Milwaukee Tests Train Communication

Engineman using the train telephone

Inductive system gives good results in head-end to rear service on freight trains and between wayside stations and trains

On December 6, the Chicago, Milwaukee. St. Paul & Pacific inaugurated an extensive series of tests to determine the benefits of train communication on different divisions of the railroad as well as on different types of trains and locomotives. In the initial series of tests, the equipment was installed on a diesel-electric locomotive which is regularly assigned in through freight service between Milwaukee, Wis., and Kansas City, Mo., 527 miles. The apparatus for the rear of the train was installed in an express car temporarily assigned to this service and made up in the train just ahead of the caboose. One test wayside station was equipped at Beloit, Wis., which is 84 miles from Milwaukee on the route to Kansas City. After tests on this territory have been completed, the apparatus is to be removed from the diesel-electric locomotive and installed on a steam locomotive for further tests on lines between Chicago and Minneapolis. Then later, the equipment will be tested on electric locomotives in the electrified territory between Harlowton, Mont., and Avery, Idaho, 440 miles, as well as between Othello, Wash., and Seattle, 216 miles.

The equipment in the caboose used by the conductor is the same as that in the locomotive cab used by the engineman. Normally the hand set, including the transmitter and receiver, is hung on a hanger at the left side of the case as shown in the accompanying illustrations. On the face of this case is a dial for adjusting the volume of the loud-speaker which is mounted on the wall to the rear of the cab.

Conductor in caboose using the train communication apparatus to talk to engineman

How It Is Used

Normally the equipment in the locomotive and in the caboose is in service to receive incoming calls which are reproduced by the loud speaker. For example, if the conductor wishes to talk to the locomotive, he removes the hand set from the hook, holds it to his head and, when speaking, he presses a button on the handle of the hand set. The conductor would say—"caboose number 11 calling engine 44, over." The word "over" indicates the end of the call or statement so the engineman will know when to come in with his answer. The engineman when hearing the call, takes his hand set and answers—"engine 44 answering caboose 11. What do you want? Over." When the conversation is finished, both handsets are returned to the hangers.

To the left of the dial there is a small lamp which is lighted to indicate that the equipment is energized ready to receive messages. A lamp to the right of the dial is lighted when a message is being sent and a lamp marked "speech control" above the dial flashes intermittently when the person talking is using the correct volume of voice. This is an aid to a man learning to use the communication system.

During the first trial trip between Milwaukee and Kansas City on December 6, there were several occasions when the train communication was useful. When cars were set out at Sturtevant, Wis., 23 miles from Milwaukee, the conductor and engineman used the telephone to an advantage in recoupling the train and reporting when the train line was pumped up as well as when the conductor gave a verbal highball for the train to depart.

A few miles east of Lucerne, Mo., the train parted at 10 cars ahead of the caboose. Both portions of the train came to a smooth stop with a spacing of about 15 car lengths. The train communication was used to an advantage in keeping all persons informed of the progress made in setting out the damaged car, recoupling, pumping up the train line, and getting under way again. As the tests are being continued, a record is maintained of the numerous instances in which the use of the train communication system is an aid in train operations. When within 25 miles on either side of Beloit, communication was available between the wayside office at that station and either the locomotive or the caboose. On tests made a few days later, the normal range was established as about 50 miles.

After analyzing the records, J. P. Kiley, assistant general manager, made a statement to the effect that train communication will justify itself in reducing the duration of delays due to unusual circumstances such as hot boxes or when trains break in two, and in fact on every occasion when trains make unusual stops. Thus from the few tests made already, it would seem that the operating officers are convinced of the benefits of train communication to train operations. The tests are to be continued for several months, not only to assemble more information on the use of the system, but also to determine the adjustments required to adapt the inductive system of train communication to all the various local conditions on different parts of the Milwaukee as well as on the steam, electric and diesel-electric types of locomotives.

Details of Inductive Communications

The equipment used in these tests is the Union Switch & Signal Company's inductive system of train communication, in which the transmission between the head end and rear of the train as well as between the train and the wayside station is accomplished by means of 88 kc. frequency modulated carrier impressed inductively on the rails and the wires on the pole line, so that the energy is not broadcast over an extended area as in conventional radio, but rather is confined to the railroad right-of-way and immediate vicinity thereof.

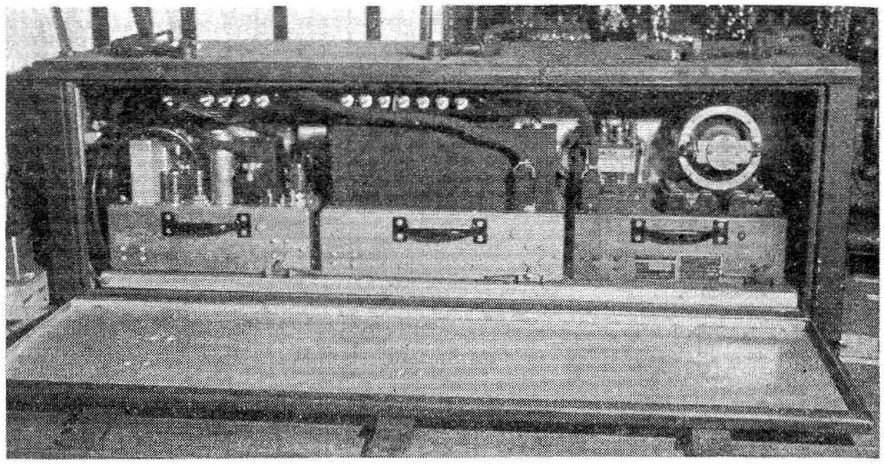
Low Power Limit

This installation of inductive train communication is adjusted to operate within the low power limits of the Federal Communications Commission and, therefore, is not in the same class as radio broadcasting, and, for this reason, no assignment of frequencies is necessary. When transmitting from the caboose for example, the message could be picked up by an efficient radio receiving set tuned to 88 kc. located any distance up to about 2,000 ft. from the track, providing the atmospheric conditions are good for radio reception. No commercial F-M radio receiving sets are tunable in this range.

Transmitting from a caboose for example is accomplished by a single wire loop, one end of which is connected to a bearing on a truck at one end of the car, then the wire extends through the electronic sending apparatus, then up to the roof for the full length of the car and down to connect with a bearing on the truck at the other end of the car, so that the sections of rail which are at various times between the two trucks are included in the one-turn loop. The wire in this loop is No. 4 copper. The installation does not require that either truck be insulated from the car. The rail joints need not be bonded, and, as a matter of fact, no bonds are in service on more than half of the 527 miles of the Milwaukee route between Milwaukee and Kansas City.

The voice currents delivered from the microphone circuit modulate the carrier frequency delivered by an oscillator. The modulation is a frequency modulation and is accomplished by means of a reactance tube which varies the frequency of the oscillator over a predetermined range at a rate which depends on the frequencies of the voice currents. The output of the modulator is amplified in the driver and again in the power amplifier consisting of four 6L6 tubes. The modulated carrier current goes to the output transformer which supplies the energy to the transmitting loop.

The supply to the electronic transmitting equipment requires about 0.5 amp. at 400 volts d-c. The transmitting loop, when sending, carries about 10 amp. and about 60 watts.



The sending and receiving sets are plug connected in the equipment case

Receiving Apparatus

The receiving coil, which consists of 100 turns of wire about 10 in. in diameter, is mounted on the roof of the caboose, this being preferable to a location under the car over a rail because, when so mounted, noise was introduced when passing over insulated rail joints.

The energy picked up by receiving coils is amplified in its received form in two stages of a carrier current amplifier. It is then heterodyned with the output of an oscillator to produce an intermediate frequency which is chosen higher than the carrier frequency. The intermediate frequency which carries the initial modulation is then amplified through three stages, the last of which serves as a limiter. After this amplification it goes through a discriminator which is the frequency modulation 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