

term for a de-modulator. Here the voice frequency is separated out from the intermediate frequency. The voice frequency is then further amplified and delivered to the loud speaker or telephone receiver. The band of frequencies used in this system is about 6,000 cycles wide, that is 3,000 cycles on either side of the nominal carrier frequency. This makes available a voice band from approximately 200 to 2,750 cycles which is capable of giving a satisfactory reproduction of voice.

Part Played by Rails and Line Wires

In this system when adjusted to operate at 88 kc., transmission by rails only between vehicles is limited to about 2,000 ft., and for greater distances the use of line wires is essential. On the territories where these tests were conducted, the number of wires on the telegraph and telephone pole lines varies from about 50 on the 28 miles between Milwaukee and Sturtevant, to 2 on the 35 miles between Clinton, Ia., and Davenport. In general the system will operate with even one line wire but the efficiency increases in proportion to the square root of the number of line wires; for example, 100 wires would be 10 times better than 1 wire. For normal operation, the pole line should be about 100 ft. from the track, but the system is designed to operate satisfactorily where the pole line is up to 200 ft. from the track. On sections of railroad where the standard location of the pole line is nearer the track, the power required for the operation of the train communication system can be cut in half for every 15 ft. less than 100 ft. distance. On the other hand, if the pole line is uniformly 15 ft. more than 100 ft. from the track, then the power required would be twice as much as if the distance were 100 ft. Expressed in other terms, it is roughly estimated that 1 decibel is lost for every 10 ft. increase between the track and pole line.

When the train was being made up in the Muskegon yard in Milwaukee, the diesel-electric locomotive was being serviced in the roundhouse about 1.5 miles away. No pole lines extend in the general direction between this yard and the roundhouse but there are several overhead viaducts which carry street car lines in this general direction. As a result, satisfactory communication was maintained between the caboose in the yard and the locomotive while in the roundhouse as well as en route to the yard. On the other hand, when passing through certain cities, such as Savanna, Ill., Clinton, Ia.,

and Davenport where there are no pole lines within the vicinity of the tracks, the train communication system did not function.

Power Supply for Communication

The electronic equipment of this train communication system operates on a supply of 400 volts d-c. which is produced by a small dynamotor rated at 500 m.a. output at 400 volts. On the caboose, the dynamotor is fed from a set of 16 cells of 450-a.h. storage battery. For these tests, as explained previously, an express car is being used ahead of the caboose, and, this set of battery is included in the regular car-lighting

system on this car. When in condition to receive messages, the discharge from the battery to the dynamotor is about 6 amp. at 32 volts, and, when sending, the discharge is about 12 amp. On the locomotive the train communication equipment is fed from the 32-volt sources of d-c. used also for lighting.

The electronic equipment for either the caboose or locomotive is all contained in a sheet metal case 16 in. high, 16 in. deep and 48 in. long. As shown in one of the illustrations, the equipment is in three separate units, a sending set, a receiving set and a power unit, each of which is plug connected and can be removed or replaced independently.

I.C.C. Calls for Switch Locks

A RECOMMENDATION that the Chicago & North Western install electric switch locking at all main-track hand-operated switches in automatic train control territory has resulted from the Interstate Commerce Commission's investigation of a side collision at a crossover at Missouri Valley, Iowa, on that road's double-track Chicago-Omaha main line, in which 9 passengers were killed and 95 injured. According to the report prepared under the supervision of Chairman Patterson, the accident was caused by "failure to provide adequate protection for a crossover movement."

Train Control, No Wayside Signals

This collision occurred about 7:32 p.m. on September 28, and involved a 28-car fast freight, No. 256, the "Calumet," eastbound from Council Bluffs to Chicago, and a 9-car passenger train, No. 203, the "North American," operating from Minneapolis to Omaha, which was beginning a westbound movement (by timetable direction) at Missouri Valley, where it entered the main line from a wye connection with the single-track line to that point from Sioux City. Operations on the main line were by timetable, train orders and continuous-inductive type automatic train control in conjunction with visual and audible cab signals, and there were no wayside signals except at interlockings, although the switch-stands at the crossover were equipped with oil lamps displaying green for main-line

movements and red for movements through the crossover.

The current of traffic was to the left, this being the road's standard practice.

The main tracks were divided into blocks as if wayside signals were in use, circuits being arranged so that when a block was occupied or a main-track switch was open a restricted zone was set up extending at least far enough to provide stopping distance in approach of the entrance to that block. When an engine entered such a restricted zone the cab signals, normally green, would display a red-over-yellow indication, requiring a speed reduction to less than 23 m.p.h. At the same time the speed control mechanism would begin to function, an audible speed indicator and an acknowledging indicator would sound, and an automatic brake application would occur unless the engineer forestalled it by moving an acknowledging lever and by reducing speed to 23 m.p.h. within a set distance in accordance with a tapered speed control limit, with the automatic application still becoming effective if and when such limit was not attained by manual brake application.

When a train was moving under the 23 m.p.h. speed restriction, recurrent acknowledgment was required, upon sounding of the acknowledging indicator at intervals of about 3,600 ft., to prevent further automatic brake application, and such automatic application became effective if speed at any time exceeded 23 m.p.h. so long as

the restricted zone was operative. Removal of the restriction produced an immediate visual and audible indication in the locomotive, whereupon maximum authorized speed could be resumed.

Apparatus Functioned

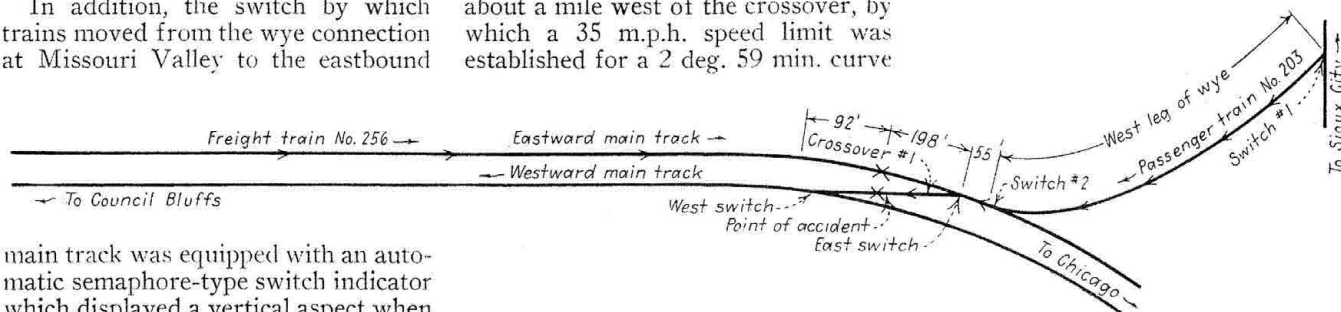
In addition, the switch by which trains moved from the wye connection at Missouri Valley to the eastbound

cator semaphore arm was in horizontal position, but the brakeman was positive it was in vertical position just before he moved the switch.

The eastbound freight was moving about 50 m.p.h. on level tangent track as it approached Missouri Valley, the authorized speed being 60 m.p.h. up to a speed restriction sign located about a mile west of the crossover, by which a 35 m.p.h. speed limit was established for a 2 deg. 59 min. curve

and the speed of the passenger train was about 10 m.p.h.

The third to eighth cars, inclusive, of the passenger and the engine and first four cars of the freight were derailed and damaged, the fifth, sixth and seventh cars of No. 203, which were coaches, being badly damaged.



main track was equipped with an automatic semaphore-type switch indicator which displayed a vertical aspect when the block connected with the control circuit was not occupied, this changing to horizontal when a train entered the block. The control circuit extended 9,998 ft. west of this switch, and the block within which train control restriction was set up by lining this switch for movement to the main track from the connecting track likewise extended 9,998 ft. westward from the switch. Tests made after the accident indicated that all the apparatus involved in these arrangements was functioning properly.

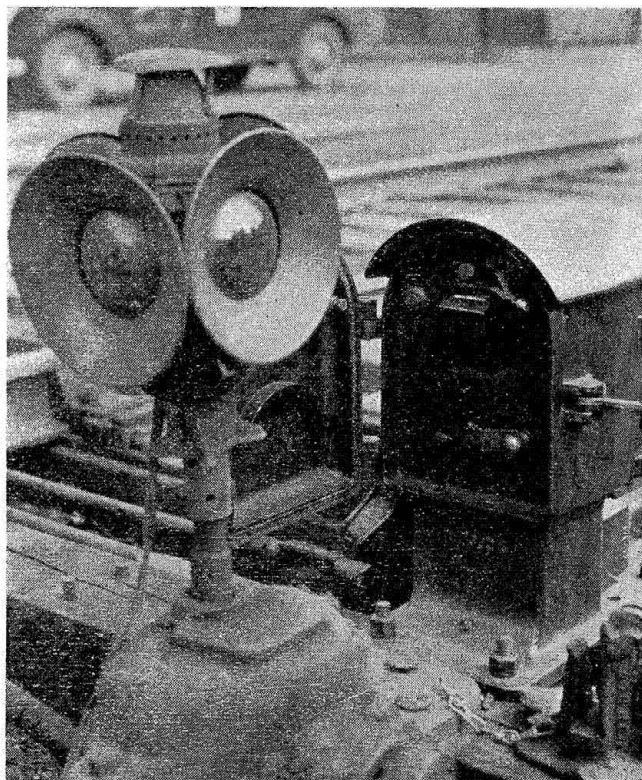
About 4 min. before the collision occurred, the passenger train had stopped on the wye connection, clear of the main track. The front brakeman reported the arrival of the train at that point to the dispatcher by telephone, then set the switches involved so his train could proceed from the wye track to the eastbound main track, then by the adjacent crossover to the westbound main track. He asserted that the switch indicator at the point where the eastbound track was entered displayed a vertical aspect (clear block) when he lined this switch for the movement into the eastbound track. The conductor and other members of the crew of No. 203 were in various cars in the train. Before this train entered the eastbound track its brakeman and fireman observed a train approaching on that track at a distance estimated at $1\frac{1}{2}$ miles, but did not realize it was closely approaching until their engine entered the crossover, at which time it was about 1,200 ft. distant. The engineer of No. 203 endeavored to clear the eastbound track by increasing the speed of his train through the crossover, but its fourth car was struck by the eastbound freight at the fouling point.

No flag protection was provided for the movement, which was within yard limits. Under the rules, flag protection was required for a movement from the wye track if the switch indi-

to the right which began about 636 ft. west of the point of the accident. The cab signals indicated a clear block until the engine reached a point about 2,800 ft. west of the switch leading from the wye to the eastbound track, at which point they first indicated a restricted speed zone, resulting from movement of the switch, although the block affected by the switch involved extended almost 7,200 ft. further west. The engineer immediately reduced speed to forestall the automatic apparatus. His view ahead was obscured by smoke until he saw the passenger train about 1,500 ft. ahead, when he applied the brakes.

The freight was moving about 15 m.p.h. when the collision occurred,

Commenting on the circumstances, the I. C. C. report said: "In view of the high speeds at which trains are authorized to proceed through Missouri Valley and the fact that the only protection provided for the crossover movement of No. 203 was the aspects displayed by switch indicators, additional protection for these movements is required. If the switch connecting the west leg of the wye and the eastward main track had been equipped with electric switch-locking, it would not have been possible to operate the switch to permit a movement to the eastward main track when a train was closely approaching, as in this case, and the accident would not have occurred."



An electric switch lock on a hand-thrown switch on the N.C.&St.L. Ry.