

AUTOMATIC TRAIN CONTROL

A COMPARISON OF CONTINUOUS AND INTERMITTENT SYSTEMS

PREPARED FOR

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INTRODUCTION

Automatic block signaling provides for the safe operation of trains based upon the capabilities of the engine driver. Unpredictable human failures, however, may negate such protection. It is for this reason that automatic train control systems have been installed on heavy traffic, high-speed lines to ensure an extra margin of safety. Such systems assist the driver in the proper performance of his duties.

Efficiency of operation, a byproduct of safety, is achieved with automatic train control. Train control - and particularly continuous train control with cab signals - makes possible better on-time operation, as trains can maintain their schedules during all types of weather, even at zero visibility.

The term "automatic train control" has both a general and a specific meaning. In the general sense, it is used loosely to describe all mechanical and electrical systems which establish connection between wayside signal circuits and certain controlling elements on the train, particularly the train braking system. Specifically, it is applied to a system which establishes direct control of the movement or speed of a train when conditions of track occupancy ahead, or other conditions, require that the speed of the train be reduced, or that the train be stopped.

An automatic train stop system is primarily for stopping trains, while an automatic train control system effects the control of train speed. Both systems directly enforce proper train operation in accordance with track and block conditions. They supplement wayside signals by assuming direct control of the train if the engine driver should fail to operate in accordance with displayed signal aspects.

Modern electronic techniques and the rapid advances in solid state engineering have led to the development of compact, low-energy automatic train control equipment. Utmost reliability of operation is thus retained, while gaining space saving advantages so important in today's motive power units. Also, lower power consumption eliminates the need for special energy supplies aboard the train. It thus becomes economically feasible to install automatic train control of the

continuous type which provides a constant check of train speed, and initiates corrective action should the engine driver fail to do so. Modern electronic train control equipment is illustrated in Figure 1. A comparison with older equipment, as shown in Figure 2, reveals the compactness that has been achieved by employing modern techniques and devices.

BACKGROUND

Automatic train control was first conceived in 1859 as a means of enforcing safe operation of trains. As train density and speed increased, accidents became more frequent, and a positive solution was called for. It was not until the turn of the century, however, that serious development activity was directed toward the need for providing such protection.

By 1920, practical automatic train stop and automatic train control Systems became available and were rapidly installed on many railroads. As of today, there are 24, 505 track miles protected by automatic train stop, automatic train control, and automatic cab signals in the United States,

Accident statistics for the last 15 years, as compiled by the Interstate Commerce Commission, reveal that there are ten times as many accidents in territories equipped only with wayside signals, as there are in automatic train control territories. Granted, there are five times more track miles in non-train control territories; however, train control was chosen for the high-speed, dense traffic tracks where safety and efficiency of operation are most important, and also where the possibilities of accidents are much greater.

In 1947, the Interstate Commerce Commission issued an order re-

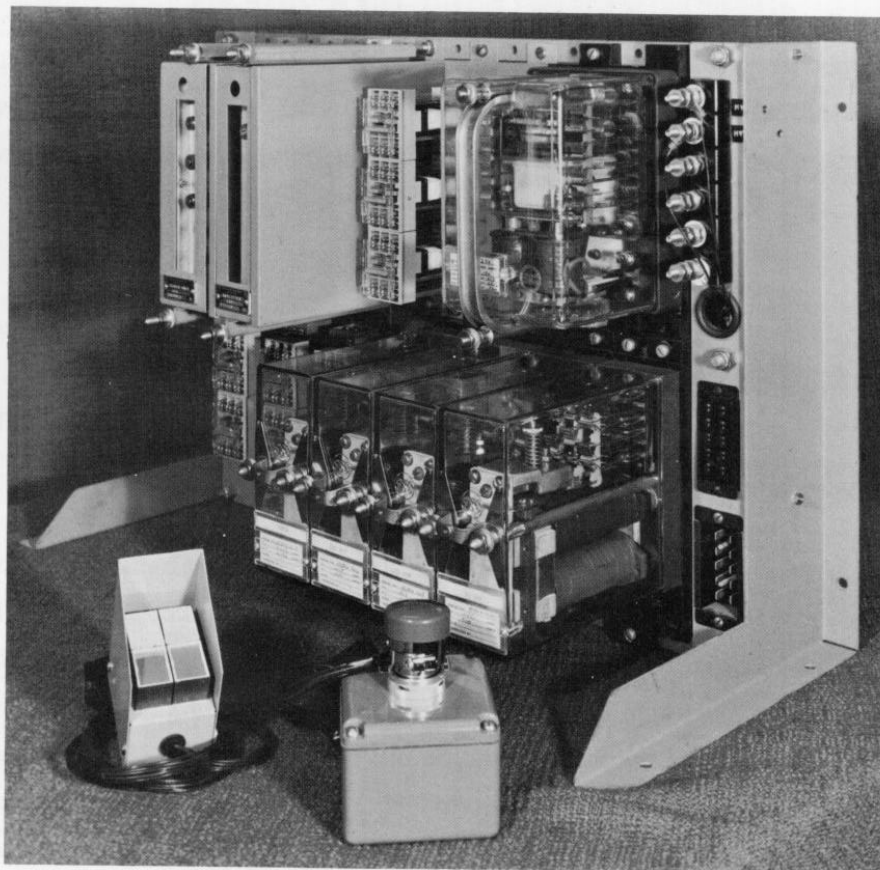


Figure 1. Modern continuous train control equipment is readily adaptable to installation in motive power units.



Figure 2. Old style equipment was large and heavy.

quiring U.S. railways to install "automatic train stop or train control systems or automatic cab signal systems on such portions of their lines over which any train is operated at a speed of 80 or more miles per hour".

SYSTEMS

Automatic train stop is an intermittent inductive system which allows a train to pass a restrictive signal without an automatic brake application -PROVIDING that the engine driver operates an acknowledging lever to acknowledge that he has observed the restrictive signal.

One of the most widely used systems consists basically of an inductor, which is placed beside the track in approach to each wayside signal, Figure 3; an equipment case, which is installed on the engine; a receiver, which is mounted on an engine truck, Figure 4; and an acknowledging lever in the engine cab, Figure 5. When a wayside signal is restrictive, the receiver, in passing over the wayside inductor, completes a magnetic circuit between the two units. Normally, the driver operates the acknowledging lever, when approaching a restrictive signal, to forestall an automatic brake application. However, should he fail to acknowledge -due to being incapacitated or for any other reason - the brakes are applied automatically.

The system thus ensures that the engine driver has observed the restrictive signal. However, the complete safety of the train is still up to the good judgement of the engine driver. He can, for example, continue to acknowledge, yet fail to apply his brakes, thus inviting disaster.

The continuous-inductive automatic train control system has a speed control feature whereby the train is forced - automatically - to assume a series of reduced speeds in accordance with the conditions ahead. The number of speed reduction steps will depend, of course, on the degree of control desired on the particular installation. As a typical example, the system would automatically require the engine driver to assume a suitably



Figure 3. A typical wayside inductor installed in intermittent train stop territory.

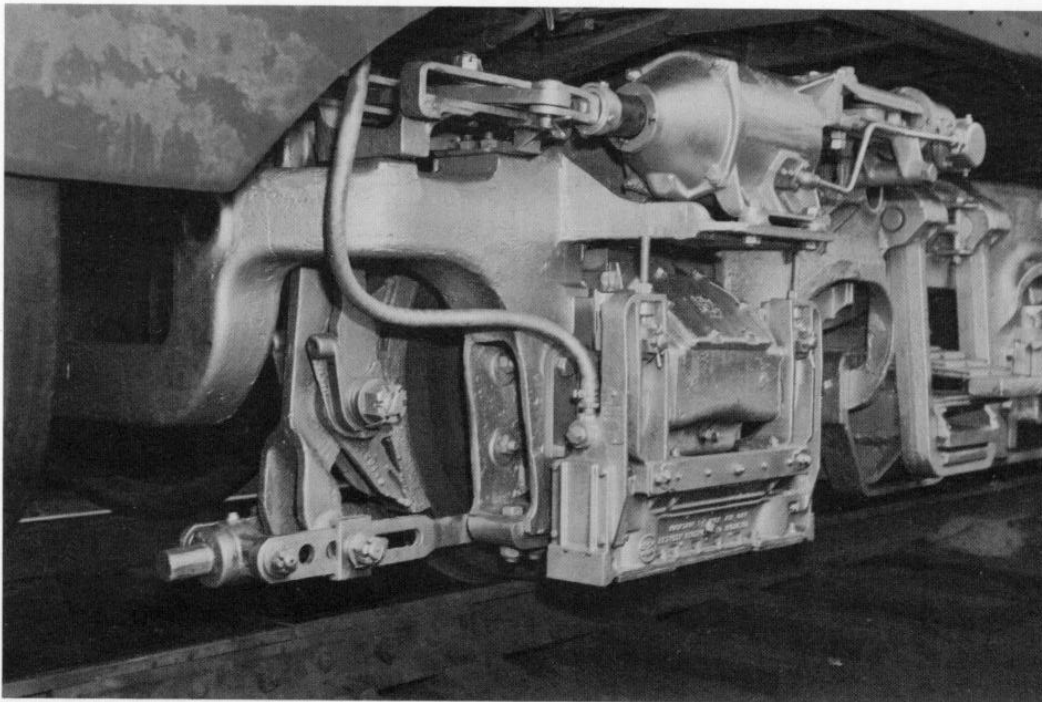


Figure 4. An intermittent system receiver mounted on the truck of a diesel-electric engine.

reduced speed upon passing any signal more restrictive than proceed but less restrictive than stop. Immediately upon passing a stop signal, the system would automatically enforce a reduction to slow speed - a speed at which the train could be stopped short of another train, misplaced switch, obstruction, etc. Continued progress at this speed would require recurrent operation of the acknowledging contactor by the engine driver.

Continuous train control systems can also be arranged, if desired, to enforce a full stop at a stop signal and then to permit the train to proceed, after a timed interval, at slow speed. This arrangement also requires recurrent operation of the acknowledging contactor to avoid an enforced stop.

The continuous system consists basically of coded energy impulses which are applied to the track circuit towards the movement of the train in advance of each signal. These coded pulses, which reflect the block conditions, are detected by receiving coils mounted on the engine and suspended over the rails, Figure 6. The brake applying apparatus on the engine reacts to the coded pulses to apply the brakes if the driver should fail to acknowledge a restrictive indication.

The speed control portion of the train-carried equipment includes an axle-driven frequency generator, Figure 7, which is mounted so that the rotating element is driven by an axle. The generator produces an a-c voltage with a frequency which is proportional to actual train speed. The output of the generator is amplified in a transistor amplifier, passed through the speed filter which is set for the frequency which corresponds to the speed being detected, further amplified, and then applied to the output relays. The speed indication unit is independently checked to protect against open wires, failure of electronic components, etc. Equipment failure results in a higher speed indication than actual speed. As a consequence, the brakes are applied immediately.

The continuous-inductive system is organized so that the engine driver



Figure 5. An engine driver operating his acknowledging lever.

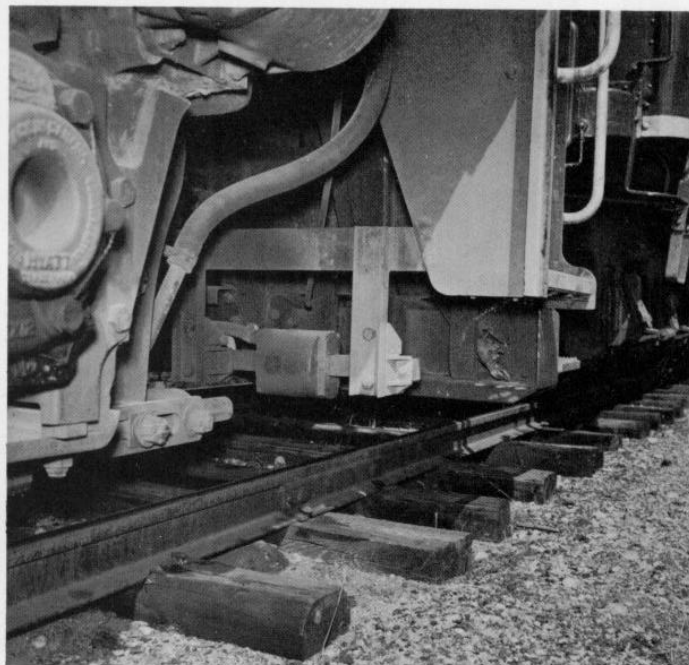


Figure 6. A typical continuous system receiver mounted underneath a diesel-electric engine.

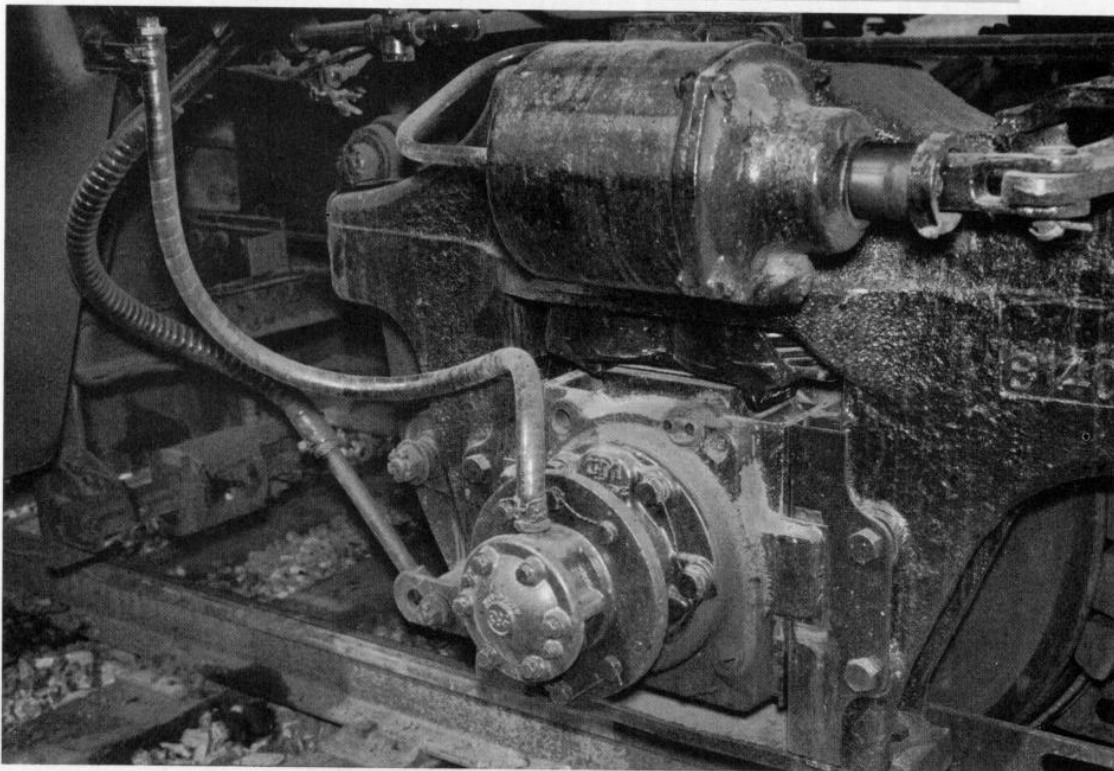
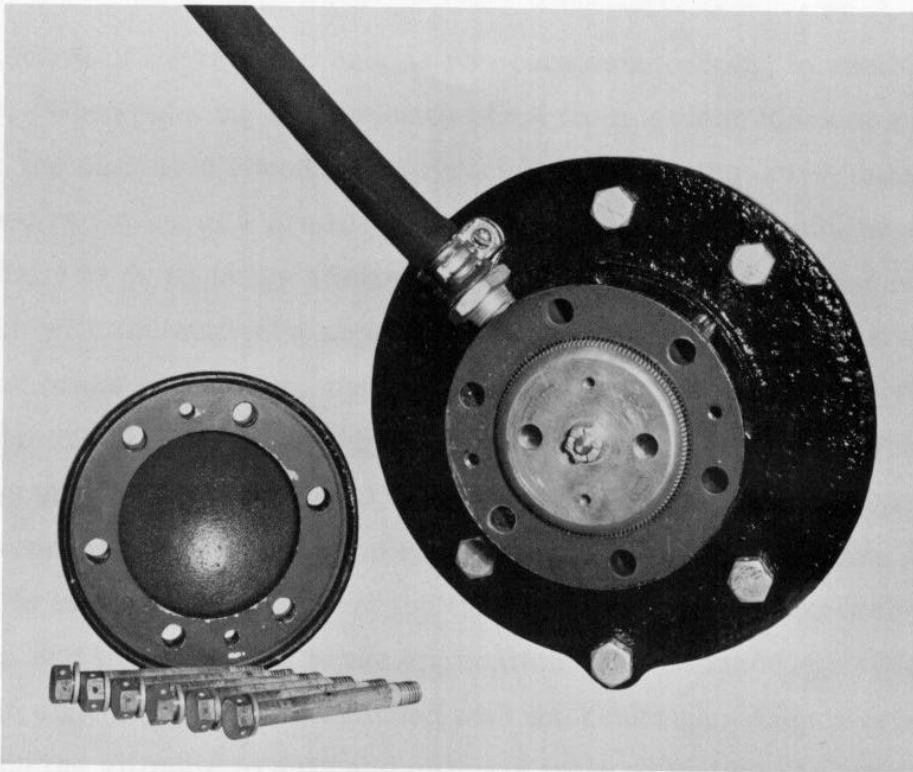


Figure 7. This axle-driven frequency generator, a part of the speed indication portion of the continuous system, mounts on the engine journal box.

has control of the train as long as he operates according to established rules. When entering a restrictive block from a clear block at a speed above the allowable speed in the restrictive block, the driver must begin a speed reduction at a predetermined rate which is built into the system. If he fails to do so in the allotted time, usually about five seconds, the system will automatically apply the brakes. In case of such a train-control brake application, the system is usually arranged to impose a penalty. Ordinarily, the train is brought to a complete stop before the brakes can be released. Also, if a speed limit is exceeded, a similar train-control brake application results. Audible indications are provided to inform the driver that the train is proceeding at excessive speed, and that a manual brake application must be made.

Cab signals, generally included with the continuous-inductive system, provide the ultimate in safe and efficient train operation, as they continuously reflect block conditions ahead of the train. Cab signals may be used to repeat the aspects of the wayside signals, or may entirely replace the wayside signals. Considerable savings can be realized by eliminating the wayside automatic signals, while, of course, retaining the interlocking and home signals. Improved operation also results, as the driver need concern himself with only one set of signals - those in the cab and directly before his eyes. Cab signals are available in a number of different styles - colored lights being the most common.

ADVANTAGES OF A CONTINUOUS SYSTEM

The time-proven track circuit continuously provides occupancy detection, broken rail protection, and a check of proper switch point position. These conditions are reflected in the wayside signals. But wayside signals can provide only intermittent indications to the engine driver, the use of intermittent-inductive train stop apparatus enforces compliance with these intermittent indications.

Continuous-inductive automatic train control with cab signals provides a system that not only checks at each signal location, but continues to check all along the railroad as to conditions in advance of the train. Cab signals, therefore, do all that wayside signals do for the safety of train movements, and furthermore, provide up -to-the - second information of conditions ahead. They show current conditions whereas wayside signals are past history when the train has gone by them. Cab signals are unaffected by fog, smoke, tunnels, mountains, or other physical obstructions to the driver¹s view. They eliminate all possibility of confusion caused by the glaring, colored brilliance of illuminated advertising display signs that may be along the right-of-way in the vicinity of the wayside signals.

All of these advantages give the engine driver greater confidence. He is able to take advantage of changes in block conditions at the moment they occur, rather than having to wait until he can observe the next wayside signal, which may be a mile or more away. This feature is illustrated in Figure 8.

In summary, the advantages of continuous automatic train control with cab signals are as follows:

1. First - and extremely important to improved train operation -audible and visual indications instantly notify the engine driver of changes in track or block conditions. Thus, he can act immediately to increase speed in the case of a less restrictive indication, or to reduce speed in the case of a more restrictive indication.
2. The engine driver has at all times, directly in front of his eyes, unmistakable visual indications of track and block conditions ahead.
3. The driver no longer has any doubt or uncertainty about the indication of the last wayside signal passed - no matter how long ago.

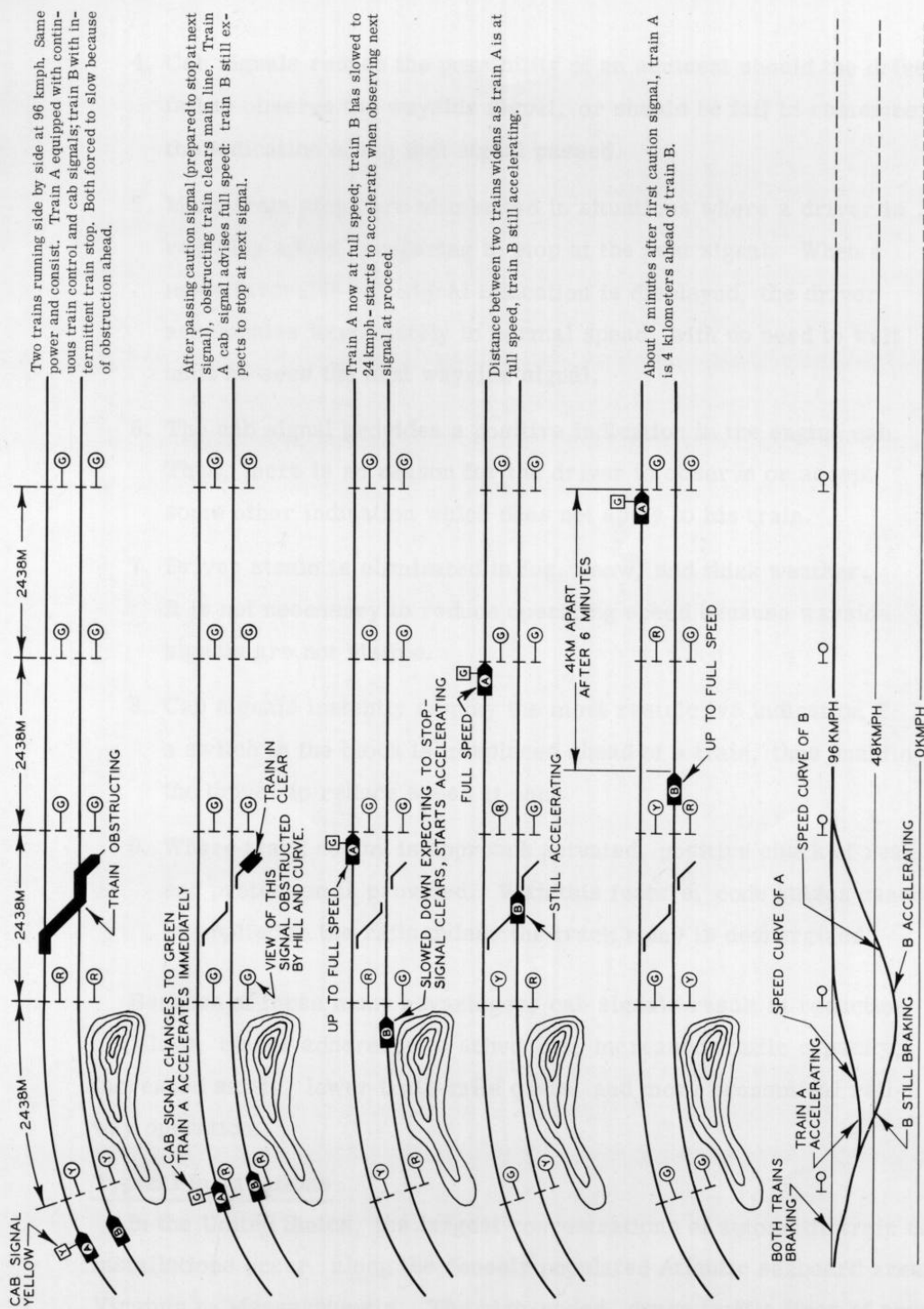


Figure 8. Continuous train control with cab signals provides immediate information about changes in block conditions ahead, including protection against broken rails, drifting switch points, unexpected track occupancy, etc.

4. Cab signals reduce the possibility of an accident should the driver fail to observe the wayside signal, or should he fail to remember the indication of the last signal passed.
5. Many train stops are eliminated in situations where a driver is reducing speed, preparing to stop at the next signal. When a more favorable cab signal indication is displayed, the driver accelerates immediately to normal speed, with no need to wait until he sees the next wayside signal.
6. The cab signal provides a positive indication in the engine cab. Thus, there is no reason for the driver to observe or accept some other indication which does not apply to his train.
7. Driver strain is eliminated in fog, snow, and thick weather. It is not necessary to reduce operating speed because wayside signals are not visible.
8. Cab signals instantly display the most restrictive indication if a switch in the block is misplaced ahead of a train, thus enabling the driver to reduce speed at once.
9. Where track coding is approach actuated, positive check of rear end protection is provided. With this feature, code pulses cannot be applied to the rails unless the track relay is deenergized.

Because of these many advantages, cab signals result in reduction of delays, closer adherence to schedules, increased traffic capacity, increased safety, lower train-mile costs, and more economical railway operation.

Typical Installations

In the United States, the largest concentrations of automatic train control installations occur along the densely populated Atlantic seaboard area from Virginia to Massachusetts. The high-speed, dense traffic lines of several railroads are required to operate under dense fog conditions for many months of the year. Also, they handle the heavy, short run passenger traffic into and out of the big coastal cities.

A commuter line in this area installed a continuous, two-speed, three-indication automatic train control system with cab signals on the

heaviest traveled lines approaching New York City. Approximately 300,000 commuters go to work each day in more than 1,100 trains. The installation provides maximum safety and expedites traffic during inclement weather, especially when dense fog reduces visibility to near zero. With cab signal to keep the driver informed of conditions ahead, and with automatic speed control, the trains run safely and on schedule.

On still another railroad, in territory without cab signals, trains lost as much as a half hour on a two-hour run when operating under weather conditions of poor visibility. Later, however, when the trains entered the cab signaled territory, they were enabled to regain much of the lost time, despite the fact that the cab signaled territory follows a river valley and includes many curves.

In midwestern United States, a large railway installed a cab signal and speed control system and removed all wayside signals, except those through interlocking plants, in a 500-mile double-track territory. As a result, many train stops were eliminated, thus saving in fuel and in wear and tear on rolling equipment. The responsibility for the protection of all train movements was placed directly upon the automatic train control system.

On the Pacific coast, a cab signal and speed control system was installed in order to maintain close headway on heavy grades and sharp curves with varying lengths and weights of trains traveling under foggy conditions. An exhaustive study proved that the required schedules were economically prohibitive under a system of automatic block with wayside signals. With cab signals and continuous train control, approximately 1000 trains were run daily on a headway of only 63 seconds.

FOR EFFICIENT SERVICE

On busy, heavy traffic railroads, signaling should be selected and installed so as to achieve not only maximum safety but also the greatest possible advantages in expediting traffic.

True, the intermittent-inductive system provides a certain measure of safety and requires less equipment than the continuous-inductive systems. However the extra man hours required for installing the continuous system are well spent. This system provides the ultimate in safety, as well as improved on-time performance. To compromise such advantages with anything less than a complete system, would result in an installation which fails to provide the highest degree of safety and facility.

Because of the nature of an intermittent system, frequent maintenance involving a large maintenance force is required. Continued checks must be made that both the receivers on the locomotives and the inductors along the track are in the proper position, in precise alignment with one another and adjusted for proper clearance. A continuous system uses the rails as the transmitting medium. Furthermore any failure of a continuous system is instantly self-detecting and, of course, failures are always on the side of safety.

FOR THE FUTURE

Continuous train control equipment, partial automation in itself, is the basis for complete automatic train operation. Direct brake control, automatic throttle control, etc., can be added to this equipment to provide for the operation of unmanned trains with safety and reliability.

Similar automation equipment is now in service on the Times Square - Grand Central Shuttle in the New York City Subways. A considerably

more sophisticated, continuously controlled automated system is in service on a mining railway in canada, where unmanned trains operate simultaneously between an ore crusher and an open pit mine, as well as perform precisely controlled movements for individual car loading and dumping.

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