I.C.C. Proposes to Order Train Control on Forty-nine Roads

THE Interstate Commerce Commission on January 10, 1922, at a general session held at its office in Washington, D. C., ordered that 49 carriers should show cause, if any, on or before the fifteenth day of March, 1922, why the order of the Commission requiring them to make installations of automatic train control should not be entered. The Commission has had under consideration the matter of the specifications and requirements to be prescribed by it for the installation of automatic train-stop or train-control devices pursuant to Section 26 of the Interstate Commerce Act. After investigation as provided in that section the Commission has determined upon certain specifications and requirements and the carriers by railroad subject to the Act which should now be required to install automatic train-stop or train-control devices which comply with these specifications and requirements that are set forth in the report presented below:

In the Matter of Automatic Train Control Devices

Decided January 10, 1922

Certain carriers ordered to install automatic train control devices over designated portions of their roads in accordance with prescribed specifications and requirements.

REPORT OF THE COMMISSION

By the Commission:

This is a proceeding initiated by us under Section 26 of the Interstate Commerce Act under which we are authorized after investigation to order any carrier by railway subject to the act to install automatic train-stop or train-control devices or other safety devices.

Under Public Resolution No. 46, approved June 30, 1906, the Congress directed us to investigate and report on the use of and necessity for block signals for automatic control of railway trains in the United States. The Sundry Civil Appropriation Act, approved May 26, 1908, contained a provision directed to the same end and appropriated some fifty thousand dollars for the purpose. Under the above resolution the Block Signal and Train Control Board was created and was employed by the Commission from 1907 to 1912 to study the subject and to investigate numerous automatic train-stop and train-control devices presented by various designers and patentees. Report of these investigations have been made to us with recommendation as to specifications and requirements. Since 1912 the Commission's Bureau of Safety has continued these investigations. Under the United States Railroad Administration investigations were made by a special Automatic Train-Control Committee and further specifications and requirements were recommended. The records and files of this committee have been transferred to this Commission.

The conclusions arrived at as a result of these several investigations conducted from 1906 to 1920 were identical in substance, namely, that automatic control of trains is practicable; that the use of automatic train control devices is desirable as a means of increasing safety and that the development of automatic train control devices had reached a stage warranting the installation and use of such devices on a more extended scale. The results of these investigations and the conclusions thereon were published from time to time and attracted widespread attention commensurate with the importance of the subject. The successive investigations with their satisfactory results, and the recognized obvious need for some such device resulted in the inclusion in the Transportation Act of 1920 of a section which places upon us the duty after investigation of ordering the installation by the carriers, in locations designated by us, of automatic train-stop or automatic train-control devices which comply with prescribed specifications and requirements. That section, now Section 26 of the Interstate Commerce Act, provides:

"That the Commission may, after investigation, order any carrier by railroad subject to this Act, within a time specified in the order, to install automatic train-stop or train-control devices or other safety devices, which comply with specifications and requirements prescribed by the Commission, upon the whole or any part of its railroad, such order to be issued and published at least two years before the date specified for its fulfillment."

Since that section was passed we have been urged to require the installation of various automatic train control devices. We were not disposed, however, to issue an order requiring the installation by any carrier of any such device without further investigation and a review of past investigation and performances together with a thorough check under our own supervision of the actual performances of these devices as installed and in operation.

To that end and in order to carry out the provisions of Section 26 in the most effective and expeditious manner, we invited the co-operation of the American Railway Association. A Joint Committee on Automatic Train Control, consisting of representatives of the Signal section and the Operating, Engineering and Mechanical divisions of that association was appointed in November, 1920.

In presenting the matter to the joint committee we said:

Numerous tests of automatic train control devices have been made, but there has been little effort to co-ordinate this work and to forestall unnecessary duplication of tests of substantially similar devices. As a result there are a number of devices listed in published reports, the functions of which can readily be accomplished under service conditions, but the adaptability of which to meet the varied operating conditions and requirements has not been thoroughly established.

In the administration of Section 26 of the Interstate Commerce Act the preliminary work may be regarded as already accomplished. Exhaustive studies and comprehensive reports have been made and experimental tests have been conducted, the records of which are available. The next steps to be taken are the selection of one or more suitable locations on railroads equipped with automatic block signals where automatic train control installations may be made sufficient in extent to determine beyond question the practical utility of systems of this character: specificaions and requirements to which the device to be installed in a designated location must conform are then to be prepared; the device is to be selected, and installed in accordance with these specifications and requirements; it is to be placed in service and kept under close observation for whatever length of time may be necessary.

Record has been kept by our Bureau of Safety of service operation on portions of the lines of the Chesapeake & Ohio, the Chicago, Rock Island & Pacific, and the Chicago & Eastern Illinois railroad companies, equipped with different automatic train-stop and train-control devices, each of which shows a high degree of efficiency. Data have been gathered upon the effect of the devices upon railroad operating conditions, upon problems of installation and maintenance on an extended scale, upon installation, operating and maintenance costs and upon the revisions made or required in the several devices.

The matter of cost is the basis upon which the carriers have raised objection to an order requiring the installation of automatic stop or train-control devices. Like objection has been made to the installation of all other safety devices which are now in use and which have long since demonstrated their practicability and necessity. This objection has been raised in prosperous as well as in non-prosperous years. Yet the compensation from a financial standpoint, which will result from the securing added safety in train operations should not be overlooked. In the hearings before the Committee on Interstate and Foreign Commerce when Section 26 was under consideration certain statistics gleaned from our accident reports were presented showing that from 1909 to 1917, both inclusive, there were 13,339 head-on and rear-end collisions resulting in damage to railroad property alone of over nineteen million dollars. These collisions resulted in death to 2,454 persons and injury to 37,724. In other words, the annual average of these collisions amounted to 1,482, the average number of killed to 272, and of injured to 4,191. During the two and one-half years from January 1, 1918, to June 30, 1920, inclusive, there were 3,226 such collisions, resulting in the deaths of 635 persons and injury to 6,240. The damage to railroad property amounted to over seven million dollars. If to the large property loss there be added the death losses and the damages paid for persons injured the total rises to enormous figures. If these vast sums which represent total losses to the carriers had been expended in the installation of block signal systems or automatic train-stop or train-control devices many thousands of miles of road could have been equipped.

In the report of the chief of the Bureau of Safety for the fiscal year ended June 30, 1921, it is shown that during the fiscal year, 97 train accidents were investigated, consisting of 62 collisions and 35 derailments. The collisions resulted in the death of 194 persons and the injury of 849 persons. The derailments resulted in the death of 77 persons and the injury of 518 persons, a total of 271 killed and 1,367 injured. Twenty-six of the collisions occurred on lines operated by the block signal, and of these 17 occurred where automatic signals were used. Of the 17, 8 were rear-end collisions, 4 were head-end collisions, and 3 were side collisions. Of the 17 collisions occurring in block signal territory there were 13 cases in which enginemen, pilots or motormen failed properly to observe or obey signal indications. These undoubtedly would have been prevented had an adequate automatic train control system been in use.

Since the above report was made several accidents resulting in large loss of life and property have occurred. A rear-end collision between two passenger trains on the Pennsylvania near Manhattan Transfer, N. J., in which 46 persons were injured could doubtless have been prevented had the automatic train-control system in use from the Pennsylvania terminal, New York City, to the Hackensack river been extended to the Manhattan Transfer, a distance of some two miles. In December, 1921, a wreck occurred on the Philadelphia & Reading a few miles out of Philadelphia, resulting in the death of 23 persons and injury to many others. Had there been an adequate automatic train-control device on that road this wreck would not have occurred.

Our investigations have shown that automatic train control has long since passed the experimental stage. In fact, no safety devices such as the automatic coupler, the air brake and the automatic block signal were perfected to as high a degree as the automatic train control before they were either ordered installed or were voluntarily adopted.

The fourteen years of investigation and study, the service tests under varying conditions and the results obtained in the actual employment of these devices over periods of years upon some of the roads have clearly demonstrated the practicability of and the necessity for automatic train stop or train control. The time has now arrived when the carriers should be required to select and install such devices or device as will meet our specifications and requirements. Under the act our order cannot be made effective before the expiration of two years from the date thereof. The fixing of a time limit must be based upon a consideration of the time which has already run since the passage of the act, and the progress and present state of automatic train control. There must be considered also the time reasonably required to enable the carriers to select suitable devices from among those available, to develop them to meet their operating conditions and requirements in the designated locations and to provide for the manufacture and installation of the apparatus.

The railroads hereinafter designated which are required to install upon the designated portions of their roads, automatic train control devices in accordance with our specifications and requirements, have been selected with regard to the measure of the risk of accident in connection with traffic conditions thereon.

We have decided not to limit by our order the installation of these devices to roads or parts of roads already equipped with automatic block signals, because we have no desire to discourage efforts for automatically controlling trains without the aid of the fixed wayside signals. The statement, therefore, as to the primary function of automatic train-stop or train-control devices recognizes the possibility of establishing such a device without the use of automatic block signals in conjunction therewith.

The following carriers by railroad subject to the Interstate Commerce Act are required to install on or before the first day of July, 1924, an automatic train-stop or train-control device or devices which comply with the specifications and requirements set forth, such device to be applied to or operated in connection with all road engines running on or over at least one full passenger locomotive division included in the part of each of such carriers' main line between points designated in the order:

An appropriate order will be entered.

Order

At a General Session of the Interstate Commerce Commission, held at its office in Washington, D. C., on the .... day of ...., A. D. 1922.

No. 13413.

In the Matter of Automatic Train Control Devices.

It appearing, That by Section 26 of the Interstate Commerce Act, it is provided, among other things, "That the Commission may, after investigation, order any carrier by railroad subject to this Act, within a time specified in the order, to install automatic train-stop or train-control devices or other safety devices, which comply with specifications and requirements prescribed by the Commission, upon the whole or any part of its railroad, such order to be issued and published at least two years before the date specified for its fulfillment;" and

It further appearing, That the Commission has conducted the investigation, as provided in said section of said Act;

It is ordered, That specifications and requirements as provided therein be and the same are hereby prescribed as follows:

Specifications and Requirements for Automatic Train-Stop or Train-Control Devices

The purpose of this general specification is to define automatic train-stop or train-control devices and to outline essential features involved in their design, construction and installation on railroads.

Definition of Automatic Train-Stop or Train-Control Devices

A system or installation so arranged that its operation will automatically result in either one or the other or both of the following conditions:

First—Automatic Train Stop.—The application of the brakes until the train has been brought to a stop.

Second—Automatic Speed Control.—The application of the brakes when the speed of the train exceeds a prescribed rate and continued until the speed has been reduced to a predetermined and prescribed rate.

Functions

In prevailing practice the primary function of automatic train-stop or train-control devices is to enforce obedience to the indications of fixed signals; but the feasible operation of essentially similar devices used without working wayside signals may be regarded as a possibility. The following features may be included, separately or in combination, in automatic train-stop or train-control systems:

1. Automatic Train-Stop.

Without manual control by the engineman, requiring the train to be stopped, after which the apparatus may be restored to normal condition manually and the train permitted to proceed.

2. Automatic Train Control or Speed Control.

(a) Automatic stop, after which a train may proceed under low-speed restriction until the apparatus is automatically restored to normal or clear condition by reason of the removal of the condition which caused the stop operation.

(b) Low-speed restriction, automatic brake application under control of the engineman who may, if alert, forestall application at a stop indication point or when entering a danger zone and proceed under the prescribed speed limit, until the apparatus is automatically restored to normal or clear condition by reason of the removal of the condition which caused the low-speed restriction.

(c) Medium-speed restriction, requiring the speed of a train to be below a prescribed rate when passing a caution signal or when approaching a stop signal or a danger zone in order to forestall an automatic brake application.

(d) Maximum-speed restriction, providing for an automatic brake application if the prescribed maximum speed limit is exceeded at any point.

General Requirements

1. An automatic train-stop device shall be effective when the signal admitting the train to the block indicates stop, and so far as possible when that signal fails to indicate existing danger conditions.

2. An automatic train-control or speed-control device shall be effective when the train is not being properly controlled by the engineman.

3. An automatic train-stop, train-control or speed-control device shall be operative at braking distance from the stop signal location if signals are not overlapped, or at the stop signal location if an adequate overlap is provided.

Design and Construction

1. The automatic train-stop or train-control device shall meet the conditions set forth under general requirements applicable to each installation.

2. The apparatus shall be so constructed as to operate in connection with a system of fixed block or interlocking signals, if conditions so require, and so inter-connected with the fixed signal system as to perform its intended function:

(a) In event of failure of the engineman to obey the signal indications; and

(b) So far as possible, when the signal fails to indicate a condition requiring an application of the brakes.

3. The apparatus shall be so constructed that it will, so far as possible, perform its intended function if an essential part fails or is removed, or a break, cross or ground occurs in electric circuits, or in case of a failure of energy.

4. The apparatus shall be so constructed as to make indications of the fixed signal depend, so far as possible, upon the operation of the track element of the train-control device.

5. The apparatus shall be so constructed that proper operative relation between the parts along the roadway and the parts on the train will be assured under all conditions of speed, weather, wear, oscillation and shock.

6. The apparatus shall be so constructed as to prevent the release of the brakes after automatic application until the train has been brought to a stop, or its speed has been reduced to a predetermined rate, or the obstruction or other condition that caused the brake application has been removed.

7. The train apparatus shall be so constructed that, when operated, it will make an application of the brakes sufficient to stop the train or control its speed.

8. The apparatus shall be so constructed as not to interfere with the application of the brakes by the engineman's brake valve or to impair the efficiency of the air brake system.

9. The apparatus shall be so constructed that it may be applied so as to be operative when the engine is running forward or backward.

10. The apparatus shall be so constructed that when two or more engines are coupled together, or a pushing or helping engine is used, it can be made operative only on the engine from which the brakes are controlled.

11. The apparatus shall be so constructed that it will operate under all weather conditions which permit train movements.

12. The apparatus shall be so constructed as to conform to established clearances for equipment and structures.

13. The apparatus shall be so constructed and installed that it will not constitute a source of danger to trainmen, other employees or passengers.

14. The apparatus shall be so constructed, installed and maintained as to be safe and suitable for service. The quality of materials and workmanship shall conform to this requirement.

It is further ordered, That the following carriers by railroad subject to the Interstate Commerce Act be, and each of them is hereby, required to install on or before the first day of July, A. D. 1924, an automatic train-stop or train-control device or devices, applicable to or operated in connection with all road engines running on or over at least one full passenger locomotive division included in the part of each of such company's main line between points hereinafter designated.

Atchison, Topeka & Santa Fe, between Chicago, Ill., and Newton, Kan.

Atlantic Coast Line, between Richmond, Va., and Charleston, S. C.

Baltimore & Ohio, between Baltimore, Md., and Pittsburgh, Pa.

Boston & Albany, between Boston, Mass., and Albany, N. Y.

Boston & Maine, between Boston, Mass., and Portland, Me.

Buffalo, Rochester & Pittsburgh, between Rochester, N. Y., and Butler, Pa.

Central Railroad of New Jersey, between Jersey City, N. J., and Scranton, Pa.

Chesapeake & Ohio, between Richmond, Va., and Clifton Forge, Va.

Chicago & Alton, between Chicago, Ill., and Springfield, Ill.

Chicago & Eastern Illinois, between Chicago, Ill., and Danville, Ill.

Chicago & Erie, between Chicago, Ill., and Salamanca, N. Y.

Chicago & Northwestern, between Chicago, Ill., and Omaha, Neb.

Chicago, Burlington & Quincy, between Chicago, Ill., and Omaha, Neb.

Chicago, Indianapolis & Louisville, between Chicago, Ill., and Louisville, Ky.

Chicago, Milwaukee & St. Paul, between Chicago, Ill., and St. Paul, Minn.

Chicago, Rock Island & Pacific, between Chicago, Ill., and Rock Island, Ill.

Chicago, St. Paul, Minneapolis & Omaha, between Minneapolis, Minn., and Omaha, Neb.

Cincinnati, New Orleans & Texas Pacific, between Cincinnati, O., and Knoxville, Tenn.

Cleveland, Cincinnati, Chicago & St. Louis, between Cleveland, O., and St. Louis, Mo.

Delaware & Hudson, between Wilkes-Barre, Pa., and Albany.

Delaware, Lackawanna & Western, between Hoboken, N. J., and Buffalo, N. Y.

Erie Railroad, between Jersey City, N. J., and Buffalo, N. Y.

Galveston, Harrisburg & San Antonio, between El Paso, Tex., and Houston, Tex.

Great Northern, between St. Paul, Minn., and Minot, N. D.

Illinois Central, between Chicago, Ill., and Memphis, Tenn.

Kansas City Southern, between Kansas City, Mo., and Texarkana, Tex.

Lehigh Valley, between Jersey City, N. J., and Buffalo, N. Y.

Long Island, between Jamaica, N. Y., and Montauk, N. Y.

Louisville & Nashville, between Louisville, Ky., and Birmingham, Ala.

Michigan Central, between Chicago, Ill., and Detroit, Mich.

Missouri Pacific, between St. Louis, Mo., and Kansas City, Mo.

New York Central, between Albany, N. Y., and Cleveland, O.

New York, Chicago & St. Louis, between Chicago, Ill., and Cleveland, O.

New York, New Haven & Hartford, between New York, N. Y., and Providence, R. I.
Norfolk & Western, between Roanoke, Va., and Columbus, O.
Northern Pacific, between St. Paul, Minn., and Mandan, N. D.
Oregon-Washington Railroad & Navigation Company, between Portland, Ore., and Pendleton, Ore.
Pennsylvania, between Philadelphia, Pa., and Pittsburgh, Pa.
Pere Marquette, between Grand Rapids, Mich., and Detroit,
Philadelphia & Reading, between Philadelphia, Pa., and Harrisburg, Pa.
Pittsburgh & Lake Erie, between Pittsburgh, Pa., and Youngstown, O.
Pittsburgh, Cincinnati, Chicago & St. Louis, between Pittsburgh, Pa., and Indianapolis, Ind.
Richmond, Fredericksburg & Potomac, between Wahington, D. C., and Richmond, Va.
St. Louis-San Francisco, between St. Louis, Mo., and Springfield, Mo.
Southern Pacific, between Oakland and Sacramento, Cal.
Southern Railway, between Washington, D. C., and Atlanta,
Union Pacific, between Omaha, Neb., and Cheyenne, Wyo.
West Jersey & Seashore, between Philadelphia, Pa., and Atlantic City, N. J.
Western Maryland, between Baltimore and Cumberland, Md.

Principles of Alternating Current Signaling

Chapter X—The Track Circuit. The Various Units and Characteristics That Cause Variations in Operation

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We are now in a position to take up the study of the alternating current track circuit. The object of these calculations is to determine the voltage and current required at the secondary of the track transformer, and also the phase relations in the track circuit. In order to make such calculations we must know the power required by the relay itself (volts, amperes and power factor); the impedance of each part of the circuit, and also the leakage resistance.

We will begin with a simple case, a single element relay on a short track circuit, on steam roads. The following data is typical for such a case:

Power available—60 cycles.
Normal power for relay—3.0 volts, 2.5 amp., 0.5 p. f.
Relay leads—300 ft. No. 9 copper (resistance 0.24 ohm.).
Transformer leads—same as relay leads.
Length of track circuit—1,200 ft.
Rails—90 lb. copper bonds. Impedance 0.28 ohm. at 0.55 p. f. per 1,000 ft. track.
Leakage resistance—6 ohms. per 1,000 ft.
Reactance used between transformer and track.

The track circuit is outlined in Fig. 87. The total impedance of the rails for the 1,200 ft. section is $1.2 \times 0.28 = 0.34$ ohm. This quantity is usually denoted by Z. We also will require the total leakage resistance for the 1,200-ft. section. Since the resistance varies inversely as the area, the resistance will be $6 \times \frac{1{,}000}{1{,}200} = 5$ ohms.

In the track circuit formulas it is customary to use conductance instead of resistance. The conductance is the reciprocal of the resistance and it represents the current taken at one volt. Obviously the current at any other voltage is found by multiplying the conductance by the voltage. In this case the leakage conductance is $\frac{1}{5} = 0.2$.

The Center Leak Method

We will first work the problem by an approximate method called the center leak method, which requires nothing beyond the problems we have solved already. For the track circuit, we are considering that this method gives all the accuracy required. This method assumes that the track circuit of Fig. 87 is equivalent to the circuit shown in Fig. 88. The leakage resistance is assumed to be concentrated at the middle and each of the four impedances shown, is equal to one-fourth of the total rail impedance Z. In Fig. 88 all the impedances and resistances are known except the impedance between the transformer and the track and this may usually be varied over a considerable range and a value for it may be deter-

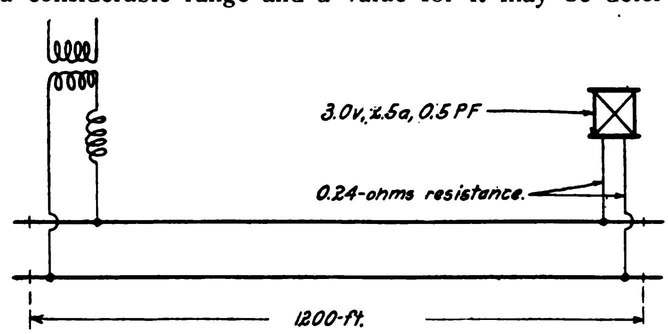

Fig. 87.

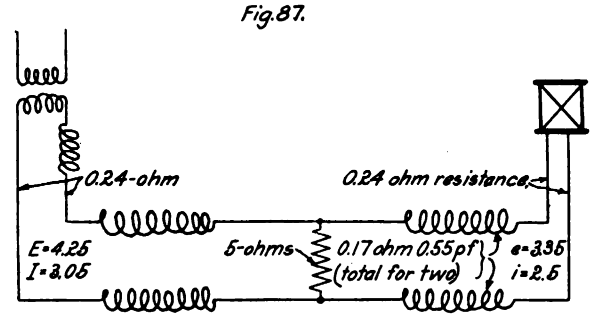

Fig. 88.

Track Circuit Diagrams of the Center Leak Method

mined when we find the volts and amperes required on the rails at the transformer end of the track circuit.

The first part of the problem is an exact duplicate of the one illustrated in Fig. 47, the resistance drop in relay leads will be 2.5×0.24, or 0.60 volt. In Fig. 89, OB represents to scale the relay voltage (3.0) and OH represents the relay current (2.5). The angle BOH is the angle whose cosine is the power factor of the relay. (It is not necessary to use the same scale for the currents and for voltages.) The lead drop is represented by BC, drawn parallel to OH. Then the voltage on the rails op-