AUTOMATION

Remote Control Train:

French National Railroads have successfully tested remote control of a road train and a switching locomotive. A description of these tests was presented by D. M. Scher, Director of Research, and J. C. Blumstein, Technical Director, French National Railroads (SNCF), before last month's meeting of the Railway Systems and Procedures Association. Here is an abstract of their paper.

● By remote control of a train, we understand that: (1) The engineer should be released from any decision and from any control regarding the acceleration and deceleration of the train; and (2) the required orders should be prepared in a centrally located office and transmitted through an adequate medium to the locomotive.

The basic requirements for operating a train by remote control are: (1) Transmission of information and orders from a centrally located point to a train in motion; (2) control of the speed of the locomotive at a predetermined rate.

The solution to the first requirement was found by transmitting information to a remotely controlled train running for 10 miles on a mainline.

During this test, a dc electric locomotive of the BB 9000 type, hauling a five-car train, was started, accelerated, slowed down and stopped. Orders were given from a rail car running on tracks parallel to those of the experimental train and transmitted via a wayside radio station. The results of this test were very promising, transmission was effective.

The second requirement was met by experimenting with a shunting locomotive, operating in a yard. The speed was entirely controlled by the switch tower over the whole range from 0 to 25 mph. We limited this step to a shunting locomotive in order to avoid the difficulties arising from the deceleration of long trains with pneumatic brakes.

Furthermore, we can expect—and this fact has been proved—that when the locomotive is controlled by the switch tower, the efficiency of the operation can be increased.

We would also like to mention that research work is being carried out to develop an electro-pneumatic brake equipment which will probably bring a solution to the problem of deceleration of long trains.

When the French National Railroads decided to test a shunting locomotive, they had six objectives in mind:

(1) The shunting locomotive had to be controlled by radio, usually from the general yard tower. In our initial program, we anticipated control at three different speeds, namely, 25 mph, 9 mph and the cutting speed of 2.4 mph, with slight variations possible around this value. Later on, we thought better to achieve continuous control over the entire range of speed, that is to say, betwen 0 and maximum value 25 mph.

(2) The forward and reverse positions should be remotely controlled.

(3) A device to obtain an adequate approaching speed should be provided so that the locomotive may escape tower control as soon as it approaches a freight car, this at a distance such as to enable the locomotive to slow down automatically to an impact speed of 1.3 mph and then come back under tower control, once coupled.

(4) If required, remote control should be possible from other locations, for instance the receiving yard. The limit between the control areas of every tower should be defined by a "barrier" beyond which the control is automatically passed on to the next tower. If no signal is sent at that time, the locomotive stops.

(5) It should be possible, when required, to control the locomotive from any part of the yard by portable transmitters.

(6) The locomotive should be immediately available for normal manual control, should remote control fail, or should the engine be used out of the yard limits.

Up to the present, four of these requirements have been perfected, namely, control of speed, control of forward and reverse operations, control of approaching speed, and instantaneous change-over from automatic to manual operation.

The locomotive chosen for the experiment was a six-axle diesel-electric switcher weighing 110 tons and delivering 660 hp at nominal rating.

As on all diesel-electric locomotives, the regulation of the power plant is such that, for a given speed of the diesel engine, the power delivered to the main generator has a definite value, independent of the speed of the locomotive.

The power transmitted to the wheels is under the control of the diesel-engine governor, actuated by a servo motor, itself being controlled by an air reduction valve. Varying the air pressure in this valve from 0 to 57 psi, by means of the throttle, enables the engineer to control the speed of the diesel engine and, thus, the tractive effort of the locomotive.

Remote Control Equipment

The three major components of the remote control equipment, namely: (1) the electro-pneumatic servo mechanism controlling the diesel engine and the brake application; (2) the control of the speed S of the locomotive at a predetermined rate, related to a voltage e_o applied to the electrical circuit of the servo mechanism; and (3) the radio transmission of the reference voltage e_o from a control tower to the locomotive.

An accurate and continuous speed control of the locomotive requires only that a reference voltage e_o, proportional to the required speed S_o, be applied to the electrical circuit of the servomechanism.

How is this reference voltage e_o transmitted by radio from the control tower to the locomotive? In the tower we have a transmitter with a carrier of 160 mc, together with a modulating device which allows the modulation of the carrier at 1,000 cps. This modulation is interrupted with a frequency of 15 cps, so that, during a period P, modulation is maintained for a time T_1 (see drawing).

The ratio $r = \frac{T_1}{P}$ gives the ratio of the remote controlled speed S_o to the maximum speed S_M of the locomotive, i.e.:

$$S_o = rS_M$$

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Successful Tests in France

The advantage offered by such a principle is to define the required speed by means of a number—"r" being the ratio of two lengths—rather than by a physical magnitude likely to depend on the quality of radio transmission.

Radio transmission not being interrupted, other "modulation bands" may be used for transmitting additional information such as that needed for the forward and reverse control system.

On the locomotive, the receiver (to which is connected a synchronized thyratron oscillator) is tuned so that when there is no modulation (during the intervals $P-T_1$), no current is set up; and when there is modulation (intervals T_1), the circuit oscillates with a constant amplitude, in synchronism with the pilot modulation. This device eliminates, therefore, any possible fluctuation of transmission.

If we take a period long enough as regards to P, the average value "m" of the ac amplitude during this interval will be:

$$m = \frac{T_1}{P} \text{ or } m = rA, \text{ A being constant.}$$

Therefore, to obtain a continuous current, hence a continuous voltage e_m, proportional to r, a demodulator-integrator device is connected after the synchronized thyratron oscillator.

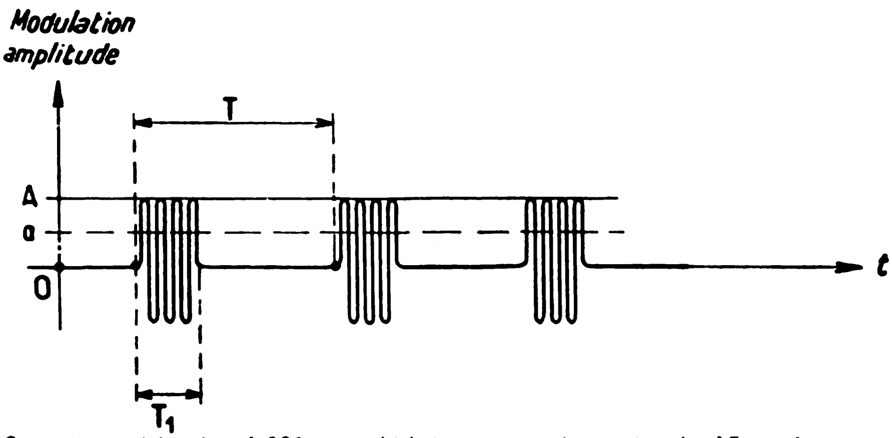
The remote control of the directional equipment—forward and reverse motion—is achieved by using the same carrier as for speed control. Three low frequency modulations are used: 110 cps for forward motion; 125 cps for neutral position, and 140 cps for reverse.

A remarkable feature of this equipment is that reversing of the direction can be ordered while the locomotive is in motion, without taking any special precaution. "Memory relays" coupled with appropriate safety devices, give the possibility of performing the operation automatically in the correct sequence.

Although the first solution which comes to mind is the use of radar, we have not done so because radar is too expensive and, furthermore, it might present some difficulties in view of the very short distances involved. Actually, detection must be made over a distance of about 100 ft in order to enable the locomotive running at 9 mph to slow down to 1.3 mph.

In a first test, we therefore used the ultrasonic technique. The locomotive emits periodically brief ultrasonic signals which, after being reflected by the obstacle, are received by a microphone installed on the locomotive. The time elapsed between emission and reception gives the distance between locomotive and obstacle. The performance was mostly satisfactory, but irregularities due to parasitic echoes and wind effects, led us to seek another method.

This second method uses a track circuit of a very special type based on the flow of high frequency currents in the rail. An oscillation generator, on the locomotive, induces current in the rail. The length of track between locomotive and freight car forms an oscillating circuit, the proper frequency of which is related to its length and is, therefore, a function of the distance between locomotive and freight car. When this distance corresponds to the oscillator setting, the oscillator is brought into resonance with the track circuit and this effect actuates a relay.



Carrier is modulated at 1,000 cps, which is interrupted part time by 15 cps frequency.

This initiates two simultaneous actions: (1) the locomotive is momentarily cut off from the tower control; and (2) the speed control is set automatically to an approaching speed of approximately 1.3 mph. As soon as coupling is completed, a device brings the locomotive back under radio control.

Once the theory was laid down, we had to test it in the field. To that end, the French National Railroads' research department designed and built the prototype equipment: transmitter, receiver and control mechanism for remote control operation of the locomotive.

An experiment was then run on a mainline where steep up-and-down grades are encountered. The locomotive was hauling a dynamometer car equipped with radio transmitter, speed control apparatus and various recording instruments. A speed of 13 mph was kept over the whole run with variations not exceeding ± 1.2 mph.

The locomotive performed extremely well, in fact, over the difficult route chosen remote control performance was even better than manual control with an experienced engineer. So we decided to put the locomotive in shunting service in our Achères yard, 20 miles west of Paris, which handles an average of 2,000 cars a day.

At first we feared that the unfavorable conditions existing there might create difficulities for radio transmission—a forest lies in the immediate vicinity of the yard, thus creating a zone of absorption likely to produce interference, and a concrete bridge crosses the incoming tracks where the locomotive must operate when a long train is being cut.

However, the locomotive executed all orders to our entire satisfaction. After two years of service, it is still in operation and we have added, since, four additional remote control units for shunting purposes.

Today, the French National Railroads are working on another remote control experiment which consists of controlling the operating mechanism of a booster locomotive, placed anywhere in a train consist, from the head locomotive. In other words, we seek to operate multiple units without any connecting wires between units.

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