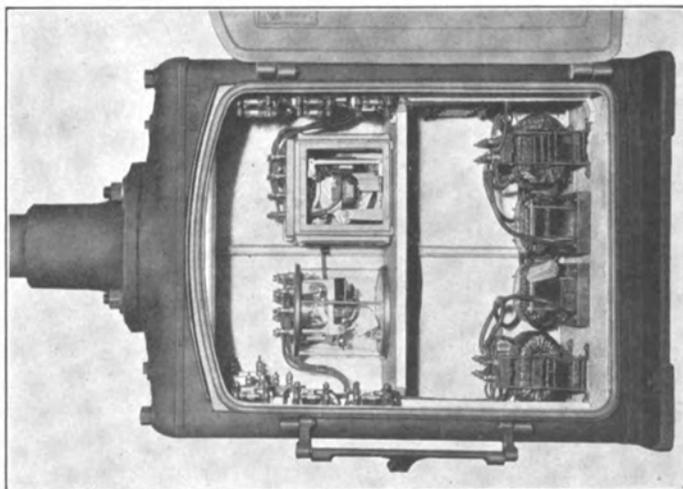


**Cuts showing signal locations in curves and entrance to tunnel at  
Continental Divide.**

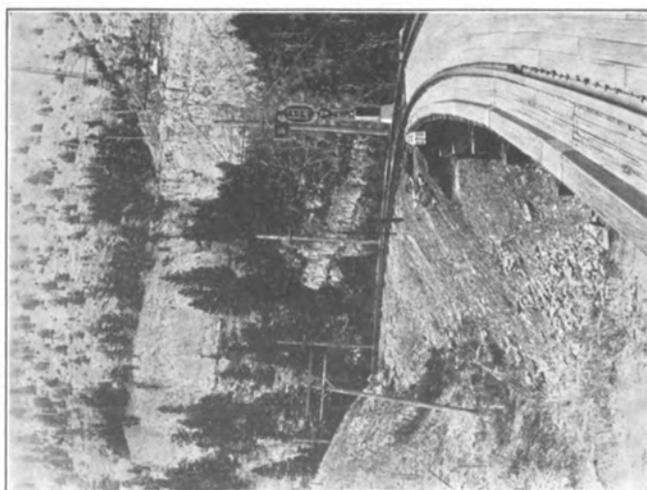
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CHICAGO, MILWAUKEE & ST. PAUL RAILWAY.



Mechanism Case.



Signal near Fanalula, Mont.



18-volt secondary, with taps giving a range of 73 to 120 volts on primary side.

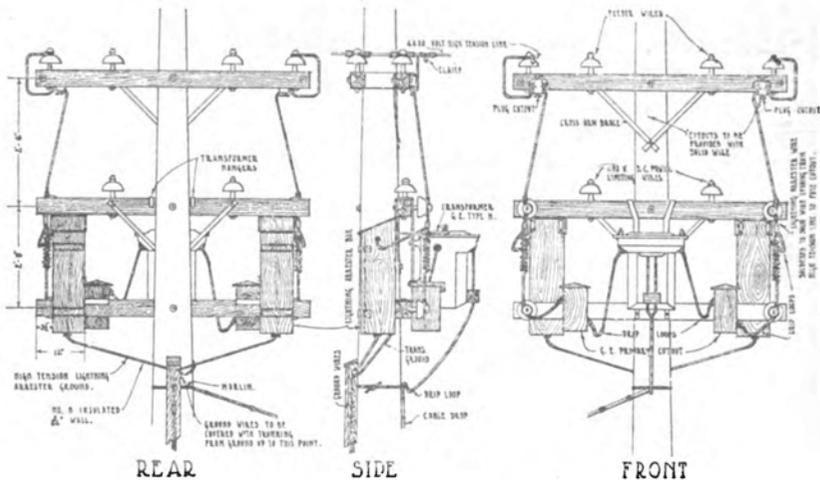
Track circuits are double rail and not exceeding 7,500 feet are end fed. In excess of this distance they are center fed.

U. S. & S. Co.'s relays are used as follows: For track, model 15, two element exclusively. For line, vane type, both simple and slow releasing, model 15, two element three-position; and model 15, single element two-position. The latter being used for stick relays.

Double mechanism cases are provided at all signal locations for housing relays, reactances, low tension transformers, low tension lightning arresters, terminals, etc. Ample capacity, and free accessibility to make tests and adjustments are thus afforded. Large relay box cable posts provide housing at points where no signals exist.

Switch indicators of "Z" armature type, two-position, upper quadrant, 110-volt are used and provided at all crossovers, and at industry spurs where it is possible for a train to clear the main line. In addition indicators are provided at all passing track head block switches and only repeat the clear position of inbound head block signals. They are intended to prevent a train on the siding making a move when a side swipe collision would likely occur.

Impedance bonds of 500 ampere capacity are used in territory where maximum grade does not exceed 1.6 per cent. In territories where grades exceed this percentage bonds of 1500 ampere capacity



DETAIL OF POLE LINE CONSTRUCTION  
A. C. SINGLE PHASE  
ELECTRIFICATION TERRITORY

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A.C. Signaling.  
C.M.&St.P.Ry.  
Ringling,  
Fenlen, Mont.

are employed. The former are of type shown on U. S. & S. Co.'s drawing C-7991, sheets 25 and 27. The latter on plate H-218, same company's catalogue. Track reactance coils are of type shown on U. S. & S. Co.'s drawing C-8013.

High tension lightning arresters are G. E. type, form "F-2," graded shunt, resistance multigap, catalogue No. 149760, drawing DS-38803. Low tension arresters are G. E. vacuum tube type "T" single pole, catalogue No. 148057, DS-38801. Separate ground connections are provided for the two types of arresters.

