CENTRALIZED TRAFFIC CONTROL

BULLETIN 169

CTC

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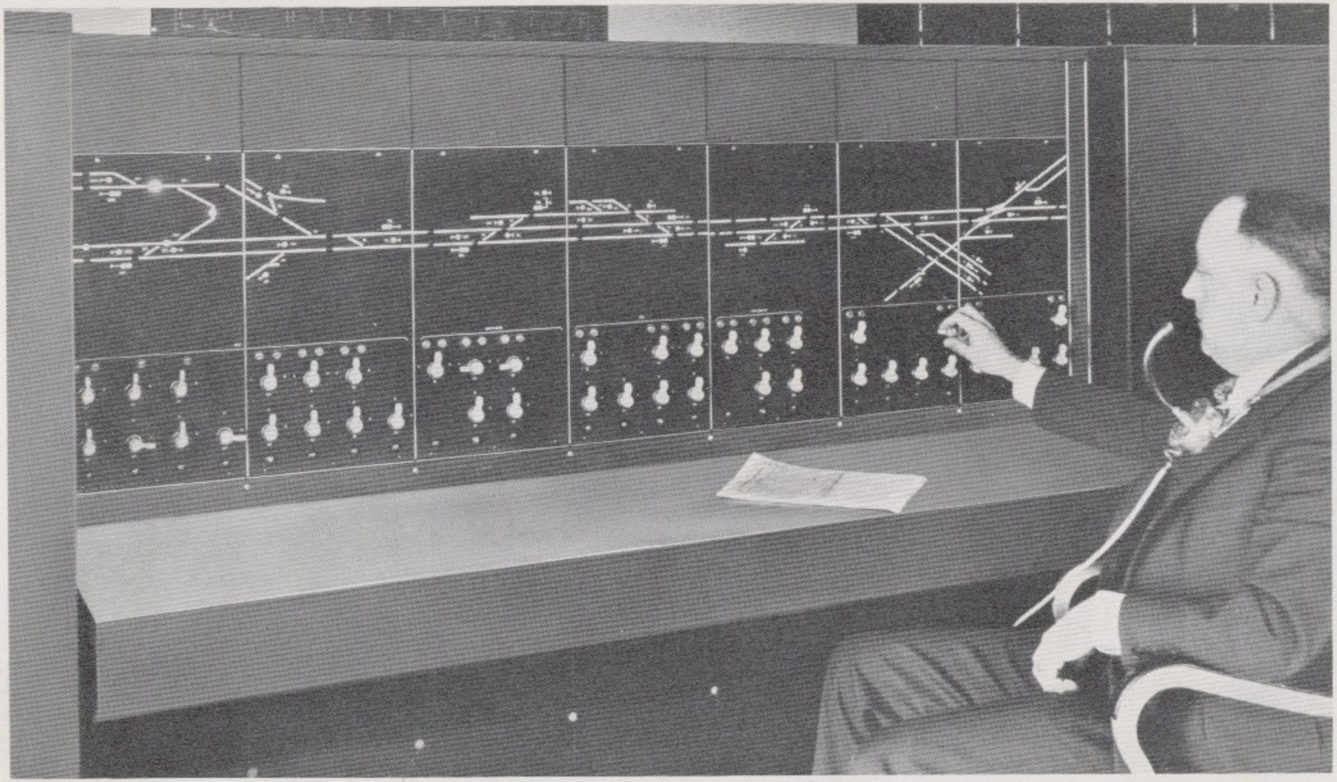

Switches, Signals, and Complete Information at the Finger-Tips of the Operator

CENTRALIZED TRAFFIC CONTROL

BULLETIN 169

March, 1938

GENERAL RAILWAY SIGNAL COMPANY
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FOREWORD

This publication has been prepared to furnish Operating Officials with general, thought provoking information about Centralized Traffic Control—the system that places in the hands of one man without intermediate help the economical and efficient means for:

> holding a train on the main, or on the siding,
> allowing it to proceed after having been held,
> keeping track of its location, and generally,
> but not necessarily, lining up its route.

It has been felt that operating officials have neither the time nor the inclination to delve into the technical aspects of how the operating accomplishments herein contained are effected, especially when these technical aspects are being improved and evolved from time to time; therefore, this phase of CTC has been omitted. Should information of this type be desired, write the nearest G-R-S District Office for a copy of one, or all, of the following publications:

Bulletin 154—Centralized Traffic Control

Bulletin 170—Centralized Traffic Control—Type F, Class M, Duplex, Coded System

Handbook 15—Centralized Traffic Control—Type F, Class M, Duplex, Coded System—Description of Circuits.

Control Machine of the Stanley to Berwick, Ohio, ctc Installation on the N.Y.C. R.R.

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CENTRALIZED TRAFFIC CONTROL

Train Operation by Signal Indication, without the use of train orders, was instituted many years ago; however, previous to July 25, 1927 every installation of any appreciable extent or requiring the operation of switches necessitated intermediate operators. In other words, the train director coordinated the activities of operators who threw certain switches, cleared certain signals, and reported the time of passage of trains.

July 25, 1927, the New York Central completed the first installation of a system that made it possible for the train director to do all of the above himself. This system, covering 40 miles and extending from Stanley to Berwick, Ohio, was called Centralized Traffic Control.

In other words, Centralized Traffic Control is the operation of trains over a division, or an extended portion thereof, without the general use of train orders or time table authority; with the use only of signal indications under direct supervisory control of one operator in sole charge of a control and indicating machine from which also he can directly control the power operation of those switches associated with and protected by the aforementioned signals.

Signal Indications Replace Time Table Rights and Written Train Orders in Conferring Superiority

GENERAL DESCRIPTION OF CTC SYSTEMS

Centralized Traffic Control (CTC) is basically a series of interlocking plants rather widely separated from each other.

Each plant may consist of a single switch with its associated signals, a crossover with its associated signals, or a complex layout of switches and crossovers with associated signals; while all the plants are controlled from the conveniently located special control machine.

The word "Interlocking" generally brings to mind the idea of control levers for the various functions so arranged that under certain circumstances certain levers are mechanically restrained from moving. In CTC, the levers are in no way restrained; however, CTC embraces the safety features of all past signaling developments. In addition, it employs special circuits in which a few wires serve the purpose of many previously required wires.

The principles of CTC are applicable to any track layout whether it is single track, multiple track, or combinations thereof.

SIGNALS SPACE, DIRECT, AND EXPEDITE MOVEMENT OF TRAINS

Safety, Speed, Economy, Track Capacity, etc., are so closely related and dependent upon one another that signaling systems actually affect each to a greater or lesser degree; however, before the advent of CTC, a signaling system was generally installed for its safety features. This was true also with Absolute Permissive Block although its feature of increasing track capacity was a contributing factor.

CTC has changed this,—for in addition to safeguarding train movements, the signals serve to direct those move-

Typical Single Switch Layout

ments. Once a train enters centralized traffic control territory, its movements are directed entirely by signal indications!

Rights, Orders, and Clearance Time have been eliminated and replaced by the indications displayed by the signals. "Proceed" indications alone authorize the train movements.

AUTOMATIC CONTROLS SUPPLEMENTED BY MANUAL SUPERVISORY CONTROL

CTC, in differing from other methods of train operation by signal indication, adds a third direct supervisory control to certain signals.

The first two controls are automatic and basic in any signaling system. They protect against track occupancy and assure the integrity of the route.

1. Track circuit control—This is the primary factor for,

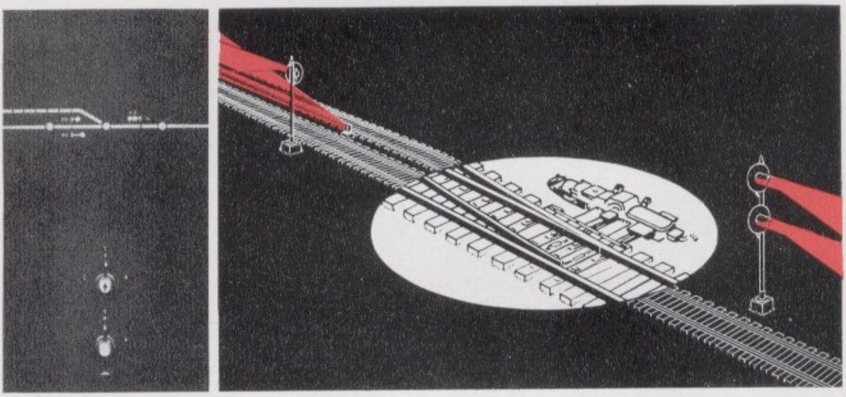
unless the track section is unoccupied and the track relay is energized, the signals governing train movements over that section can not display other than a "stop" indication for an absolute (interlocking or special) signal, or a "stop and proceed" indication for a permissive (automatic) signal.

2. Switch control—Where a power-operated switch is involved, the signals governing traffic over that track section are absolute signals and the controls are arranged so that the switch position is among those factors determining which signal may be cleared.

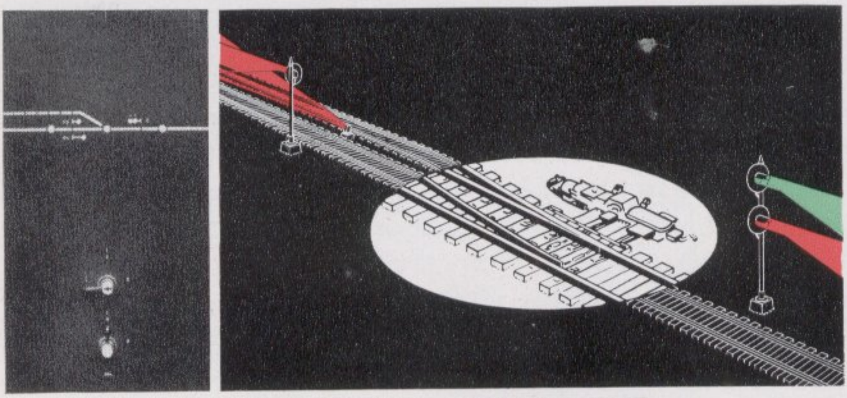
The preceding two factors in signal control are entirely automatic and, in general, result in the automatic operation of the signaling system. In CTC, certain signals are provided with a third control which represents the will of the operator in charge of the CTC control machine. As a result, when the operator so desires, he manipulates the proper control element which in turn allows a signal indication to be displayed in accordance with the conditions set up by the automatic control elements.

This means that the vital control elements are in no way superseded by the CTC system; they are merely supplemented by the special circuits so as to provide manual supervision. In other words, CTC is merely a communication system whereby the operator in effect can only say to a switch or signal, "You *may* operate if you can."

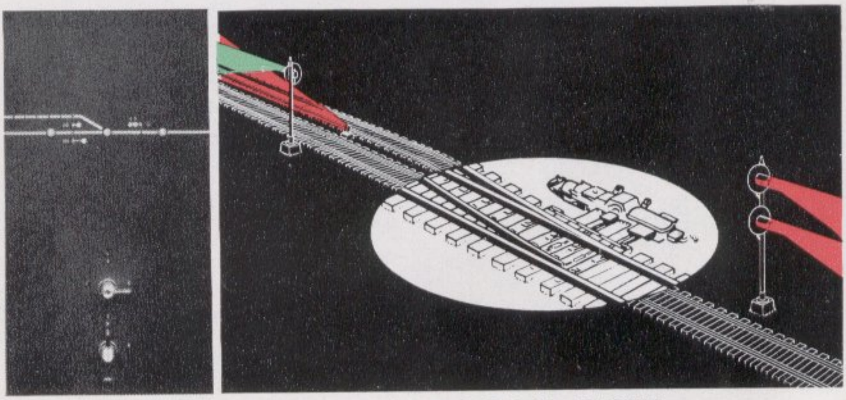
SUPERVISORY CONTROL OF SWITCH



SWITCH NORMAL — SIGNALS NORMAL

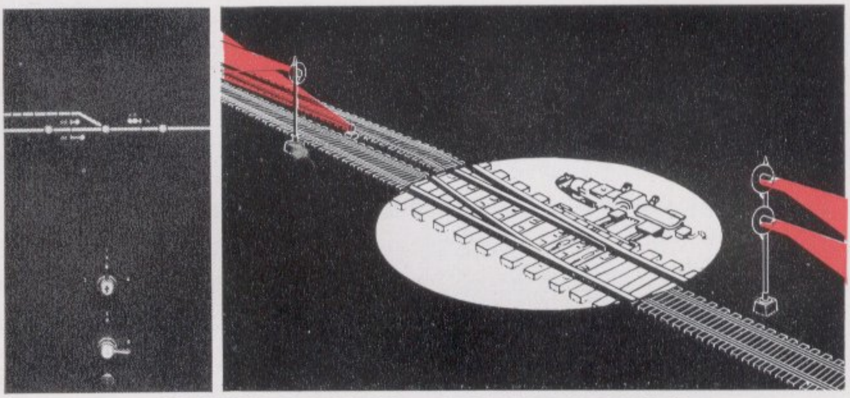


SWITCH NORMAL — SIGNAL LEFT

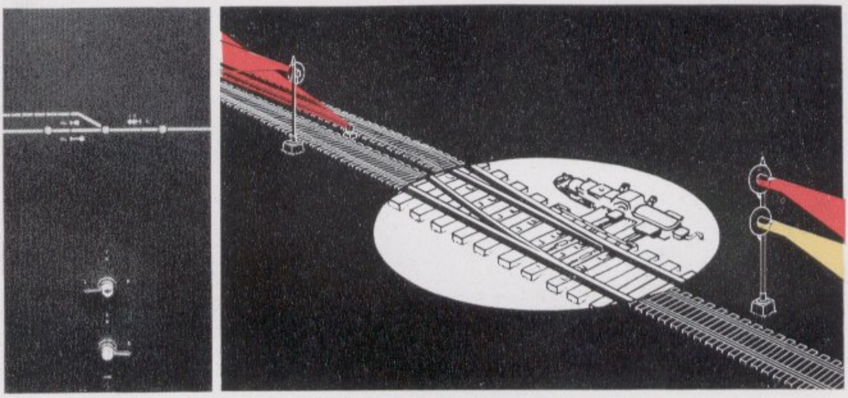


SWITCH NORMAL — SIGNAL RIGHT

AND ASSOCIATED SIGNALS



SWITCH REVERSE – SIGNALS NORMAL



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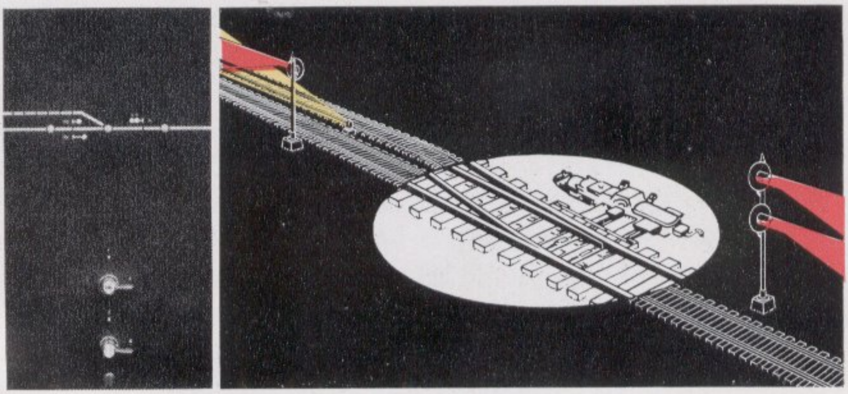
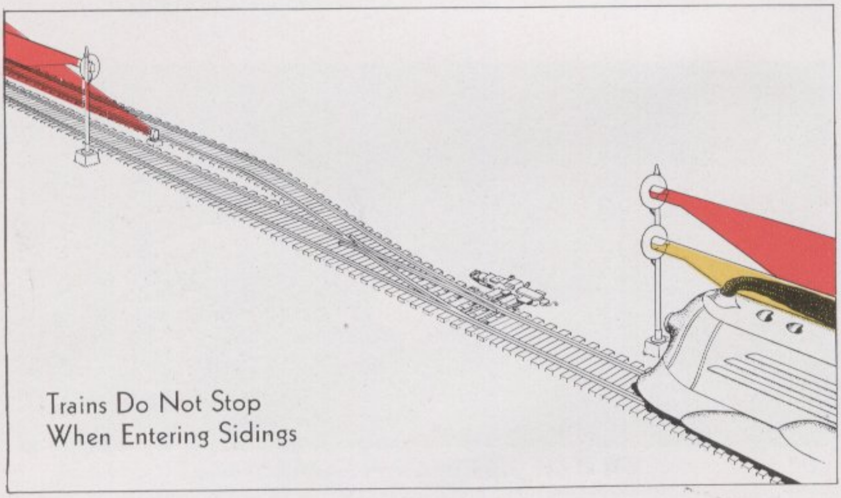


SWITCH REVERSE – SIGNAL RIGHT

POWER SWITCH OPERATION SAVES TRAIN TIME

An important feature of the CTC System, not obtainable with train operation by signal indication before 1927, is the use of special circuits whereby the operator, through the manipulation of a control element, may institute directly the power operation of corresponding siding or crossover switches almost any distance from the control machine.



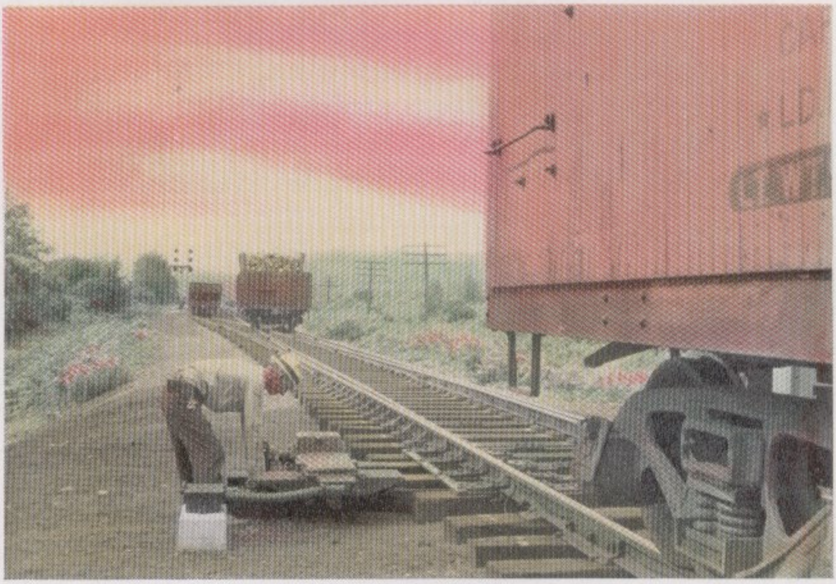
Trains Do Not Stop
When Entering Sidings

Of course, the field conditions must be such that the track section including the switch is unoccupied and that the signal governing train movements over the switch has not been permitted to "clear," for either of these will lock out the supervisory control and make it impossible to throw the switch.

It is apparent that delay incident to manual operation of the switch by the train crew before and after passing over the switch and delay due to clearance time allowance are eliminated. Frequently, the elimination of these delays permits the operator to run a train one or more sidings further than formerly to effect a meet or pass.

MANUAL SWITCH OPERATION FOR SWITCHING MOVES

In certain cases it is desirable to provide a means for manual operation by the train crew of the switch in order to secure efficiency.



Dual-Control Switch Machines Facilitate Switching Moves

As a result, dual-control switch machines are generally used in ctc territory. These power switch machines have a built-in selector lever and a built-in hand-throw switch lever. Normally the selector lever is in the "power" position which enables the operator to "throw the switch" from the control machine. When the selector lever is in the "hand position" (at the permission of the operator) it enables a trainman to "throw the switch" as if it were a hand-stand, and the operator is powerless to permit conflicting moves.

Obviously, this dual operation feature facilitates certain switching movements while providing the maximum safety.

NO INTERMEDIATE OPERATORS

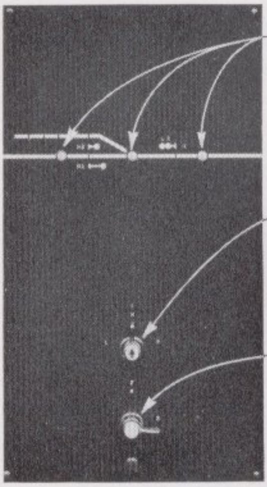
A CTC System places complete information and absolute direct supervisory control of signal and switch operation, subject to automatic field safety, in the hands of one man.

Obviously, there is no delay in ascertaining the location of trains, or in acting to change routes to care for unexpected conditions, since it is unnecessary either to call and question a remote operator or to transmit instructions or time-consuming train orders, nor is there any hindrance to the speedy handling of the problem because of unchangeable or inflexible time-table rules.

Experience has shown that the elimination of intermediate operators removes the opportunity for division of responsibility—trainmen are more respectful of the authority vested in the man at the CTC machine, and complete understanding of the other fellow's position results in mutual cooperation on the common problem of "getting the traffic over the road."

ADEQUATE INDICATIONS ON CONTROL MACHINE

Since the operator of a CTC machine has direct control over many functions previously handled by intermediate operators, those indications which facilitate the planning of train movements and the manipulation of the control machine to direct the execution of those movements have been incorporated in the control panel. In fact, the usual CTC machine provides more complete information than that available with intermediate operators. In addition, the indications are transmitted automatically and without delay as soon as a change occurs; thus, the control panel presents a picture of conditions existing at any moment.



Track Indication Lights
when lighted track is occupied

Signal Lever
when lighted signal has cleared

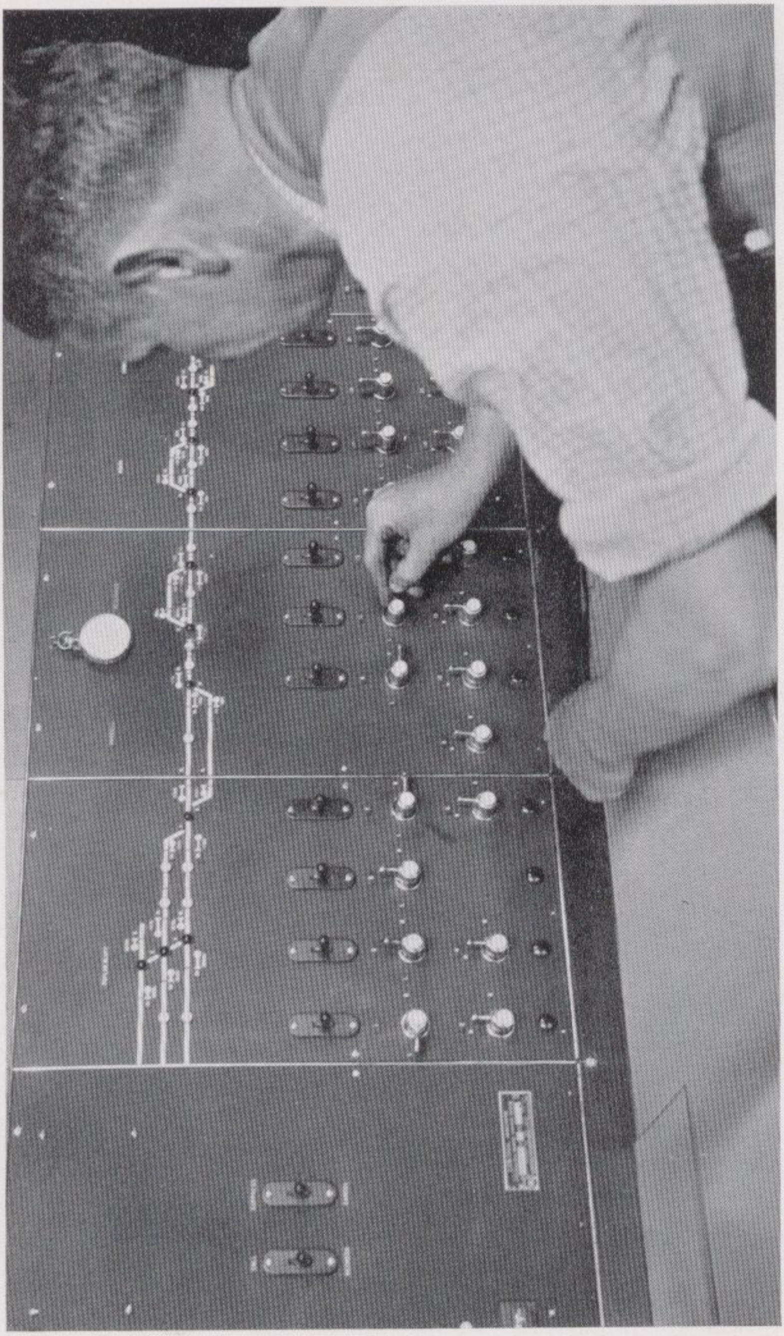
Switch Lever
when lighted switch is out of correspondence with lever

Some of the more usual indications provided are described below; however, it should be borne in mind that special indications may be included when necessary or desired.

Track occupancy indications are of major importance to the machine operator for it is this information that enables him to forecast the probable location of all trains in advance and supervise their movement so as to facilitate and expedite their passage through the CTC territory with the least interference to each other. While track occupancy indication lights are usually provided only for Switch and Approach track sections, they may be provided for any other or all track sections depending upon the train director's needs in handling the traffic under existing or probable future operation conditions. In any event, there are usually more "OS" points with CTC than with intermediate operators.

So far as the signals are concerned, it is desired generally to know only whether the signal is showing some "proceed" indication, in which case, one light is provided which is lighted when signal is displaying any one of its several "proceed" indications.

Switch operation is usually indicated by the "out-of-correspondence" method, that is, when the switch position corresponds to the switch lever position, the indication light is out.



More Time for Planning—Smoother Train Operation

OPERATOR'S TIME SPENT PLANNING MOVES

A CTC control machine may be handled directly by the division dispatcher; or it may be handled by an operator, leverman, or other designated employee working under instructions from the division dispatcher. Who shall operate the control machine depends upon its location, the extent of the installation, and other factors peculiar to the specific installation.

In the following discussion therefore, the actions attributed to the operator may be those of a dispatcher, a subordinate, or both.

With CTC, the operator does not have to transmit, or receive, and check "19" and "31" orders, which is an inherently slow and tedious task.

Generally, this work consumes an appreciable part of an operator's working time; therefore, its elimination provides the operator with adequate leisure to study the past movements and present locations of the trains within the CTC territory, plan their future movements for the least possible delay to each other, and then direct them accordingly by the mere manipulation of small switch and signal control levers on the compact control machine.

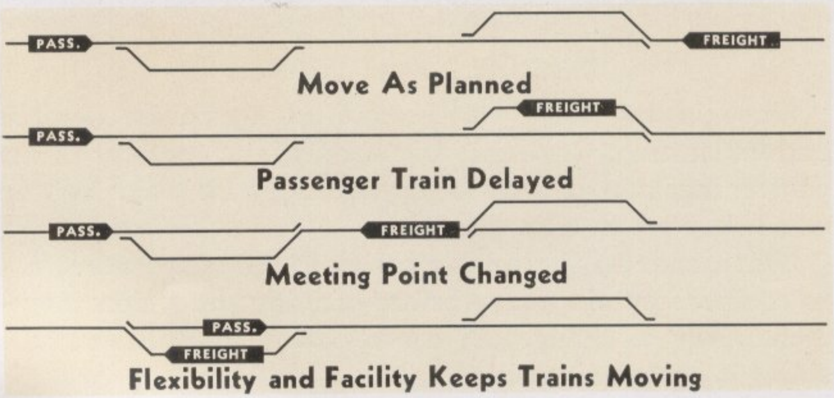
Montague on the E. Deerfield to Orange, Mass., (B. & M. R.R.) ctc Installation

DETECTION OF CONTINGENCIES—
UNUSUAL FLEXIBILITY AND FACILITY OF OPERATION

Since indication information from the field is accurate, complete, and up-to-the-minute, the operator is in an excellent position to detect contingencies at the earliest possible moment.

Should the contingency require—and it usually does—the operator can execute immediately new plans that will produce the least possible interference under the new conditions.

This facility and flexibility of operation eliminates many delays and reduces others to a minimum. For example, frequently a meet or pass between two trains several sidings apart is arranged on the basis of their present and probable future rates of speed. Then the unexpected happens—one train is delayed and will be considerably late in arriving at the anticipated meeting or passing point! Apparently this would result in an equivalent, or even greater, delay to the second train; however, ctc enables the operator to change quickly and easily the meeting or passing point to a different siding and so facilitate train movements under the changed conditions.



Move As Planned

Passenger Train Delayed

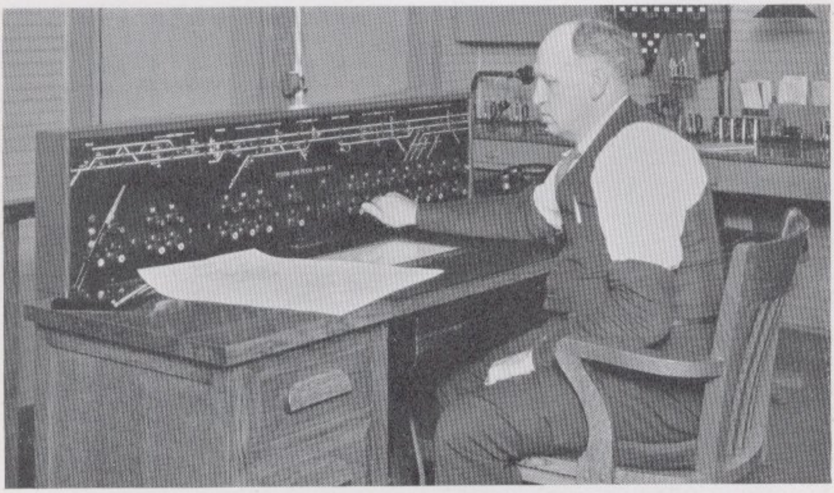
Meeting Point Changed

Flexibility and Facility Keeps Trains Moving

HANDLING OF NON-SCHEDULED TRAINS

Extra and work trains, regardless of whether they are starting from a terminal or are on the road, offer no operating problem in ctc territory for they can be run from point to point without time consuming preliminaries.

With ctc, a train is run just as far as it is convenient to do so, if there is time to run it to the next siding—on it goes; and if there is time for another siding—that too is included. *Trains are kept moving!*



Control Machine of the Peoria to Pekin, Ill.,
ctc Installation on the P. & P. U. Ry.

LESS DELAY AT SIDINGS

Since passing-siding switches are usually power operated and under direct supervisory control of the operator of the control machine, it is no longer necessary for trains to stop when they are to take the siding.

This means an appreciable saving in time for a siding not so equipped entails a stop before entering and a slow movement into the siding. Of course, delay upon leaving the siding is also eliminated.

Where tonnage trains are involved, this feature is most valuable, as stopping and starting this class of equipment is especially costly and liable to cause difficulties.

LESS DELAY AT TERMINALS

CTC simplifies train operation at terminals and yards. When a train is ready to go, the operator needs to consider only whether that train can proceed without interfering with other trains already under way. And barring breakdowns or other contingencies, an experienced operator knows what he can expect from every engineman at the throttle of any locomotive on any part of the division.

As a result, trains get under way sooner, and progress farther.

HIGH PERCENTAGE OF MEETS ARE NON-STOP

Experience has shown that non-stop meets and passes may be expected the same day the system goes into service. It also shows that within a short time mutual cooperation between enginemen and the operator results in a greatly increased percentage of non-stop meets and passes.

One railroad reports over half of all its meets are non-stop. This performance demonstrates an unusually high degree of cooperation in which the operator has studied the movements of the various trains and planned very close meets accordingly, while the enginemen involved handled their trains in a most expert manner at the sidings.

The use of power-operated passing track switches should, and generally does, more than cut in half the time lost at meeting points.

This has been found to hold for practically all average meets even though they are not "perfect meets," i.e., meets in which both trains arrive at opposite ends of the passing siding at the same time.

Non-Stop Meets Reduce Train Delays

INCREASED GROSS TON MILES PER TRAIN HOUR

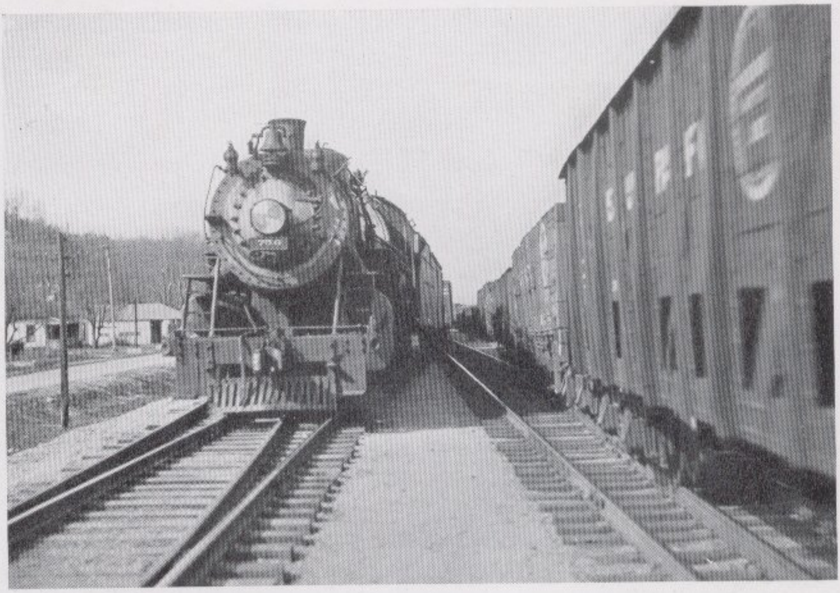
Other things being equal, Gross Ton Miles per Train Hour is an accepted measure of efficiency and earning power,—for revenue is dependent upon ton miles, while expense is largely dependent upon train hours.

For a given tonnage of freight to be moved over the given or existing mileage, it is apparent that the Gross Ton Miles per Train Hour can be increased only by increasing the Tonnage per Train and/or increasing the Average Train Speed.

ctc has demonstrated its ability to produce a large increase in the Gross Ton Miles per Train Hour—57% in one case, 39% in another, 87% in another, and so on.

INCREASED TRAIN TONNAGE

Since ctc with its power-operated switches reduces the number of stops at passing sidings, some of which are on grades where starting is difficult, and since, in general, trains



CTC Increases Track Capacity and Helps
Get Peak Traffic Over the Road

are kept moving, there is less "freezing up" of trains.

The tractive effort required to start a train, rather than the tractive effort required to keep it moving, determines the train load. As a result, it has been found that without increasing the power requirements the train tonnage may be increased.

INCREASED AVERAGE TRAIN SPEED

Because CTC reduces the time lost at passing sidings when trains meet or pass, the running time is correspondingly lowered. This assumes, of course, no changes in running speeds.

With today's competitive conditions, a lower running time is especially desirable in the interest of improved service; however, this potential Increased Average Train Speed may make its effects felt in many different ways depending upon operating conditions or practices.

19 representative installations on 17 railroads show an Average Freight Train Time Saving of 35 minutes per trip, or an average saving of 1.38 minutes per freight-train mile.

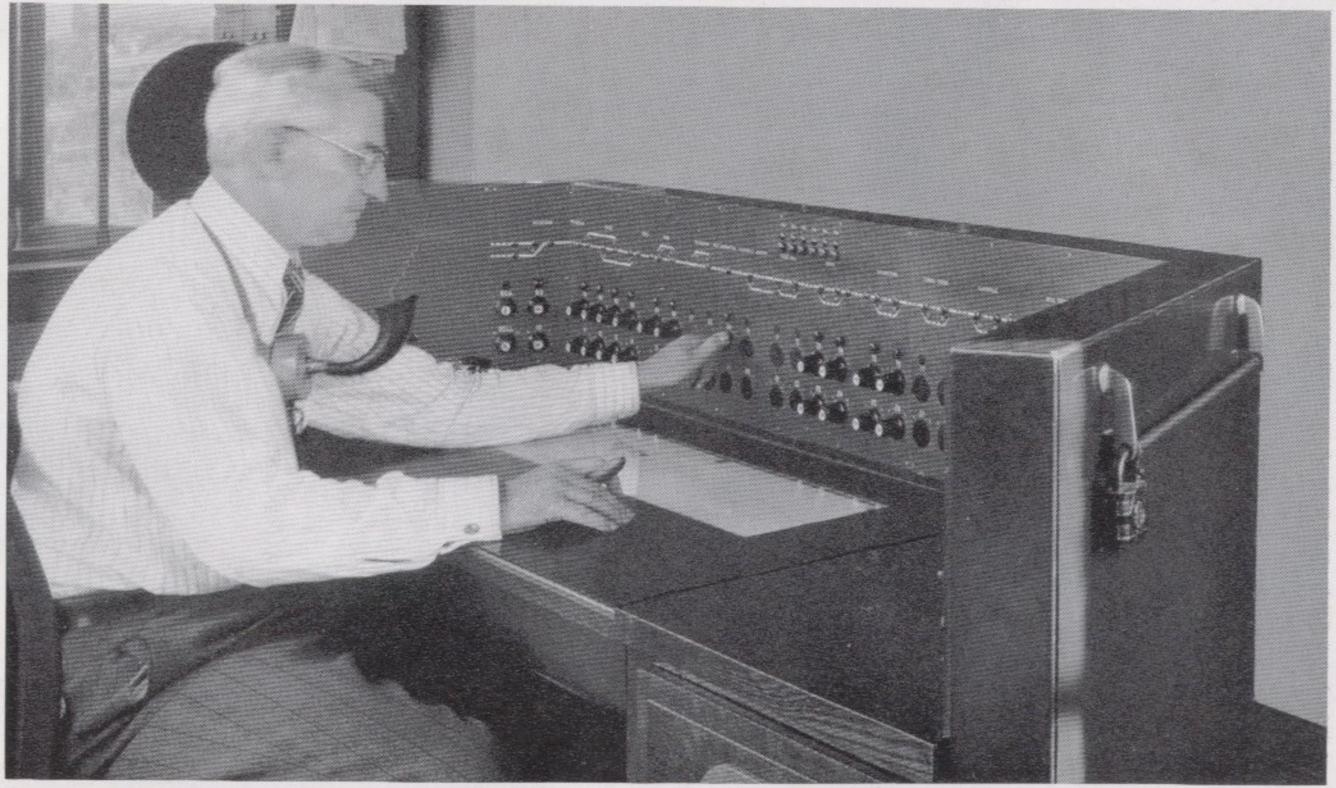
INCREASED TRAFFIC CAPACITY

The traffic capacity of any piece of railroad can be represented in train hours; therefore, when the running time of the trains is known, it is a simple matter to determine the theoretical train capacity. Obviously, a reduction in the running time (hours) increases the train capacity. The more trains that can be run, the greater is the tonnage that can be moved!

CTC makes this possible because, as shown previously, it reduces the amount of lost time.

Where trains of different speeds have been involved, which is ordinarily the condition to be met, various examples of single-track operation with CTC have shown that the train capacity and running times have been quite comparable with the usual operation of double track; while examples of double-track operation with CTC have shown an increased track capacity where one or both tracks have been signaled for either-direction running and directional congestion is an operating factor.

Experience and studies show that the track capacity has been, or may be, increased from an average of 28–36 to an average of 50–80 trains per day on single-track lines. Actual operation of 42–70 trains has been accomplished on several single-track lines without distress.



Control Machine of the Gilkeson, Pa., to Wheeling, W. Va., CTC Installation on the Baltimore & Ohio R.R.

INCREASED SAFETY IN TRAIN OPERATION

It has been shown previously that improper operation of the control machine can not produce improper operation of the switches and signals, while the safety to train operation inherent in any automatic block signaling system is universally recognized.

In addition, CTC provides the following safety features to train operation. These features are peculiar to CTC operation and are not obtainable otherwise.

Instructions governing the movement of trains are transmitted by signal indications, at the time and place they are to be acted upon, directly from the CTC operator to the engineman. This eliminates intermediary action by other, or less experienced, employees.

The indication lights on the CTC machine provide the means for checking obedience to signal indications and speed restrictions of every train passing over the territory.

Distribution of information to train crews is concentrated under control of one CTC operator, rather than under several operators (as formerly) whose individual judgment on a common problem can not be coordinated for the greatest safety.

Track occupancy lights on the CTC control machine provide a means for detecting certain types of broken rails.

In the event of word of the presence of dragging or defective equipment, possible derailment, etc., being received, the CTC operator can instantly arrange to stop the train at the first controlled signal. This can be done at more frequent intervals than is possible in other methods of train operation.

Possibility of human error in transmission, interpretation, and execution of written train orders is eliminated.

The necessity of train crews getting off to operate hand-thrown switches ahead of trains and getting back on after returning switches to normal position is eliminated. This results in decreased personal injuries. It also reduces property damage, such as pulled out draw-heads, broken knuckles,

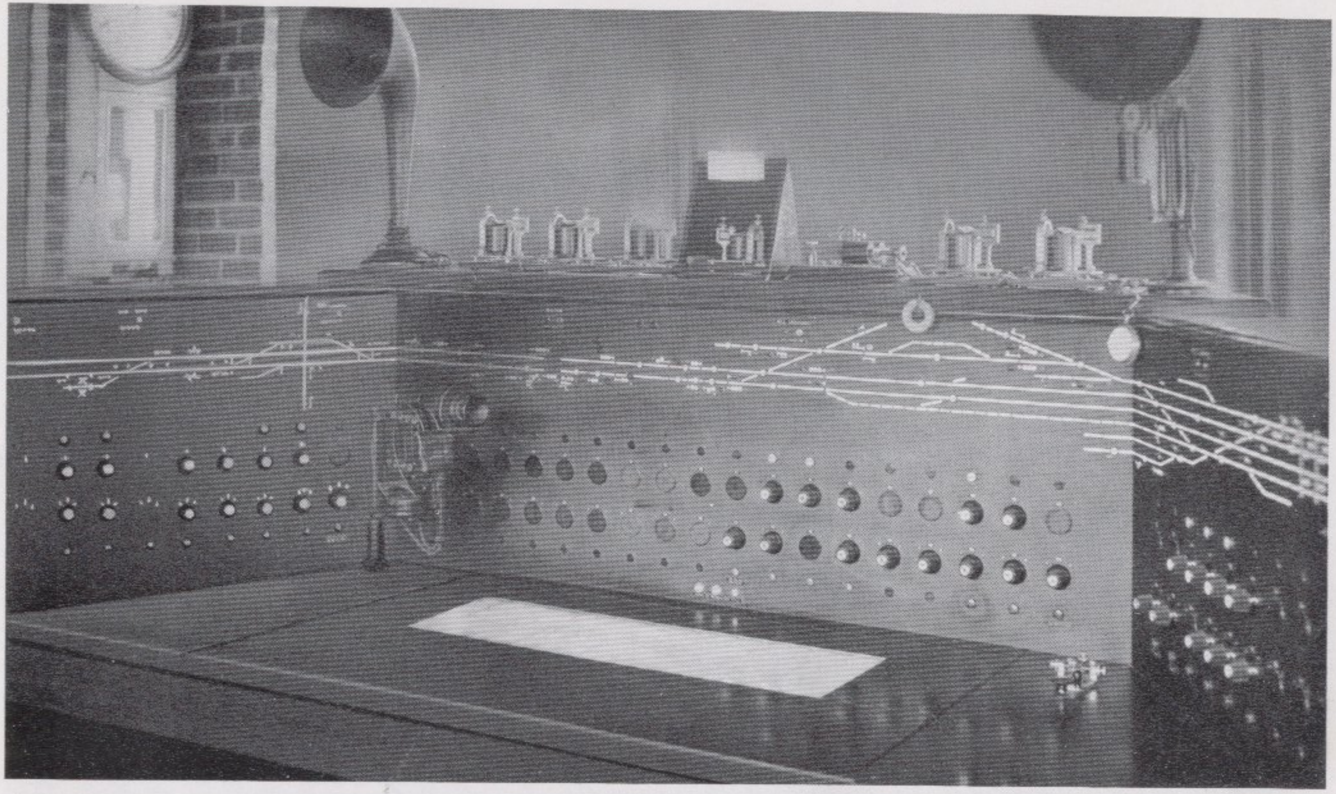
North Gate on the Albany to Watervliet, N. Y.
(D. & H. R.R.) CTC Installation

shifted lading, etc., attributable to stops.

Eliminates danger of improper operation of switches in front of, or under, trains.

Trains are kept in motion a greater portion of the time, which reduces the chances for rear-end collisions.

CTC has a psychological effect on trainmen that makes them more alert and keen, which is conducive to safer handling of trains.



Control Machine of the Ayer to Tower H, Mass., CTC Installation on the B. & M. R.R.

POSTPONEMENT OF ADDITIONAL TRACKAGE CONSTRUCTION

The introduction of CTC has made it possible to postpone the construction of additional tracks to secure increased track capacity or improved operation.

This feature is especially valuable in congested or other areas where additional right of way can not be acquired readily, or at a reasonable price, or at all due to topographical conditions.

Prior to the development of CTC, many roads constructed double-track, or even 3 or 4 tracks, to handle the traffic under the then known methods of operation. Had CTC been known, it would have been possible in many cases to have constructed less main trackage using proper signaling instead to achieve the same result more economically.

The first installation of CTC (Stanley to Berwick, Ohio, on the New York Central Lines in 1927) postponed the construction of a $2,000,000 second track.

To date, 8 CTC installations postponed the construction of 253 miles of second-track, 2 other installations postponed the construction of 24 miles of third-track, while another installation postponed the construction of 8.8 miles each of third- and fourth-track.

RETURN ON INVESTMENT

The cost of a CTC installation, whether the Total Cost or the Cost per Track Mile is considered, is a variable quantity and is dependent upon many factors.

CTC operation, to produce the greatest possible benefits, i.e., to be the best economic solution to a problem, involves automatic block signaling. It is obvious, therefore, that the application of CTC to a territory which had been modernized by the existing automatic block signal system requires a minimum of change and is naturally less costly than one which must be completely modernized including the automatic block signal system.

It should be remembered that first cost is not a true index of the economic value of an improvement. Frequently, a first cost might seem high, but due to a low annual operating cost the net cost would be lower than for other schemes of lesser first cost but higher annual cost. This is particularly true of CTC in comparison with most alternate schemes now used to secure somewhat the same final result.

Return on the investment is an indication of the economic value of CTC, and Annual Returns have been reported from 12.7% to 101%, while most of the reports show 20 to 33%. In other words, CTC generally pays for itself in 5 to 3 years. It is difficult to find a better place to invest capital, especially when the operating results of CTC are so desirable or even necessary.

REDUCTION OF SUPER-SPEED TRAIN INTERFERENCE

The number of super-speed trains has increased tremendously in the past few years so that in the summer of 1936 the United States, with its 569 runs over 60 miles per hour aggregating 30,097 miles, surpassed the rest of the world.

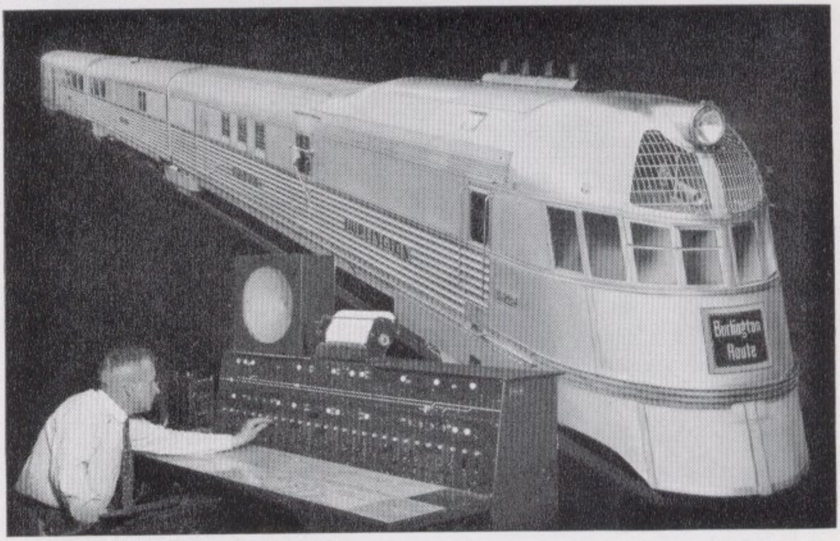
In many cases these super-speed trains have imposed a heavy burden upon the operation of lower speed passenger and freight trains which are usually the source of the largest part of a railroad's revenue. This burden is especially heavy where a number of super-speed trains are run.

The high average or scheduled speed of super-speed trains has been effected primarily because they are kept moving. True, their top speeds of 90 to 120 m.p.h. are higher than the top speeds of 80 to 90 m.p.h. of the next higher speed trains, but, in most cases, a super-speed train must cruise at close to top speed in order to make scheduled speeds of 60 to 70 m.p.h.

This means that they must be subjected to the least possible delay even though other trains suffer greater delay.

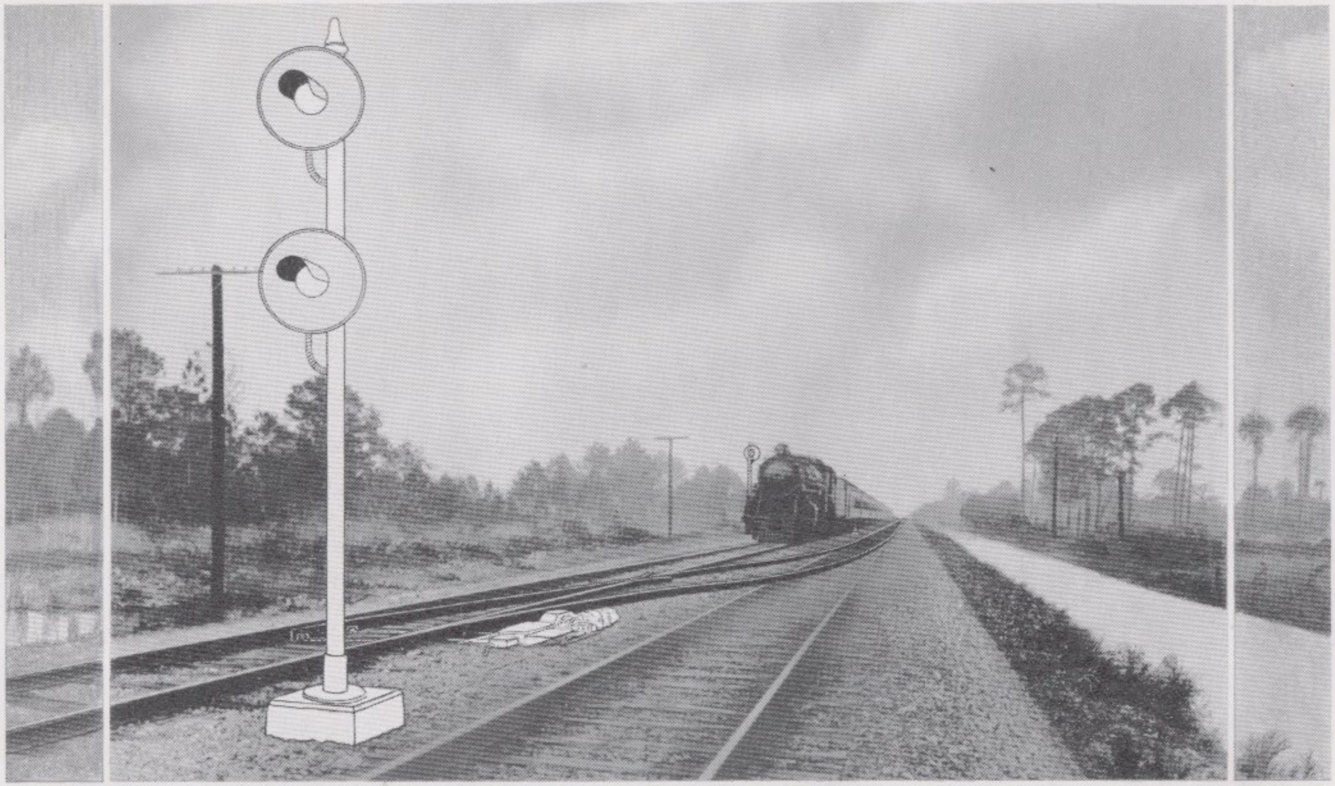
Some idea of the effect of a delay may be gained when one realizes that a train averaging 60 m.p.h. must travel 20 miles at an average speed of 80 m.p.h., or 35.2 miles at 70 m.p.h., in order to pick up a 5 minute delay. Obviously, only a few such irregular delays frequently make it impossible to get back on schedule.

It is not unusual for super-speed trains to inflict 20 to 30 minute delays on freight trains. Suppose these freight trains operate at an average speed of 40 m.p.h. Should they be able to average 60 m.p.h. after the delay, it would take 40 to 60 miles to pick up the lost time. Generally they can not make up the lost time due to the frequency with which they meet new delays.



Super-Speed Trains Cause Less Delay to
Slower Trains in G-R-S CTC Territory

CTC reduces to approximately one-half the interference between super-speed trains and regular passenger or freight trains. This reduction in interference is brought about because with power-operated switches less time is required to get the slow train into the clear, while the automatic block signal portion of the system necessitates only sufficient clear-



Handle the Traffic with CTC and Less Track ance time to maintain "clear" signals for the super-speed train.

Safe super-speed train operation is facilitated also by ctc as a result of the elimination of written train orders, the ability of the operator to change instantly meeting and passing points, and the concentration of supervision and control under one man—the operator at the ctc control machine.

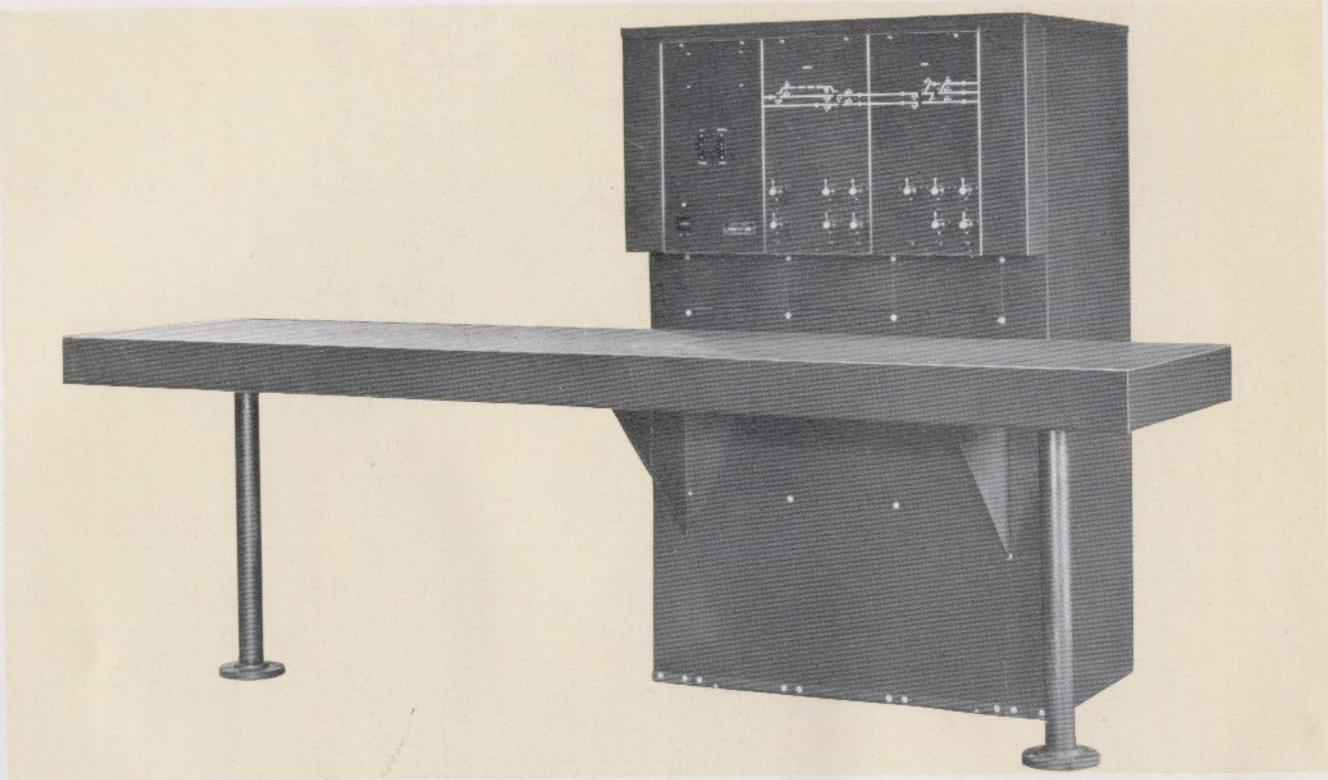
RETIREMENT OF TRACKAGE

Years ago 2, or even 3 and 4, tracks were constructed to handle the traffic. Generally, this multi-tracking was necessary to reduce delays rather than to provide sufficient capacity.

Changed conditions including the use of heavier and speedier power have, in many cases, reduced the number of trains required to handle present or probable future business. As a result, there are fewer delays and quite a bit of the track is excessive.

Today, more of this track can be made excessive and its retirement warranted by installing ctc on a portion of the layout, probably just enough to make a single-track line.

Track retirement produces Direct Benefits which can be evaluated rather easily such as savings in payrolls, maintenance, taxes, etc., and Indirect Benefits which can not be evaluated so easily such as improvements in operation, service, safety, etc.



Control Machine of the Midvale to Salt Lake City, Utah, ctc Installation on the D. & R. G. W. R.R.

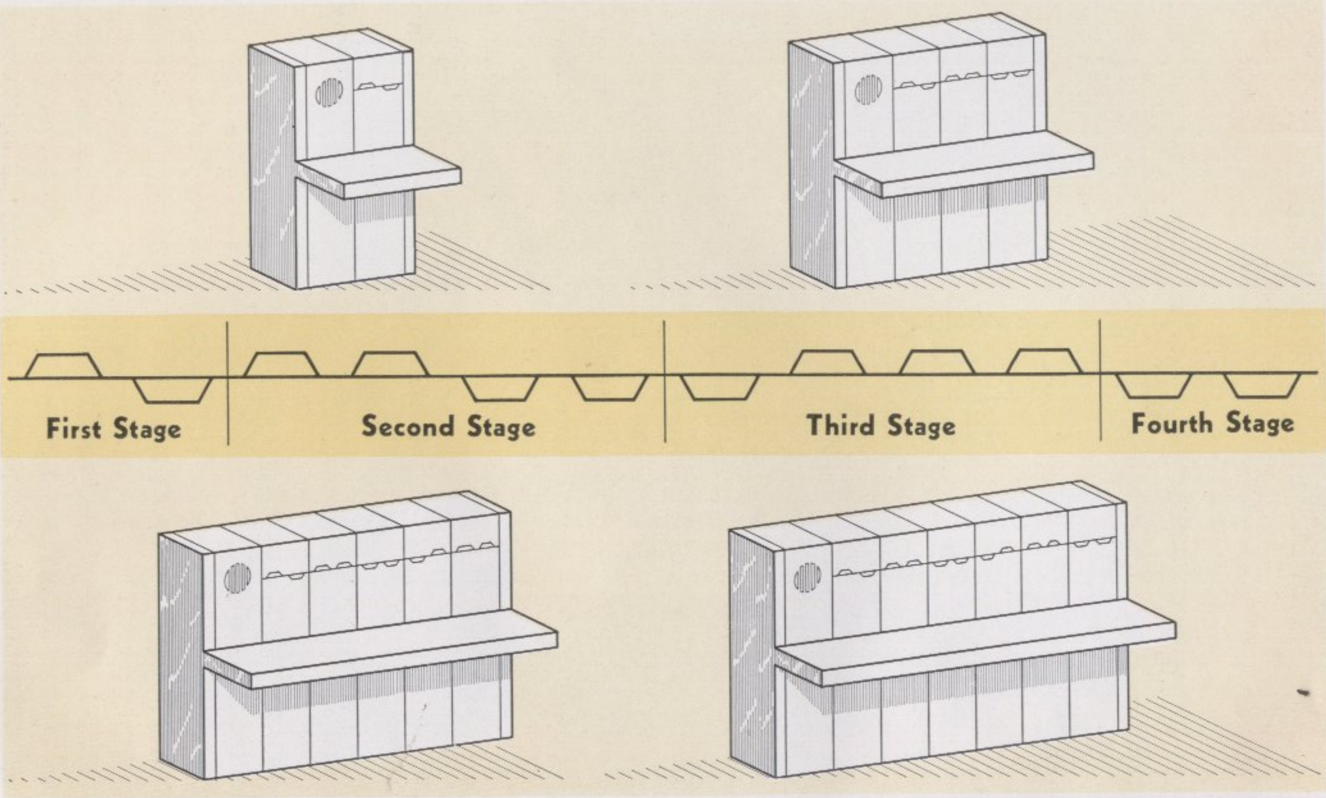
FORECASTING PROBABLE ECONOMIC VALUE

The probable economic value of a CTC installation may be, and usually is, determined by scientific methods of forecasting, not upon guesswork or hope. In other words, it is not necessary to make the expenditure for an installation in order to determine what it will do.

Another advantage of this method of approach is that several arrangements may be assumed and the probable results forecast quickly and cheaply for each; whereupon, it is a simple matter to select that arrangement which effects the most desirable results at the least cost.

This method of forecast takes into consideration the factors involved, shows the quantity of units saved and their value, and predicts the probable Gross Ton Miles per Train Hour, Average Freight Train Speed, Traffic Capacity, Return on the Investment, etc.

It also indicates if and where changes in departure times would reduce costs or improve service, permanent way changes would be advantageous, or other modifications would be of value.



Installing CTC by Easy Stages

METHODS OF INSTALLING CTC

When sufficient capital is available, it is most desirable to install a CTC system complete on the territory involved. In this way construction costs are held to a minimum, while the system effects at once the desired benefits and advantages.

Lack of capital should not cause procrastination, for certain benefits may be secured through starting a CTC system by installing a small portion, and then adding thereto as capital becomes available until a complete system is in service—probably at an earlier date than if everything were delayed pending the starting of a complete installation.

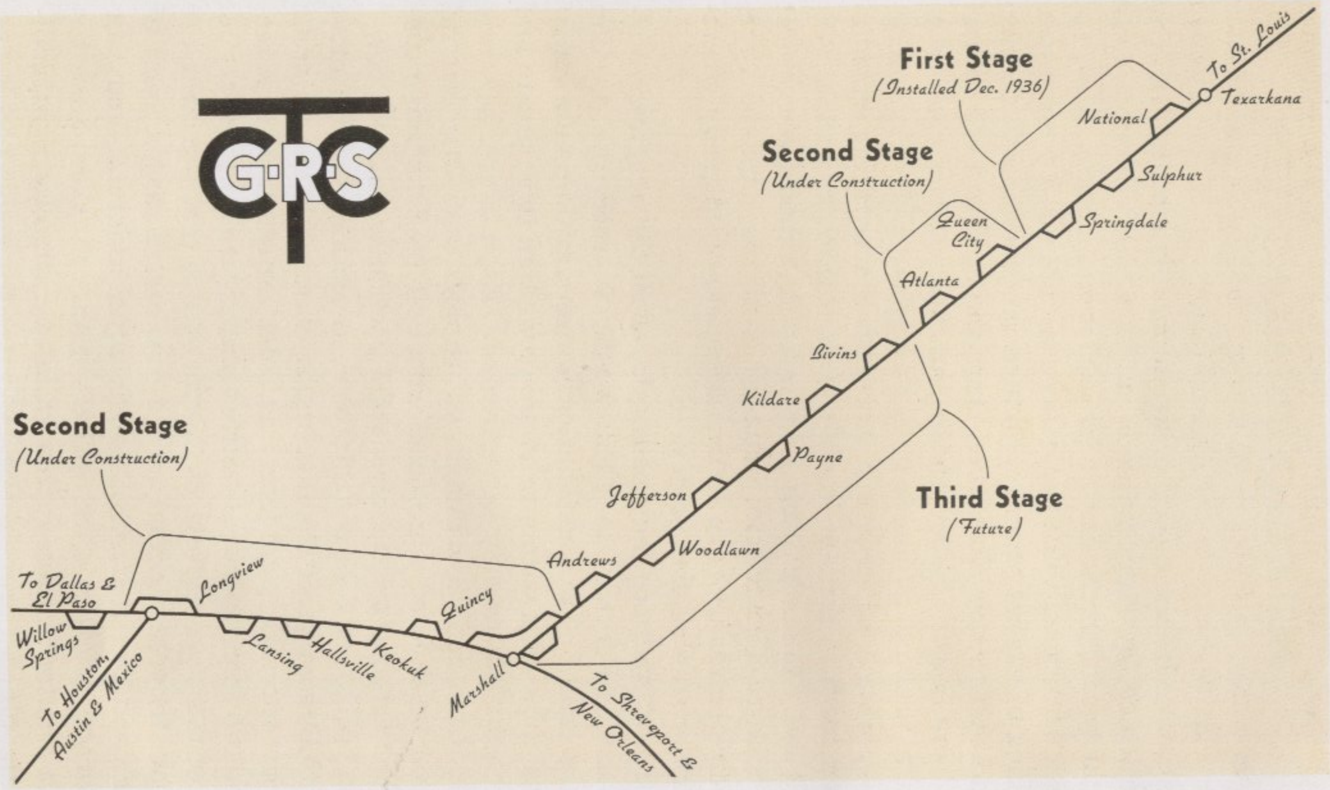
G-R-S CTC lends itself admirably to expansion by unit additions. The control machine is of the sectional type, which permits units to be added quickly and easily whereever they are needed or desired.

Several methods may be employed in the progressive installation of a complete CTC system. In each case, as soon as the extent of the installation permits, train operation by signal indication without the use of written train orders and time table rights may be instituted. Each of the following general methods has certain advantages, and that method should be selected which conforms best to the specific conditions existing and required on a particular railroad.

1. "Adjacent Section" Method—A section of one or more locations may form the first stage. Later add the adjacent section of one or more locations, later the next adjacent section, and so on until the entire territory is equipped.

The major advantage of this method is that the complete system may be divided into a number of stages, each of which will be either substantially equal in installed cost, or in accordance with some optional plan.

Another advantage is that train operation by signal indication only can probably be instituted somewhat earlier and



Map of Texas and Pacific Railway CTC Program being Installed by Easy Stages more easily than might be possible with the following methods.

Generally, this method does not take into consideration the relative train operating importance of the component locations. In other words, it is quite probable that the location which would facilitate or improve train operation most might be one of the last to be installed.

2. "Degree of Return" Method—One or more power interlocking plants may form the first stage. Later add the most important sidings (or other interlocking plants), later the next important sidings, and so on until the entire territory is equipped.

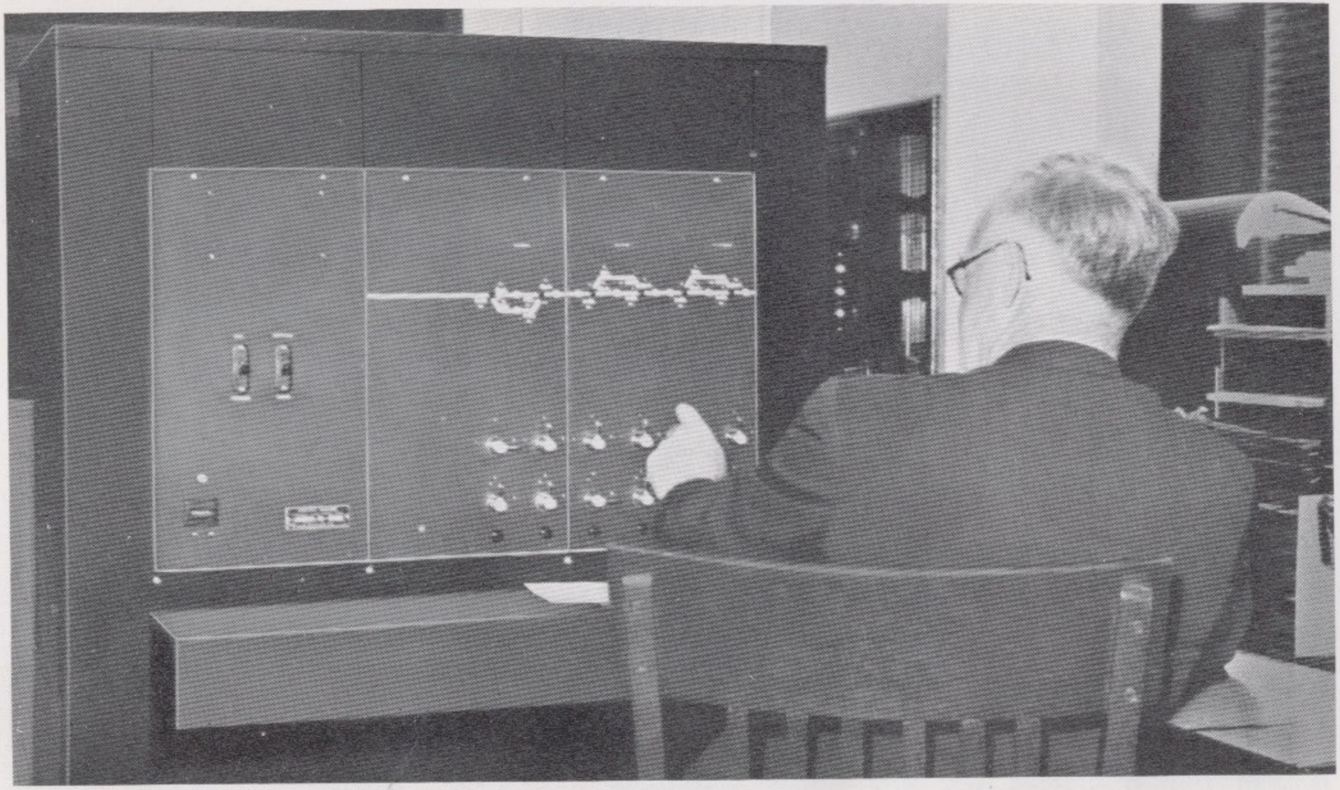
The major advantage of this method is that the initial expenditure is generally relatively low due to the fact that little new outside plant is required, while appreciable direct savings are effected immediately. As a result, the first stage produces a rather high return on the investment, and assists in financing the later stages.

This advantage is especially great where some of the plants need extensive repairs which would be unnecessary under CTC operation. In this event, the application of the repair money to the change-over would produce greater and more lasting benefits.

As with the previous method, though to a lesser extent, the installation of those units which would facilitate or improve train operation is deferred. In other words, improved train operation is secondary to return on the investment.

3. "Degree of Operating Importance" Method—One or more important passing sidings may form the first stage. Later add the next important sidings, later the interlocking layouts, and so on until the entire territory is equipped.

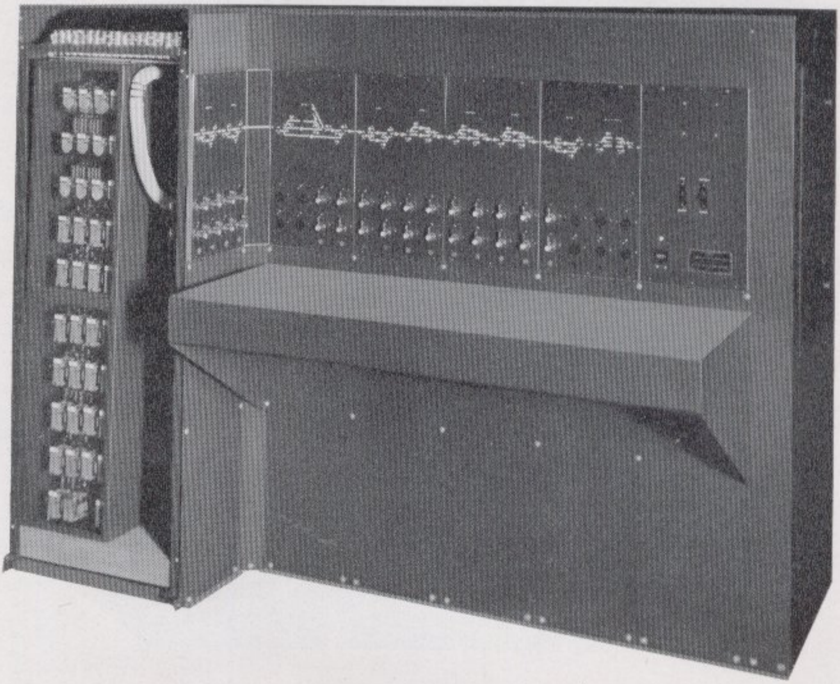
The major advantage of this method is that improved train operation is effected immediately. This improved train operation is reflected in less train delay, increased gross ton miles per train hour, increased safety, increased track capacity, etc.



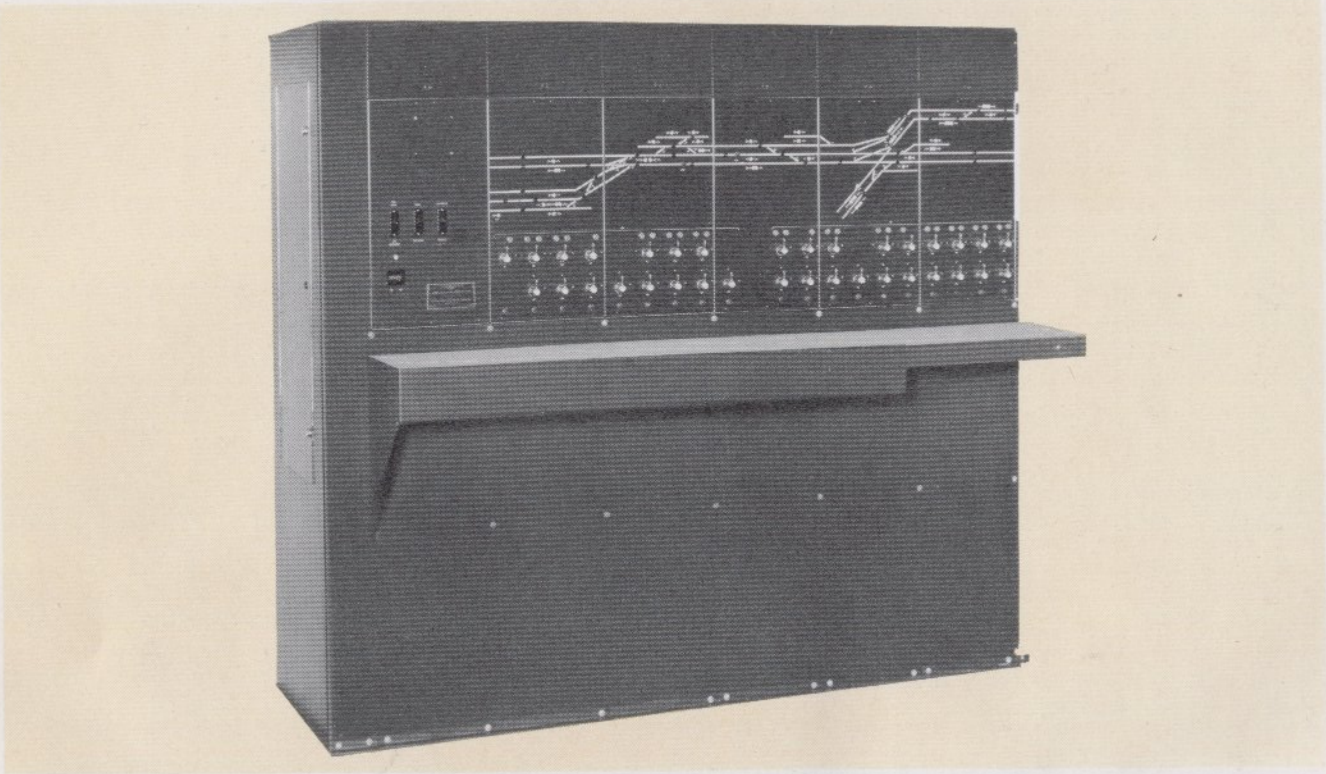
Control Machine for the First Stage of the Texarkana to Longview Jct. (Texas & Pacific Railway) ctc Installation

Of course, improved train operation usually produces certain intangible savings; however, major direct savings are deferred until the later stages by this method. In other words, the return on the investment is secondary to improved train operation.

Regardless of the method of starting a CTC system and carrying it through to completion, the final result is the same—Train Operation by Signal Indication with the attendant benefits previously described!



Control Machine Addition for the Second Stage of the Texarkana to Longview Jct. (Texas & Pacific Railway) CTC Installation



Control Machine Addition for the Second Stage of the Albany to Mechanicville, N. Y. CTC Installation on the D. & H. R.R. (See Frontispiece for First Stage)

SCOPE OF APPLICATION

Since the first CTC installation on the New York Central Lines between Stanley and Berwick, Ohio, in 1927, the application of CTC has been so rapid and varied and the results are so amazing that it is almost impossible to deal with potential applications without producing an unwarranted feeling of incredulity.

CTC is applicable to double- or multiple-track lines just as well as to single-track lines. In fact, about half the miles of road equipped with G-R-S CTC has been double- or multiple-track, while about four-fifths of that track has been signaled for either direction running.

In general, any place where train operation is difficult or operating costs are much above the average, there CTC would probably prove to be a real investment.

Should such a section flash into mind, consult the nearest G-R-S District Office. They will inform you whether an economic study is advisable, in which case a CTC Engineer will prepare a study and make a complete and comprehensive report.

The tabulation entitled "G-R-S Centralized Traffic Control Installations" gives the extent of and pertinent operating facts about each installation, while the photographs of control machines throughout this bulletin show various track layouts.

An indication of the increased recognition of the value of CTC is that the B. & M. R. R. has 8 G-R-S CTC installations, the M. P. R. R. has 6, the T. & P. Ry. and the C. B. & Q. R. R. each has 5, while the D. & R. G. W. R. R. has 4.

G-R-S CENTRALIZED TRAFFIC CONTROL INSTALLATIONS

These installations give complete train operation
by signal indication within the limits indicated.

Road	Date	Installation Limits	Single Track	Double Track	Three Track	Miles Road	Remarks
B. & M. RR.	3-29	North Chelmsford to Ayer, Mass.	0	12.3*	0.9*	13.2	Increased track capacity. Saves $37,847 annually in operating expense. Expedites train movements bunched in one direction during certain hours and in other direction at other hours.
	7-30	Lowell Jct. to Wilmington Jct.	0	2.2*	0	2.2	Increased track capacity by keeping trains moving on grades. Provides maximum track capacity first in one direction and then in the other direction, i.e., relieves directional congestion. Facilitates switching and transfer movements on one main track in industrial sections by using other main track for through movements.
	4-31	E. Portal to Soapstone, Mass.	0	0	2. *	2.	
		Soapstone to E. Deerfield, Mass.	0	27. *	1.2*	28.2	
		E. Deerfield to Orange, Mass.	0	19.2*	0	19.2	
	10-31	Orange to Westminster, Mass.	0	24.2*	5.2*	29.4	
		Westminster to Ayer, Mass.	0	18.8	0	18.8	
	11-32	Ayer to Tower H, Mass.	0	34.3	0	34.3	Eliminated 4 interlockings.

M.P. RR.	12-29	Edgewater Jct. to Atchison, Kan.	42.	0	0	42.	Costly second track construction, due to topographic conditions, postponed. Eliminated three interlocking plants and two block offices. Average running time of freight trains reduced about 45 minutes. On the average 4 stops eliminated for each through train. Increased G.T.M. per train hour 57 per cent. Increased speed 47 per cent.
	6-30	Atchison to Shannon, Kan.	10.3	0	0	10.3	
	3-31	HD Jct. to HI Jct., Mo.	3.6	31.9*	0	35.5	Either direction signaling facilitates train operation.
	7-30	Diaz to Grande Glaise, Ark.	0	15. *	0	15.	
	2-37	Poplar Bluff, Mo. to Knobel, Ark.	26.	8. *	0	34.	Movements expedited during 3rd trick peak period. Saves 6 to 8 minutes for a movement between adjacent sidings. Handled 54 trains daily during emergency flood period from Feb. 11 to Mar. 8, 1937. Saves 1 to 2 hours overtime for local freight. Freight train average speed increased 21 per cent (60% during peak periods), passenger train average speed increased 18 per cent (30% during peak periods).
		Roots to Raddle, Ill.	25.4	1.7*	0	27.1	
T. & P. Ry.	10-30	Fort Worth to Dallas, Texas	0	31.8*	0	31.8	Facilitates train operation during peak periods.

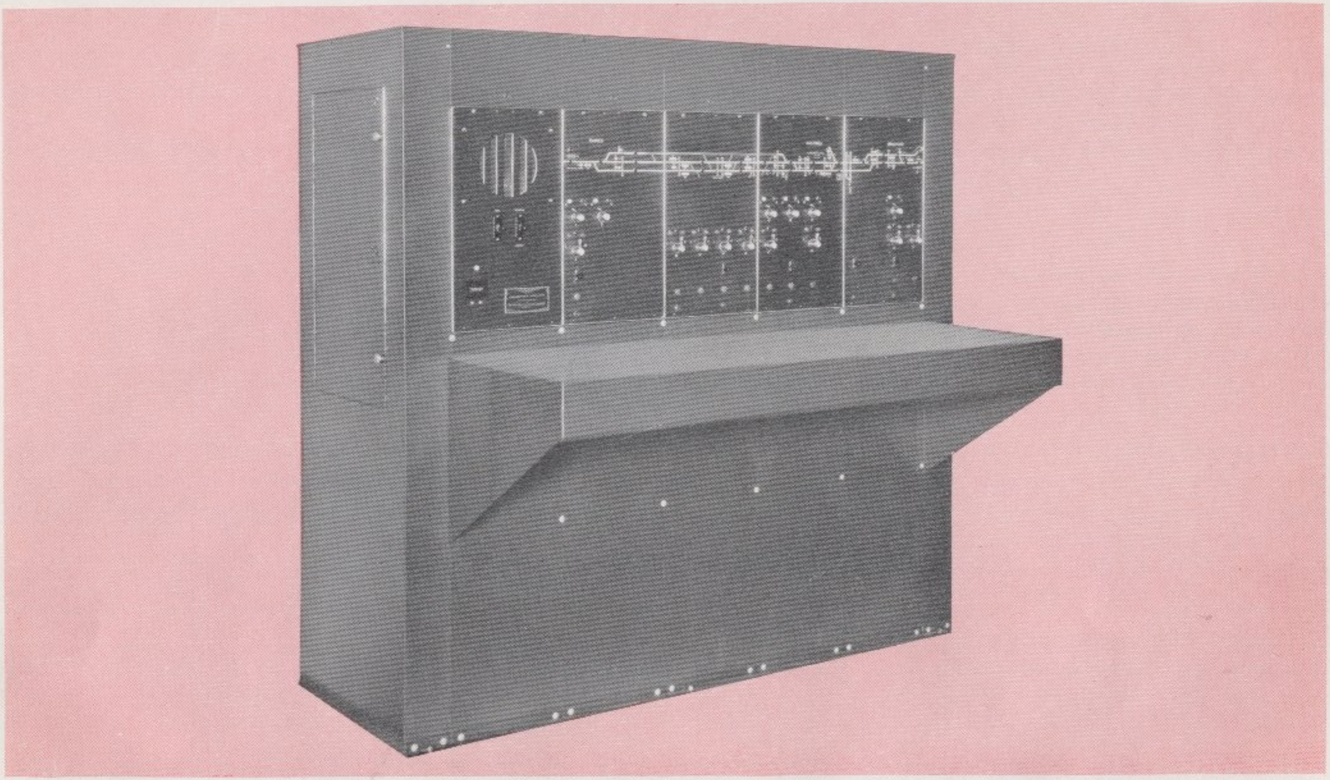
Road	Date	Installation Limits	Single Track	Double Track	Three Track	Miles Road	Remarks
T. & P. Ry. (Cont'd)	5-29	Johnson to John Spur, La.	0	10.7*	0	10.7	Eliminated necessity for additional passing tracks.
		John Spur to St. James, La.	0.5	25.9*	0	26.4	
		St. James to Edgards, La.	3.7	15.2*	0	18.9	
	12-36	Texarkana to Springdale, Texas	18.4	1.	0	19.4	Facilitates train operation during rush hours.
		Springdale to Atlanta, Texas Marshall to Longview Jct., Texas	32.	0	0	32.	Second stage added to Marshall, Texas, machine.
C.B. & Q. RR.	8-29	Steward Jct. to Flag Center, Ill.	0	9. *	0	9.	Eliminated 2 interlocking plants. $8,406 saved annually in operating expense (12.7% on Investment). Relieved directional congestion.
	2-29	Herrington Jct. to Sullivan Jct., Wisc.	14.5	0	0	14.5	Two control machines eliminated mechanical interlocking plants.
	1-30	Albia to Maxon & Halpin, Ia.	12.3	0	0	12.3	
		Gaines to Brickyard, Neb.	0	3.5*	0	3.5	
D. & R.G.W. RR.	10-28	Deen to Tennessee Pass, Colo.	4.5	2.5	0	7.	Expedites train movements through Tennessee Pass Tunnel and on 3 per cent mountain grade. Increased average train speed and G.T.M. per train hour. Reduced time on helper movements.
	10-29	Provo to Midvale, Utah	31.4	0	0	31.4	Increased track capacity. Expedites train movements. Freight

							train running time reduced one minute per mile. Reduced overtime.
	5-37	Midvale to Salt Lake City, Utah	0	10.	0	10.	
	8-37	Grand Jct. to Midwest, Colo.	13.5	0	0	13.5	Expedites peak train movements during fruit and vegetable season. Reduced freight train running time.
B. & O. RR.	8-31	Gilkeson, Pa., to Wheeling, W. Va.	42.8	0	0	42.8	8 Block Stations eliminated. Saves $30,000 annually in wages. Tonnage Train time reduced 1 hour between terminals. Through merchandise freight train time reduced 30 minutes over C.T.C. territory. Reduced overtime.
	8-31	Maynard to Fairpoint, Ohio	2.4	5.4	0	7.8	Eliminated Interlocking and Block Office. Increased Track Capacity. Saves $6000 annually.
D. & H. RR.	10-30	Lanesboro to Center Village, N.Y.	7.1	5.6*	0	12.7	Eliminated 4 block offices. Facilitates train operation. Reduces train delays. Reduced operating expense.
	10-36	Albany to Watervliet, N. Y.	0	6.1	0	6.1	Eliminated 4 interlockings and hand-throw switches at crossovers.

Road	Date	Installation Limits	Single Track	Double Track	Three Track	Miles Road	Remarks
D. & H. RR. (Cont'd)		Watervliet to Mechanicville, N. Y.	0	14.	0	14.	Second stage added to Albany, N. Y. machine to replace two interlocking plants.
I.C. RR.	9-29 3-30	Clinton to Kenney, Ill. Chebanse to Ashkum, Ill.	4.7 0	3.3 7.7*	0 0	8. 7.7	$11,000 saved annually in operating expenses (31% Return on Investment). Replaced three interlocking plants. Third-track construction postponed.
B. & G. Ry.	11-29	Magna to Bingham, Utah	17.2	0	0	17.2	Reduces delays to 5400 ton trains on 2.5 per cent grade. Facilitates train movements. Eliminated two block offices.
C.N. Ry.		Quappelle Sub. to Glenavon Sub., Saskatchewan.	3.5	0	0	3.5	
C.P. Ry.	10-28	Medicine Hat to Dunmore, Alta.	6.1	0	0	6.1	Postponed second track construction. Saves at least 30 min-

							utes and frequently 2½ hours per freight train movement. Freight train movements out of yard expedited.
C. & N.W. Ry.	5-29	Duck Creek to Green Bay, Wisc.	4.	0	0	4.	Saves 15 minutes per freight train movement. Eliminated mechanical interlocking plant.
L.V. RR.	10-29	Mountain Top to Conway, Pa.	11.1	0	0	11.1	
N.Y.C. West	7-27	Stanley to Berwick, Ohio	36.9	3.3	0	40.2	Postponed $2,000,000 second track construction. Freight train speed increased 36 per cent. G.T.M. per train hour increased 39 per cent.
P. & P.U. Ry.	3-31	Peoria to N. Pekin, Ill.	0	6.4*	0.7	7.1	$19,350 saved annually in operating expenses. Train operation facilitated during three peak periods daily. Eliminated four interlocking plants.

*Signaled for either-direction running.



Control Machine of the Gaines to Brickyard (Hastings), Neb., ctc Installation on the C. B. & Q. R.R.

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NEW YORK OFFICE

230 Park Avenue, New York, New York

CHICAGO OFFICE

421 Peoples Gas Building, 122 South Michigan Avenue
Chicago, Illinois

ST. LOUIS OFFICE

2044 Railway Exchange Building, 611 Olive Street
St. Louis, Missouri

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Singapore, Federated Malay States
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Calcutta, India
Bologna, Italy
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Oslo, Norway
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Buenos Aires, Argentine
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