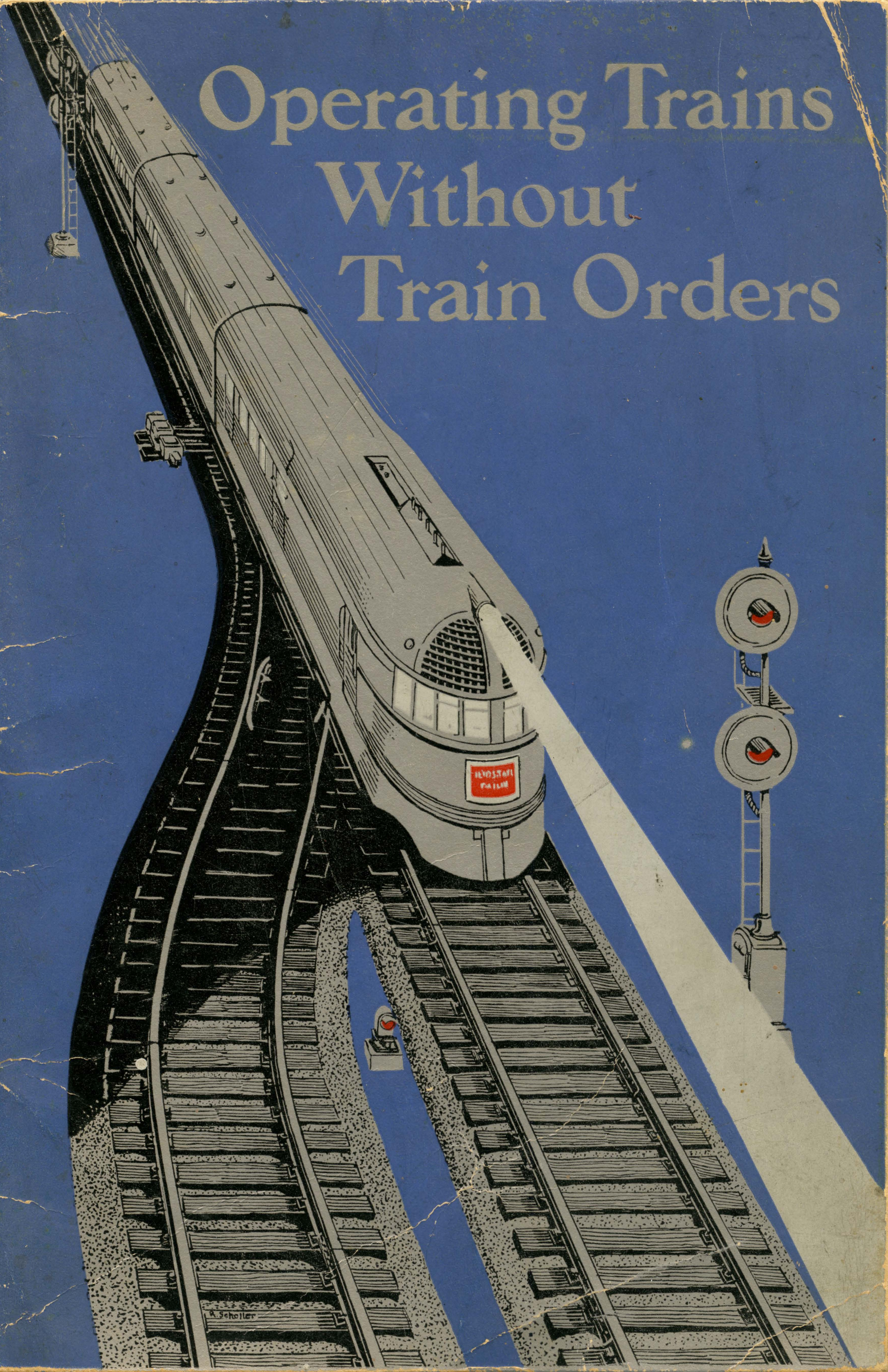
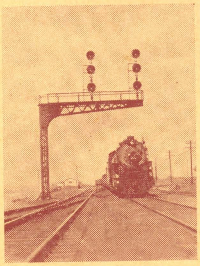
Operating Trains Without Train Orders





OPERATING TRAINS
WITHOUT
TRAIN ORDERS

BULLETIN No. 150

April, 1935

UNION SWITCH & SIGNAL CO.
SWISSVALE, PA.

FOREWORD

This bulletin describes the modern method of operating trains by signal indication without train orders—Centralized Traffic Control (C.T.C.). It has been prepared primarily from the viewpoint of the dispatcher, trainmaster and operating official, rather than that of the signal and engineering officer. It includes a brief description of the principal features of the system, a comparison between operation by C.T.C. and the train order method, and a discussion of the adaptability of C.T.C. to various operating conditions. It lists a number of advantages in operation experienced by officers of railroads having installations in service, shows how C.T.C. improves train operation, summarizes the economic results experienced on existing installations, and lists items of increased safety and other intangible advantages resulting from its operation.

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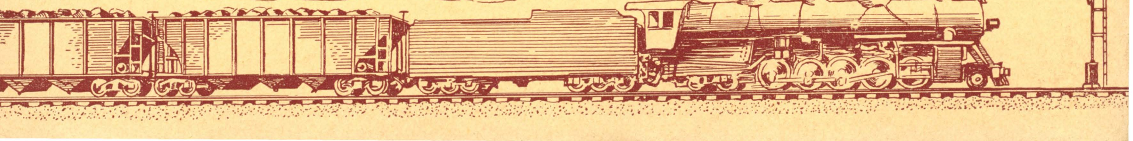


Outstanding Facts About Centralized Traffic Control

First—Thirteen C.T.C. installations, totaling 332 miles, were made to postpone double tracking estimated to cost about $19,000,000.

Second—On one single track installation, the tonnage handled amounted to 86,558 gross ton miles per train hour, an increase of 89 percent.

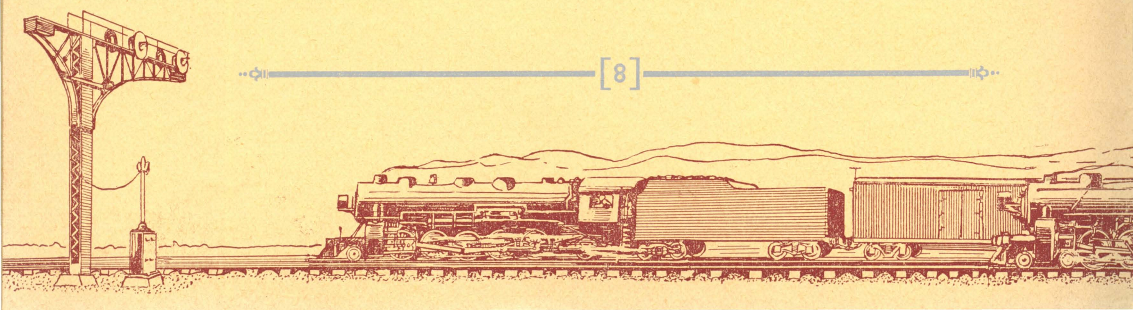
Third—On ten installations, the freight train time saved averaged 1.2 minutes per mile, or an increase of 28.1 percent.

Fourth—A power switch at an end of double track is operated from the control panel 93 miles away.

Fifth—Heaviest traffic C.T.C. territory-
Single track, Clare, Ohio—70 trains.
Double track, Philadelphia, Pa.—156 trains.
Double track, England—210 trains.
Three track, France—320 trains.

Sixth—One installation eliminated 46,355 train stops per year.

Seventh—On one installation 90 percent of meets are non-stop.



The Modern Method of Directing Trains

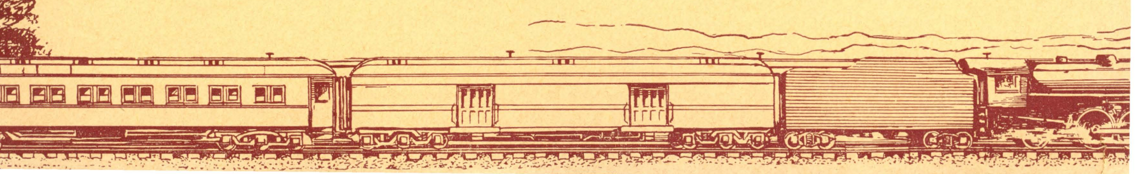
Signaling, which provided for the movement of trains in either direction on single track without train orders, was used as early as 1882 by the Pennsylvania at Louisville Bridge, Kentucky.

Early installations providing for train operation by signal indication were limited to those operating situations where it was possible to arrange for cooperative action between two or more adjacent interlockings or controlled manual block stations. They were made on lines of heavy traffic density between closely spaced interlockings, or where the additional track capacity resulting from signal indication operation was an important item in the economical operation of the railroad.

C.T.C. is the term used to designate the more complete and modern signal systems that have been developed to provide an economical means for the direction of train movements by signal indication without train orders. These systems provide for the control of switches and signals governing the movement of trains, over all or any portion of an operating division, directly from a single location, thereby materially increasing the economic scope of this form of operation. Apparatus especially designed for C.T.C. Systems has been in use only about seven years, and although much of that time comprised a period when a minimum of capital expenditures was being made by the railways, nearly one-half the road mileage on which trains are operated by signal indication today is equipped with apparatus of this type.

Employs Established Signaling Principles

C.T.C. is based upon the coordination of established practices long used in automatic block signaling and interlocking systems. All signal functions throughout the equipped territory are dependent primarily upon the occupied or unoccupied condition of the track and the check between opposing signals, and secondarily upon the will of the operator. The same electrical safeguards that prevent unsafe operation of switches and signals in an interlocking are employed to prevent the operation of switches directly in advance of a train and to lock the switch during the passage of a train. The system is completely "fool-proof" in that it is impossible for improper manipulation of control levers to set up an unsafe condition for train movements, because safety circuits are employed between the various units of controlled apparatus to make impossible the display of conflicting signals and to prevent the movement of switches, when conditions of track occupancy are such that changes in the alignment of routes cannot be made with safety.

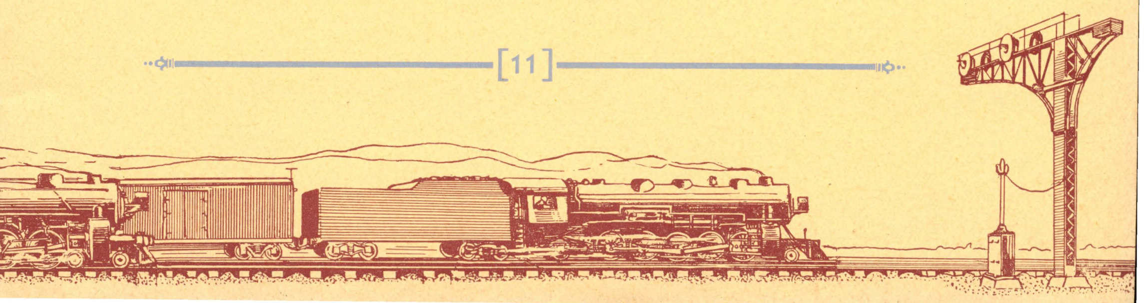


Description of the System

Briefly, the C.T.C. System consists of the following basic groups of apparatus:

1. A control machine with levers for the operation of switches and signals; indication lights showing the position of switches and signals and the occupied or unoccupied condition of sections of track; and a train-graph which records the passage of trains.
2. Equipment at the controlled location consisting of power operated switches, signals, relays, etc. Track circuits approaching and within the limits of the controlled signals are used to actuate indications of the passage of trains which appear on the control panel.
3. A set of control wires extending from the control machine to all controlled locations, over which the circuits actuating the switches and signals are carried and indications of conditions at the outside location are returned to the operating panel of the control machine.

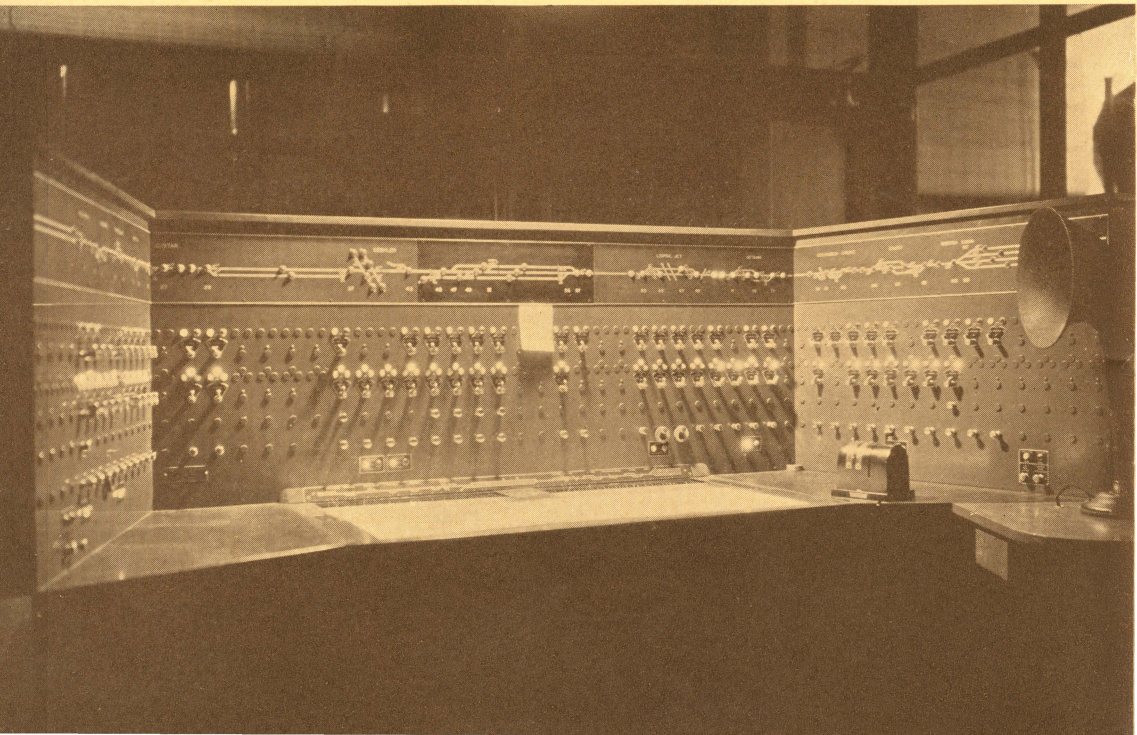
The control machine may be housed in the dispatcher's office or in some interlocking tower, telegraph station or block office and operated by a designated employee. On the machine before the control operator is a miniature track layout of the district, showing the location of controlled switches and signals and the principal tracks. Colored lights indicate the occupancy or non-occupancy of the track circuit at each controlled location and at other points to show the position of trains between stations. Indications of the position of switches and signals are shown by similar lights above the levers controlling these respective functions and advise the control operator that the functions have responded properly to the movement of the levers on the control panel. An automatic train graph is used to pro-

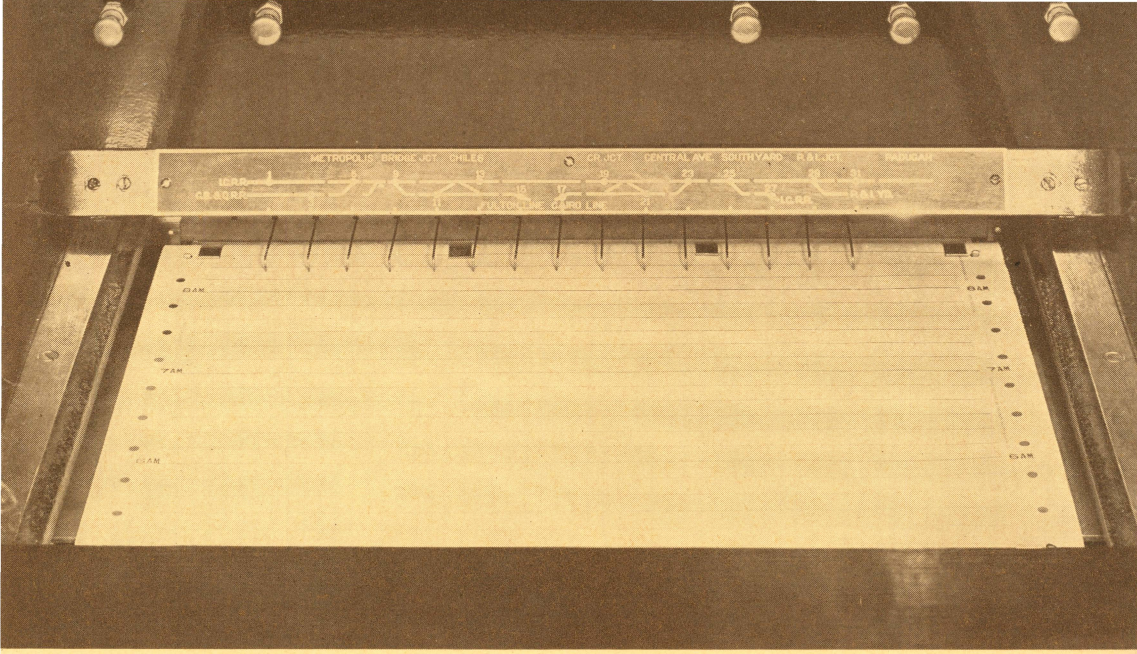


vide a permanent record of the passage of trains at each of the controlled locations. The graph consists of a clock-actuated device which moves the graph sheet under magnetically operated pens to form the record of occupancy of the track circuits at each of the controlled locations.

The graph is located in the desk portion of the control machine so as to permit notations to be made on the sheet by the control operator, to identify the train or to record information concerning its movement. The record of the automatic train graph is generally filed with the "train sheet" for the district and results in a greatly abbreviated "train sheet." The train graph, with the other indications, gives the control operator an audible, visual and recorded indication of the passage of trains. The visual indication is given by the lights in the control panel and the audible indication by a single stroke bell which may be used at the will of the operator to call his

C.T.C. Machine, Deshler, Ohio
Baltimore & Ohio

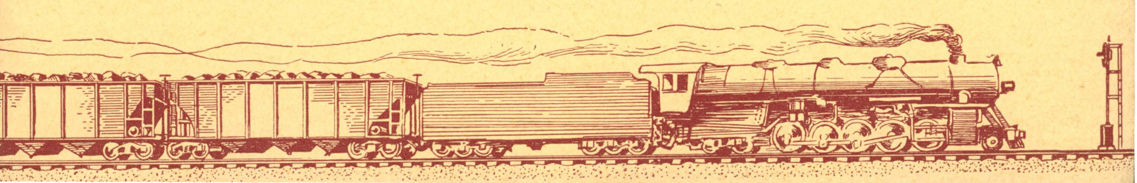


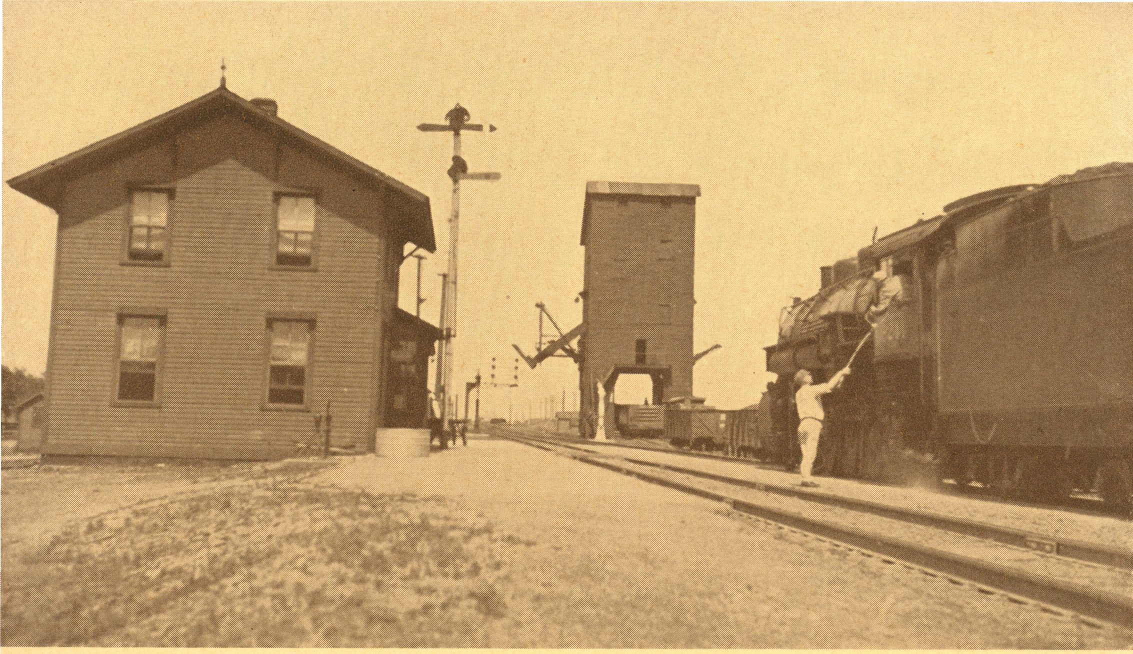


Train Graph Showing Miniature
Track Model and Recording Pens

attention to a change in the indication at a particular point immediately upon the arrival of the expected train.

The power-operated wayside signals at the controlled location may be semaphore, color-light, position-light or color-position-light and where desired the indications may be carried directly into the cab of the locomotive by the use of continuous cab signals. The switches may be operated by electric or electro-pneumatic switch movements and are equipped with a dual-controlled feature which permits hand operation by train crews for switching work. A telephone is provided at each controlled location to permit communication between train crews and the control operator when switching is to be performed, when trains are stopped in emergency, and when track repairs are made. The rules require a train finding a signal at "stop" to communicate with the control operator.



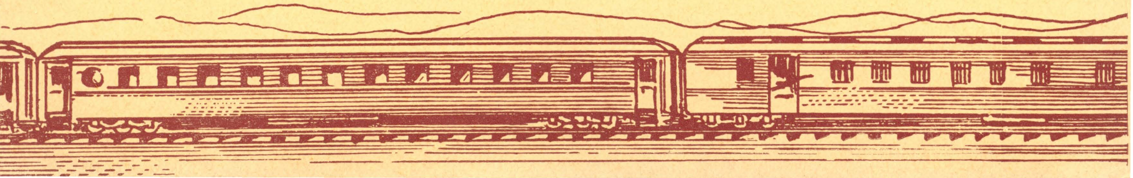


Written Train Orders Are Eliminated
by the C.T.C. Method of Operation

Comparison With Train-Order Dispatching System

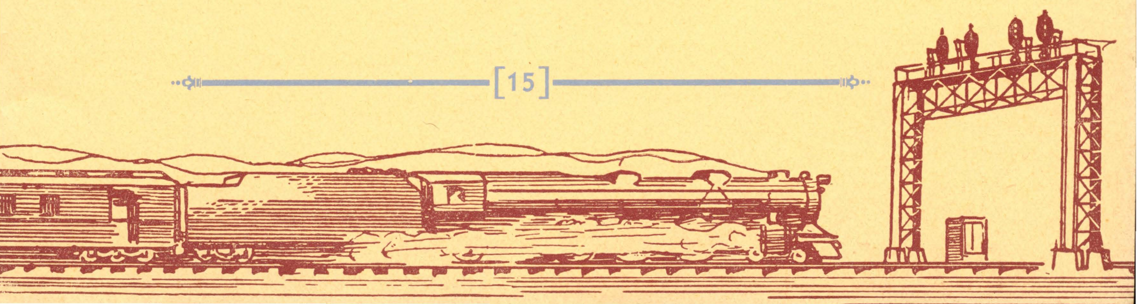
C.T.C. provides for expedited movement of trains by greatly increasing the efficiency of the train dispatcher because it provides a direct means of conveying his orders to each train without intermediary steps in transmission and without relying upon cumbersome methods of communication. Each order is given by signal indication at the point where it is to be delivered to the train which is to execute it, thus the dispatcher's control is direct and constant over all movements.

The principles of train dispatching were stated by J. J. Turner in his book on "The Telegraph as Applied to Train Movement" in a clear and concise manner. The following itemizes the way in which the C.T.C. System



meets each of the requisites set forth in this book and compares it with the train order dispatching method:

Requisite and present method of compliance	Centralized Traffic Control complies by
"**First.** That to prevent conflicting instructions and to insure safety, no more than one man can dispatch trains on the same track at the same time."—Complied with by a rule to that effect.	**First.** Conflicting instructions cannot be issued as all orders are transmitted through the control machine without involving any intermediate person.
"**Second.** That the dispatcher be kept fully advised of all delays, present or prospective, and the position of every train on the road."—Complied with by operators' reports from stations and terminals.	**Second.** Dispatcher is kept fully advised of the delays to and location of every train by the system of indications on the control panel and by the automatic train graph. These records are secured at each end of every controlled siding and form a complete and accurate source of information. Having before him graphically a picture of track and traffic conditions on the C.T.C. district, he is able to anticipate and avoid conditions that would otherwise result in delays.
"**Third.** That orders must be so clearly expressed as to render a misunderstanding of their meaning impossible."—Complied with by the use of forms of orders prescribed in standard code of train rules.	**Third.** The orders, as given by signal indication, are clearly expressed by means of a few indications at the point and time where action is required.



"**Fourth.** That the dispatcher must know that they are in the hands of some reliable party for delivery."—Complied with by operator's acknowledgement giving initials and office call.

Fourth. No second party involved in the delivery of orders.

"**Fifth.** That it is as near certain as anything human can be, that the party who is to deliver them will stop the train to which they are addressed." —Complied with at each train order office, by the use of a fixed signal which shall indicate "stop" when trains are to stop for orders.

Fifth. The signals of the C.T.C. system function without reliance upon intermediate human action to place the signal in the "stop" position and are so arranged that it is impossible to clear opposing signals.

"**Sixth.** That when delivered to trainmen, they read just as they did when sent by the dispatcher." — Complied with by rule requiring operators to repeat all orders to the dispatcher for verification.

Sixth. The orders received from signal indications are read in line with the action required by the dispatcher, because they respond directly to the manipulation of the control levers on the operating panel.

Bridgeport-Mt. Morris C.T.C. Installation—*Pere Marquette*

"**Seventh.** That the instructions given to both trains are identical."—Complied with by the use of the duplicate order system.

"**Eighth.** That the train whose rights are extended must not be moved against the trains whose rights are curtailed, without notice to the latter."—Complied with by sending the order first to the train whose rights are restricted before completing the order to the train whose right is extended.

"**Ninth.** That men who are to act upon orders, acknowledge their receipt." — Complied with by rules relating to form "31" and form "19" orders.

"**Tenth.** That men using them know that they are doing so with the full knowledge and authority of the dispatcher."—Complied with by the response "correct" from the train dispatcher, and the adherence to prescribed form of the order.

"**Eleventh.** That trains running against other trains under special orders must be able to recognize each other."—Complied by giving the number of the engine of every train mentioned in the order, or by the use of train number indicators.

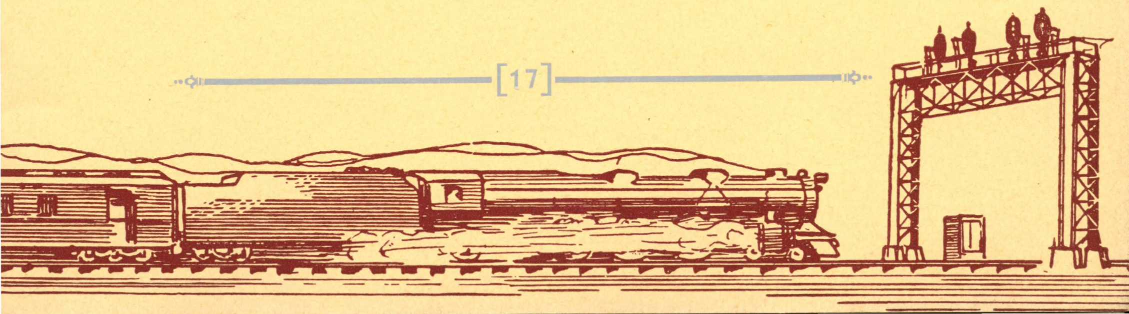
Seventh. Conflicting orders cannot be displayed by the signals because they are automatically protected by track and signal check.

Eighth. Before a signal can be displayed authorizing movement of a train, there is an automatic check which determines that the opposing signal is in the "Stop" position and that the intervening track is clear of opposing trains.

Ninth. Acknowledgment of receipt of and evidence of the action on an order are simultaneously received by the dispatcher through the indications on the control panel and the automatic train graph.

Tenth. Train crews accepting the signal indication know they are doing so with the full authority of the dispatcher.

Eleventh. There is no need for trains to identify each other, as the signal indication gives each train its authority to proceed, stop or take siding.



"**Twelfth.** That a complete record be kept of each transaction."—Complied with by use of the dispatcher's order book.

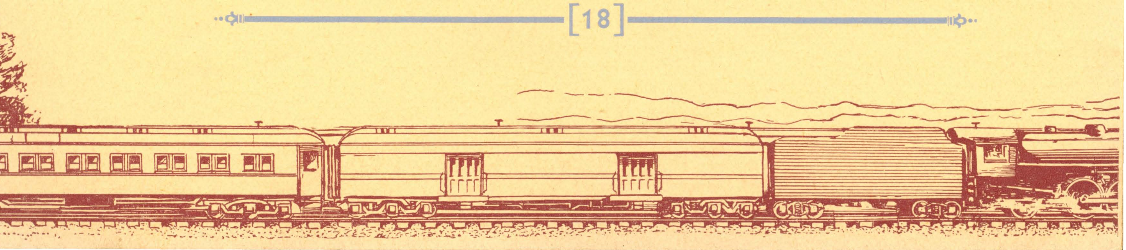
Twelfth. A complete, permanent record of each train movement is kept by means of the automatic train graph. This graph also detects and records any irregular train movements.

Thirteenth. Audible and visual indications of train movements are immediately shown on the control panel.

While the train order system, supplemented by automatic block signals, has been efficient in providing for the movement of heavy traffic and has been the means of avoiding expenditures for additional tracks, which would surely have been needed without its development, there is now a tendency to demand even greater economy of operation and greater train speed than would be possible with the most efficient functioning of the train order system. C.T.C. meets this demand by bringing the cost of installations for the operation of trains by signal indication within the economic reach of roads which have only a moderate density of traffic as well as those having heavy traffic.

Simple and Flexible Operation

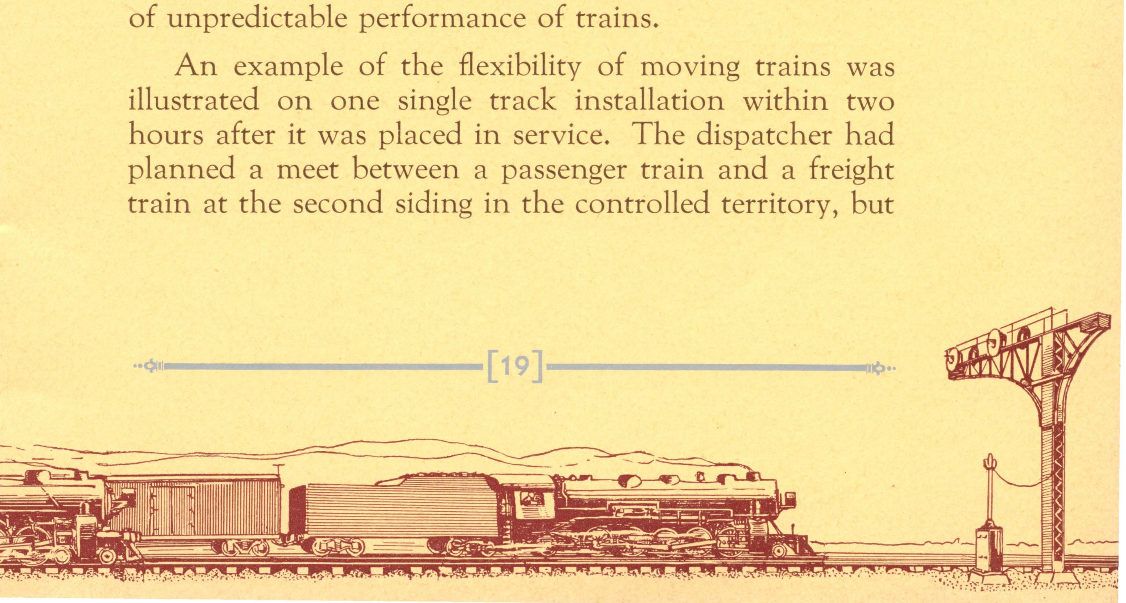
While the telephone tended to simplify the mechanics of issuing train orders and gave the dispatcher a faster means of communication, C.T.C. provides even more outstanding aid to efficient dispatching. This system cuts away all the "red-tape" in the issuing of train orders and reduces the mechanics of this operation to the simple



movement of a small lever without the intermediary action of other persons. It relieves the dispatcher from dependence upon a system of communication and form of procedure which requires a great deal of time for the completion and delivery of train orders. It gives him advantages equivalent to having an operator at each end of every siding or at every controlled location without the delays which would be involved in communicating with trains by means of the train order system. In most cases there are from three to four times as many "OS" locations as under operation by timetable and train orders because each end of a siding, and sidings which were formerly "blind," are controlled with the C.T.C. system.

With C.T.C., the dispatcher can devote practically all of his time to the planning of meets and passing moves and to the multitude of other duties which have gradually fallen to his lot. While the C.T.C. machine can be operated by anyone, without the slightest chance of causing an unsafe condition, it does not follow that the system provides a substitute for the good judgment of an experienced train dispatcher in the planning of train movements. C.T.C. provides the operating tool which makes it possible for dispatchers to quickly secure action on their planned movements, by shortening the time element between planned decision regarding a train movement and execution of the order. The dispatcher is given every facility for quickly changing his plans in the event of unpredictable performance of trains.

An example of the flexibility of moving trains was illustrated on one single track installation within two hours after it was placed in service. The dispatcher had planned a meet between a passenger train and a freight train at the second siding in the controlled territory, but



the passenger train was delayed before reaching the C.T.C. section. While the freight train was entering the siding where the meet was planned, the dispatcher decided to change the meeting point. He immediately lined up the exit switch of the siding, permitting the freight train to proceed without stopping. Meanwhile the passenger train got under way and it was possible to make a meet at the first station beyond the end of double track without either train being stopped.

Instantaneous Control Over Train Movements

One of the principal advantages of C.T.C. from the standpoint of the dispatcher is that he need not place orders far in advance for trains, but can quickly set his meeting points depending upon the performance of trains. His hands are not tied because of orders placed previously which keep him from changing a meeting point. He is constantly in control and always has the maximum facilities available for straightening out congested situations. Orders are not placed at terminals or junctions for trains a long time before they are ready to depart thus tying up other movements. It is not necessary to give a signal authorizing a movement until the train is ready to proceed and thus the last-minute delays in getting a train out of a yard do not have to be taken into account by the dispatcher.

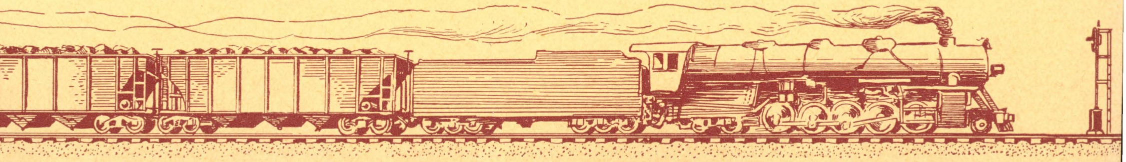
The "OS"ing system which is provided by the indication lights and the train graph on the C.T.C. machine gives the dispatcher instant and accurate information as to the performance of trains. This information is far more accurate and these indications are received in greater frequency than the operator's reports under the train order system. It is complete in that it indicates the

Typical Arrangement of Signals at End of Siding. Arrows Show "OS"ing Section.

instant of a train's arrival, the time consumed in passing and the instant the last car leaves the controlled point.

With the C.T.C. system, dispatcher's transfer requires a very short time, inasmuch as the safety checks involved in the train-order system become unnecessary. The dispatcher being relieved does not have to keep his "hand in" to insure that a particular set of conditions he has set up be carried to completion. The transfer can be made quickly, even with a number of trains on the territory.

Inasmuch as the C.T.C. System is capable of handling the maximum physical capacity of the line without the



addition of employees for the handling of train orders, the dispatcher does not have the handicap of being forced to work with inexperienced operators at the very time when efficiency is most important. At times of peak traffic the dispatcher can operate the control machine with as much ease as at lower traffic densities, and it is at such times that the greatest savings in train time over the previous method of operation are noted.

Comments of Operating Officers

Train dispatchers and operating officers who have had experience with the operation of C.T.C. installations, are enthusiastic about the improved performance experienced. Included as Appendix "A" are typical examples of the opinions of this group with regard to the advantages of the C.T.C. method of train operation.

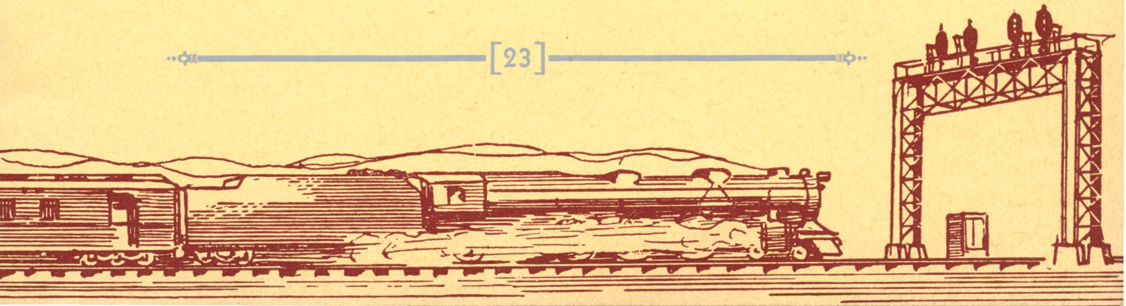
Train Stops for Throwing Switches are Eliminated.

C.T.C. Adaptable to a Variety of Conditions

C.T.C. has a variety of applications in the solution of traffic problems on a railroad at congested points where the movement of trains by signal indication over short distances provides relief. These installations do not require the direct attention of the train dispatcher, and are controlled by another designated employee, because the amount of traffic and the length of the section fall considerably short of what would be considered a dispatching district.

Most installations of C.T.C. are made in connection with automatic block signals, or are adapted to existing automatic block signal systems, because it is generally desirable to provide intermediate automatic signals to provide for close following moves. In some cases the volume of traffic does not warrant the operation of switches by the system, or the provision of intermediate block signals, and it is possible to considerably modify the installation to meet these conditions or to adapt the system to a controlled manual block installation, while at the same time the advantages of operating trains by signal indication is retained and many economies of operation are achieved, even at low densities of traffic. Each installation presents a different problem and may be designed with regard to the particular operating requirements involved.

C.T.C. is sometimes thought of as applicable only to single track railways, but, as a matter of fact, it is used on double track lines, or lines with any number of tracks, quite as effectively in providing for either direction movements. The apparatus may also be used for the remote

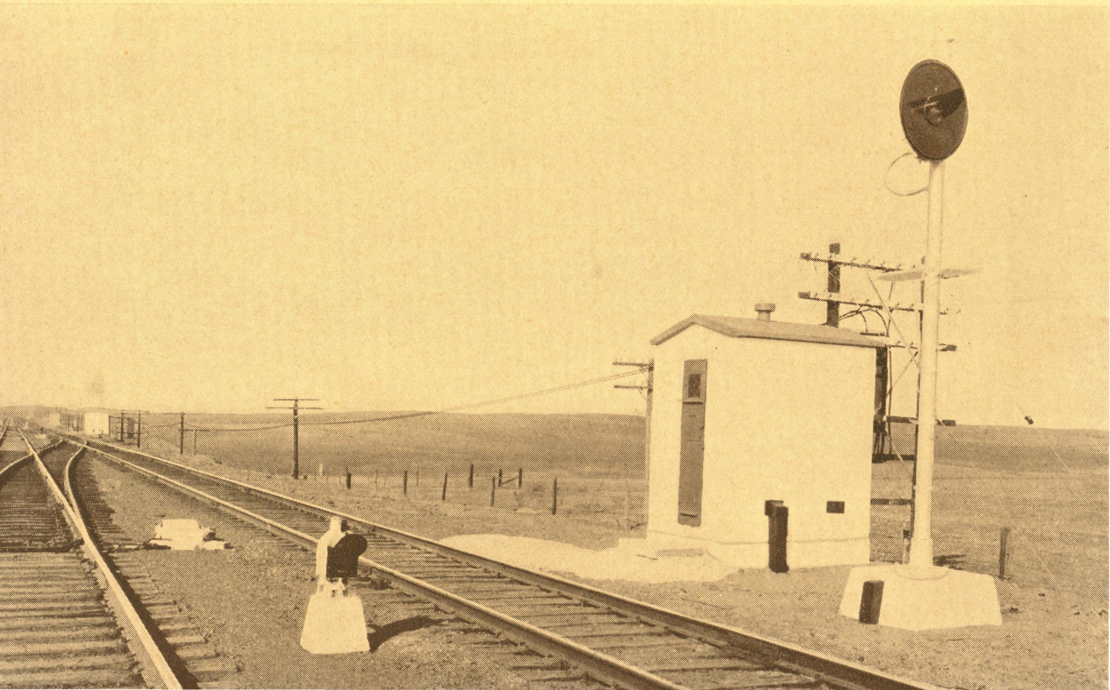


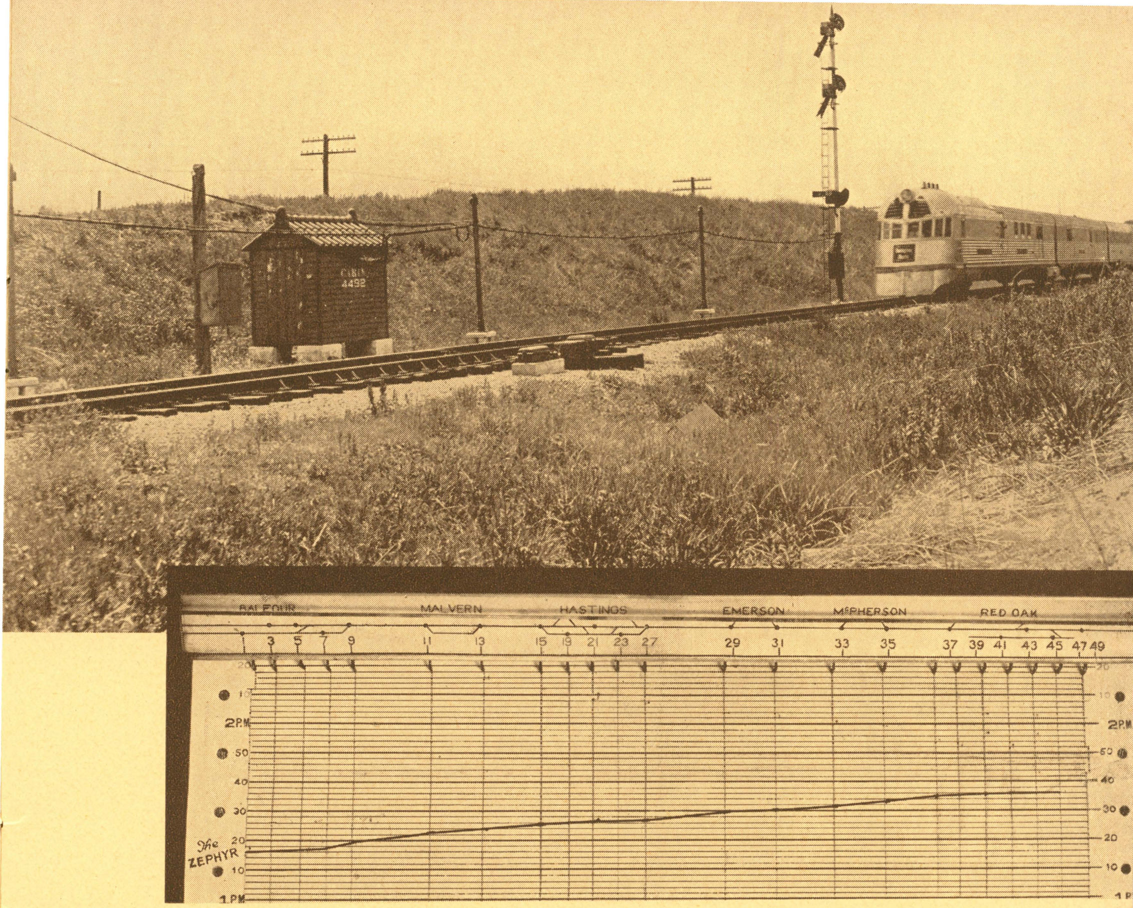
control of single switch locations and of interlocked layouts. It may be applied to sections of any length to achieve the solution of traffic problems of all kinds. Some exceedingly interesting installations of C.T.C. have been made on short "bottle-neck" sections of line and have brought about greatly expedited movement of trains. Several installations have been made to replace staff systems and have materially reduced the cost of directing trains. Short sections of C.T.C. are substantially elongated interlockings, because they involve the acceptance and handling of trains by the operator in much the same way that they are handled at any interlocking.

Applicable to Long and Short Sections

By far the most interesting application of C.T.C. is its use as a system to authorize, direct and govern the movements on a section which comprises the whole or a large portion of an operating district, supplanting the usual train dispatching system. Short isolated sections at points removed from the dispatcher's office are generally handled

C.T.C. Controlled Cross-over Dodge City-Kinsley Installation—*Santa Fe*





The Automatic Train Graph Shows that "The Zephyr" on its Record Run Averaged 84 M. P. H. through this 26.6 Mile Section Equipped with C. T. C.—*Burlington*

by an operator adjacent to the territory, under the supervision of the train dispatcher, because the local control is desirable for one reason or another and because the indirect control exercised by the dispatcher is satisfactory from the operating point of view.

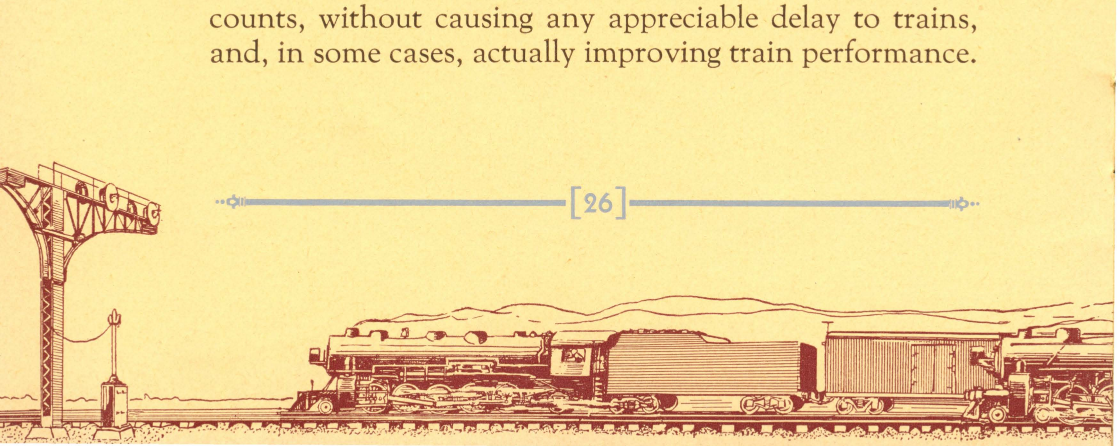
Where local conditions require an attended interlocking within C.T.C. territory, supervisory control of the signals common to the C.T.C. system and the interlocking is provided, so as to give the control operator supervision over the manipulation of signals which effect the functioning of the C.T.C. system.

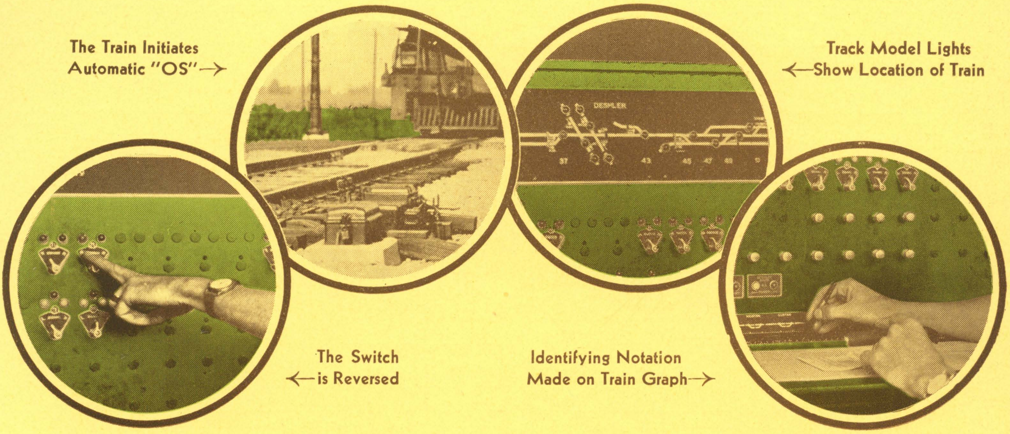
This arrangement requires the cooperation of the local operator and the control operator to clear signals for movements at the interlocking which affect through movements of trains on the C.T.C. territory, but permits all other movements within the interlocking to be handled locally in the usual manner.

C.T.C. may be used effectively on double and multiple track lines where there is a directional peak traffic or where it becomes desirable to eliminate the delay incident to passing trains. The cost of equipping certain tracks for either direction operation is small compared with the cost of additional tracks to handle the peak loads. This method of operation permits the handling of freight trains at a time when the passenger movement in the same direction is heavy and the movement on the opposite track is light.

On a road with many junctions, where the number of trains is large and the average movement short, C.T.C. eliminates the delays at junctions which are inevitable under train order operation because of the necessity for securing orders, clearances, etc.

C.T.C. has been considered as the means by which a double track section of railroad may profitably be converted to single track, when there has been a change in traffic conditions which no longer make a double track line necessary. Various studies which have been made indicate that these projects can be undertaken so as to produce substantial savings in maintenance of way accounts, without causing any appreciable delay to trains, and, in some cases, actually improving train performance.



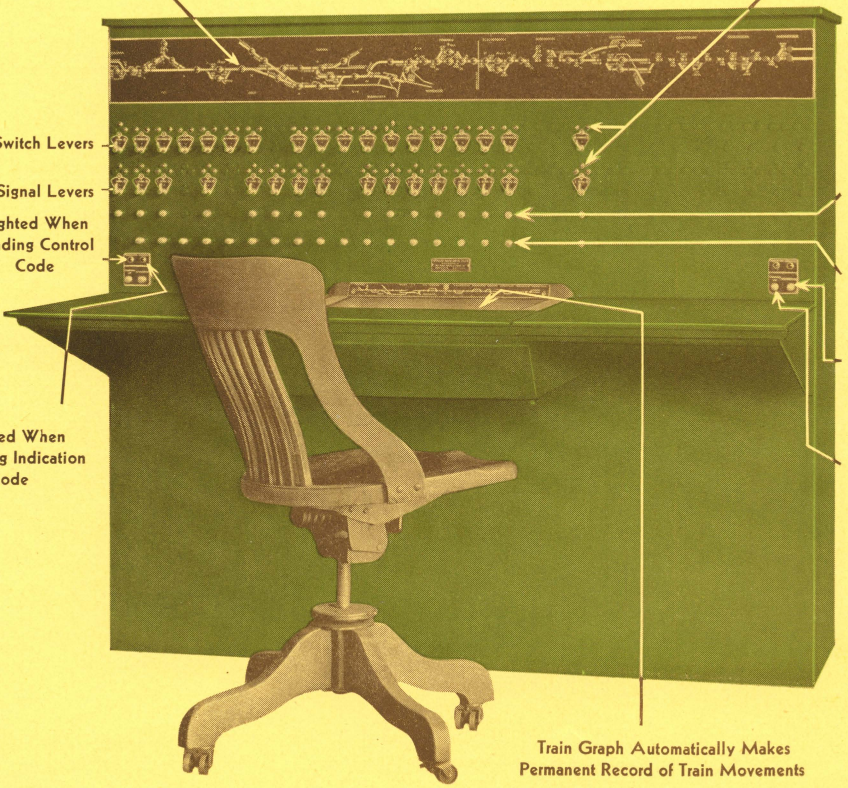


The Train Initiates Automatic "OS"

Track Model Lights Show Location of Train

The Switch is Reversed

Identifying Notation Made on Train Graph



Location of Trains Indicated by Lights on Track Model

Machine Designed to Provide for Extension of C. T. C. to Adjoining Section

Position of Switches and Signals Indicated by Lights Above Corresponding Levers

Switch Levers

Signal Levers

Lighted When Sending Control Code

"Call-On" or "Stick-Non-Stick" Button

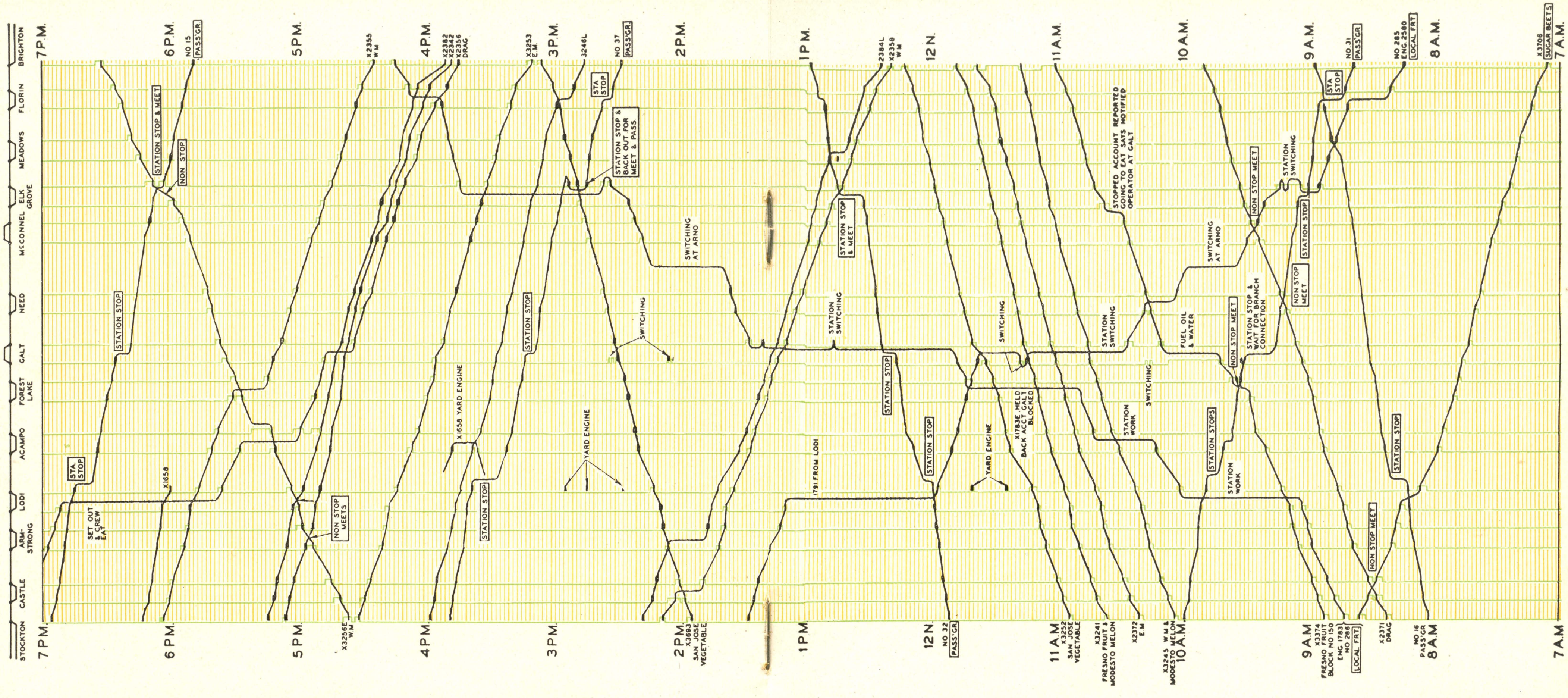
Code Starting Button

Knock-Down Button Control Code

Lighted When Receiving Indication Code

Cut-Out Button "OS" Bell

Train Graph Automatically Makes Permanent Record of Train Movements



SOUTHERN PACIFIC COMPANY ◆ STOCKTON TO BRIGHTON

CENTRALIZED TRAFFIC CONTROL TRAIN CHART

This chart is a reproduction of the 7:00 A. M. to 7:00 P. M. portion of the actual "Automatic Train Graph" of October 11, 1930, together with added comments and explanations

The traffic in this twelve hour period amounts to 24½ trains, which is at the rate of 49 trains per day. It is divided as to class and direction as follows:

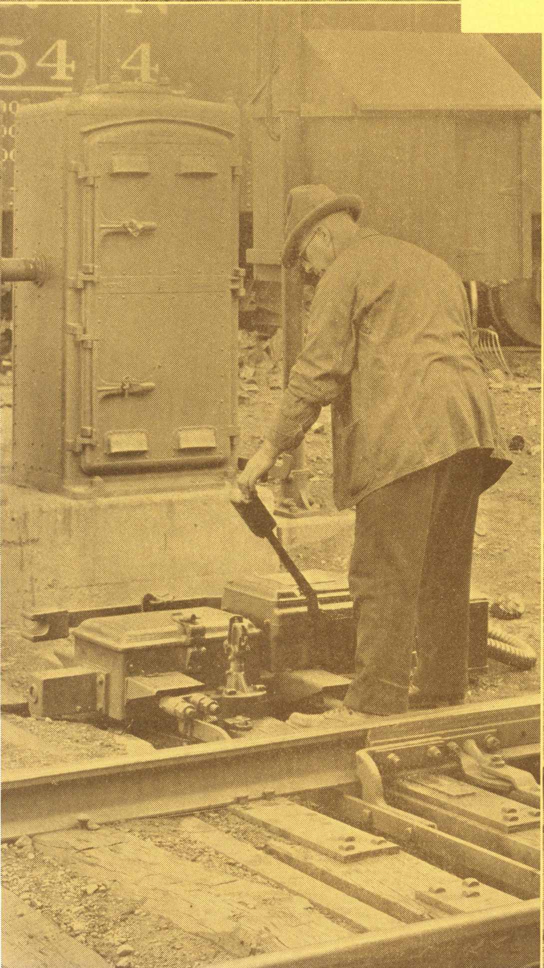
Kind of Trains	No. Trains Eastward	No. Trains Westward	Total Trains
Passenger	2	3	5
Local Freight	1	1	2
Through Freight	8	6	14
Set Out (Empties)	0	1 (X2356)	1
Light Engines	0	2½	2½
Total	11	13½	24½

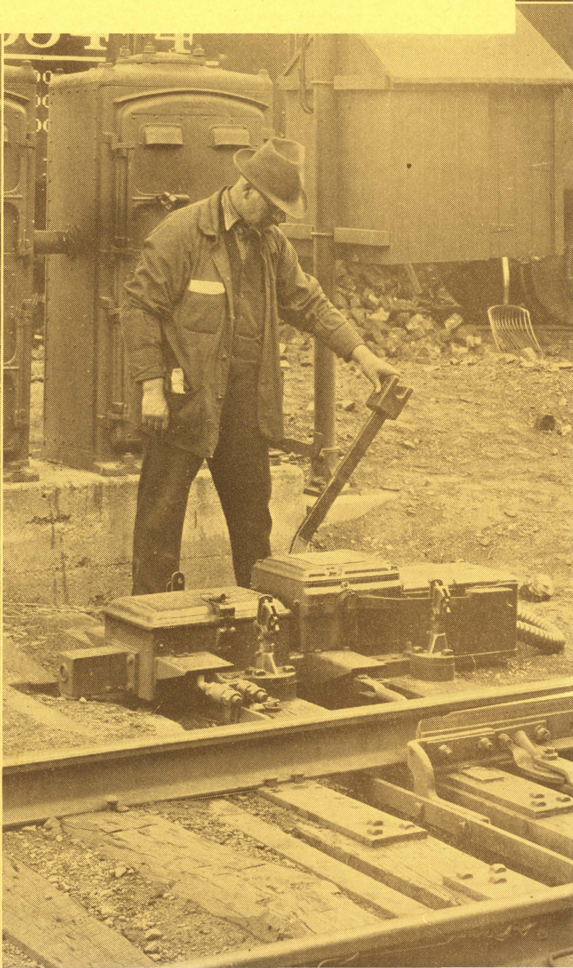
It will be noted that the delay to all trains, due to train interference, is negligible in spite of the comparatively dense traffic and is very much less than ordinarily obtained on a single track railroad with equal traffic operated under the train order system. The average speed for the 14 through freights, including some work at the intermediate stations, is 24.62 miles per hour, or 1h. 29m. for the 35.7 mile trip.

The total delay due to meets for the 14 through freights is only about 46 minutes, that is, the 14 through freights could only have made their trips at a saving of not more than three minutes on each train, if a second track had been available. However, the time saving by a second track would have been less than the 46 minutes since the passes made on the single track, with the Centralized Traffic Control System, were unquestionably made with less delay than would have been the case on double track with a train order system.

Of a total of 31 times that trains took siding for a meet or pass, apparently, 7 times neither train stopped, 16 times one of the trains stopped for station work and the train being met was not delayed, 3 times a light engine was stopped, and only on 4 of the 31 occasions was a train stop involved due entirely to a meet.

To hand-operate switch, trainman calls operator for authority. When granted, operator places tag on switch lever. Trainman then throws selector lever setting opposing signals red and hand-operates the switch as required.

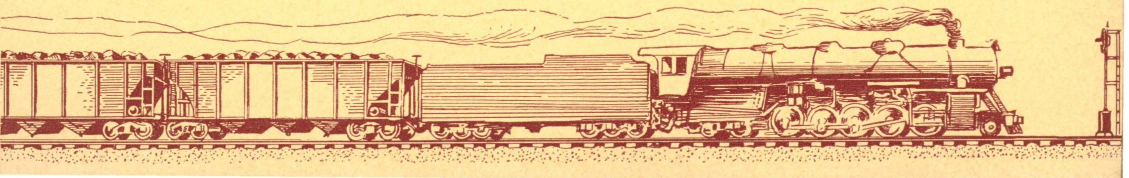




C.T.C. Controlled Junction
Boston and Maine

Power-Operated Switches Make Non-Stop Meets Possible

The operation of siding switches by C.T.C. eliminates the stop to enter siding and the stop to close switch on leaving siding, thus reducing delay time at meeting points and often making it possible for a dispatcher to advance a slow train one or more stations against a faster scheduled train. On many installations non-stop meets are frequently reported, some roads stating that practically all its meets on the C.T.C. section are of the character where neither train is required to stop. The non-stop meet is the engineman's creation and is another illustration of the extent to which C.T.C. brings about co-operation between those who operate trains and those who direct their movements. To make a non-stop meet or pass, there must first be a very close meet, planned by the dispatcher, and secondly expert handling of the speed of the train by the enginemen involved. Enginemen take pride in showing their ability to make meets of this kind.

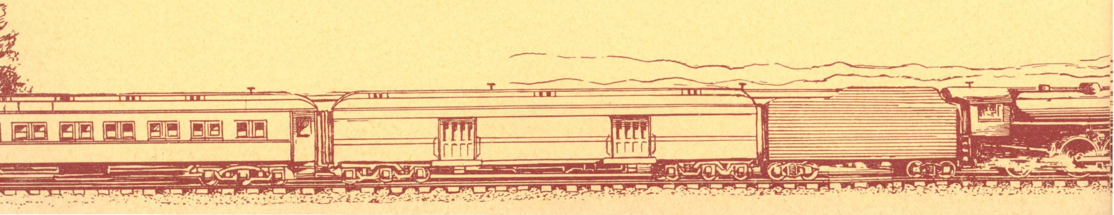


Controlled Location, Metropolis-Paducah,
C.T.C.—*Paducah and Illinois*

Local Freight Trains Aided

With the C.T.C. system, local trains may work at switches leading from the main track while other trains are routed through the siding without delay to the local work or to the through movement. The control operator can protect movements made to points between sidings. When main tracks are to be used for work by local trains, telephone authority is granted by the control operator for use of the track for a specific time, after which authority must again be obtained.

Time saved to local freights and switching crews is frequently considerable, because these trains can be moved when they are ready to go, without the delays incident to securing additional train order authority, or awaiting the arrival of superior trains appearing on timetable schedules.

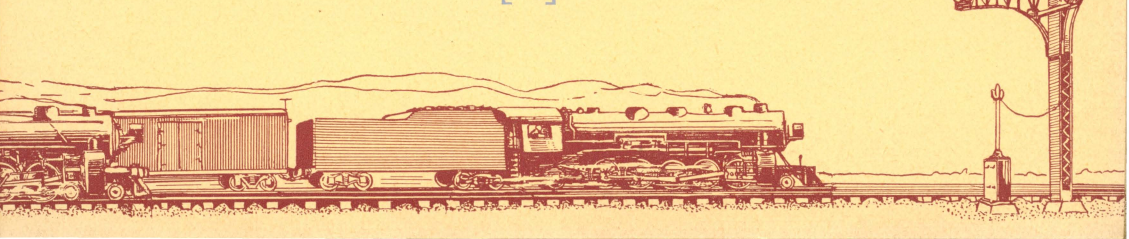


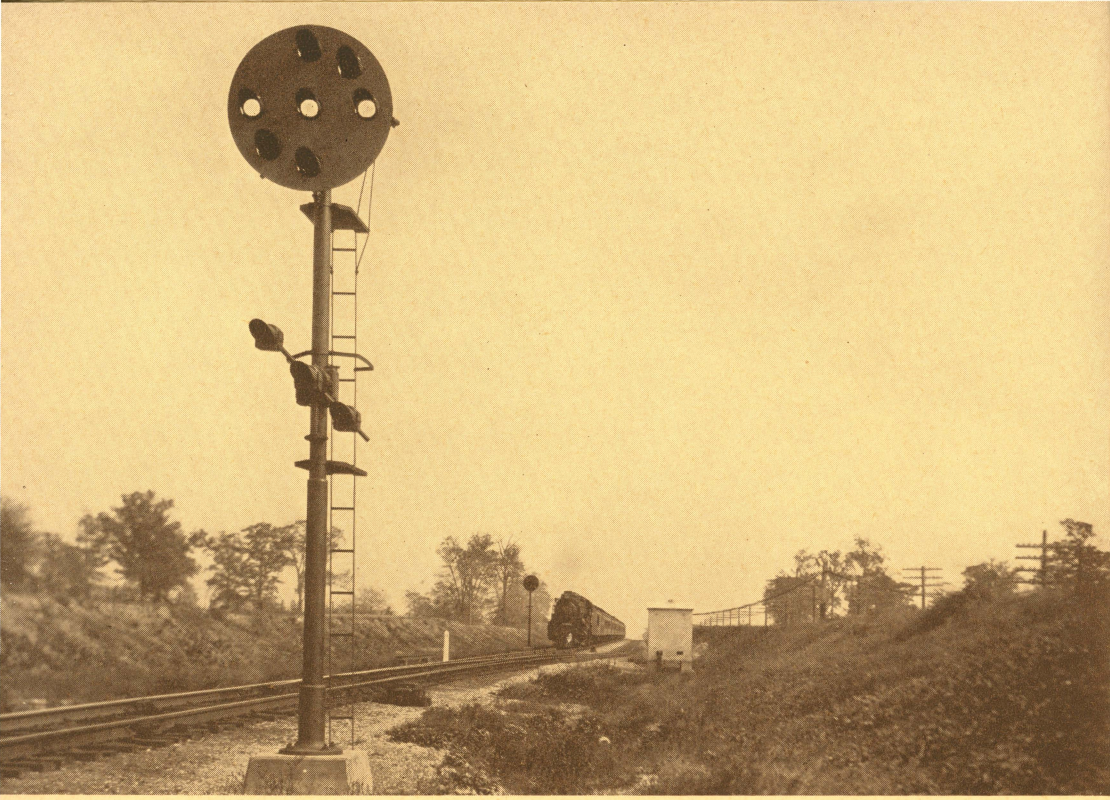
C.T.C. Aids Supervision

C.T.C. is an aid to efficient supervision of the performance of train and engine crews because it provides for the movement of all trains by signal indications, with timetable schedules being used only as information as to the running time to be maintained. Through the train graph record, frequent checks can be made on the performance of trains with regard to speed between stations and observance of signals. These time checks are fully as accurate as could be made by stop watch check between these points and are much more accurate than a check made from operator's "OS" reports.

Disregard of signal indications and running by a controlled signal in the "STOP" position are immediately detected by the indication system on the control panel and recorded on the train graph. For example, shortly after the placing in service of a C.T.C. installation on one road, an engineman, who attempted a water-tank "spot," slid by the signal at the end of the siding a few feet and had to back his train to the tank. When he arrived at the dispatcher's office, he was greeted by the dispatcher who asked him what was the matter with the handling of his train and why he had overrun the water spout. The dispatcher demonstrated the source of his information on the control machine much to the surprise of the engineman. In many instances broken rails have been detected by the indications on the control panel and often repairs made before the next train reached the vicinity of the break.

Rules for the operation of trains by signal indication are so much simpler than those for operation by timetable and train orders, that the trainmaster has an easier





C.T.C. on Heavy Traffic Single Track
Ben Davis-Almeda—*Pennsylvania*

task in seeing that they are obeyed. The controlled signals have the same characteristics as signals at interlockings and as such are accorded a wholesome respect by train and engine crews.

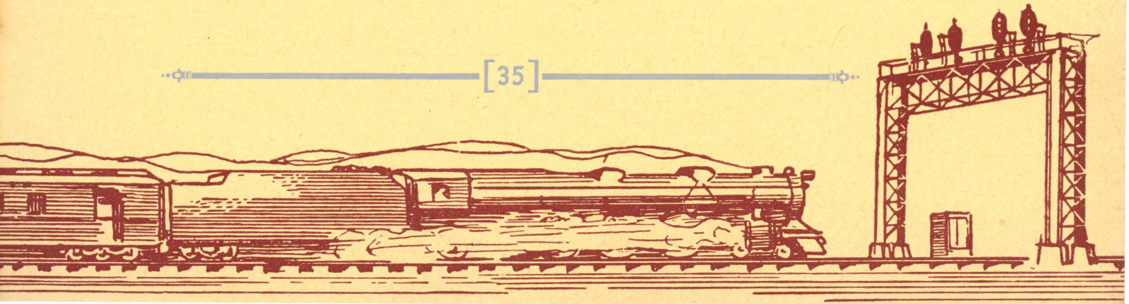
Congestion at various "bottle-neck" locations is eliminated, or greatly reduced, so that it no longer becomes necessary for a supervisory officer to spend practically all his time, during periods of peak traffic, to help untangle congested situations, caused by the tendency of trains to bunch at fuel and water stations, junctions, ends of double track, etc., when operating under the train order system.

Economic Advantages of C.T.C.

The economic advantages of C.T.C. result principally from the following basic sources:

1. The conservation of capital, by providing increased capacity of existing facilities at a much lower cost than by other methods.
2. The reduction of operating expenses, by providing for greater efficiency in the movement of trains, by reducing the number of train hours and by the elimination of train stops to take siding or receive train orders.

The operating savings will be greatest in the individual items which go to make up the direct cost of running trains, such as overtime wages, fuel, the wages of telegraph operators and the expense of maintaining telegraph and block stations; but there will also be other operating accounts in which savings will be brought about by greater efficiency. The savings in per diem charges because of expedited movement and the release of rolling equipment for a new tour of productivity is sometimes important. Freight train time savings on 10 installations ranged from 17.2 per cent to 47 per cent and averaged 28.1 per cent. The time savings ranged from 0.6 minutes to 1.85 minutes per freight train mile and averaged 1.2 minutes. The speeding up of traffic may make it possible to move the tonnage of the division with fewer locomotives. On some installations it has been possible to increase the tonnage of trains because it is possible to have trains enter sidings without stopping. On others, the reduced time over the C.T.C. territory has made it possible to load trains heavier on subsequent divisions



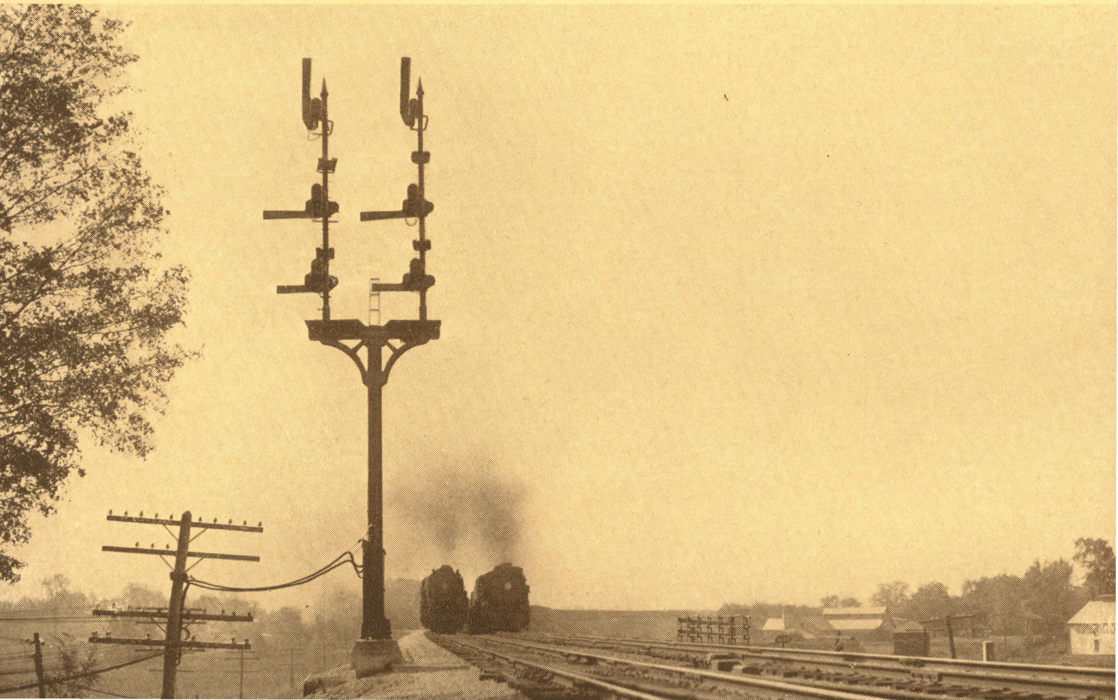
and still make delivery schedule at the final terminal. On one installation the gross ton miles per train hour increased 57 percent and on another installation the increase was 87 percent.

The return on the investment after interest charges and other expenses, ranged from about 15 percent to 47 percent on a number of installations upon which published data is available. Savings on some smaller installations often exceed this.

Included as Appendix "D" will be found a list of references to articles describing various typical installations of Centralized Traffic Control. Many of these contain discussions of the economic advantages of the installations.

The economic advantages of C.T.C. and other signaling systems are discussed in Chapter III. of American Railway Signaling Principles and Practices published by the Signal Section, A.R.A. This chapter includes a summary of published data relative to signal installations which will undoubtedly be interesting to operating officers.

C.T.C. Provides for Either Direction Operation by Signal Indication



Increased Safety and Intangible Advantages

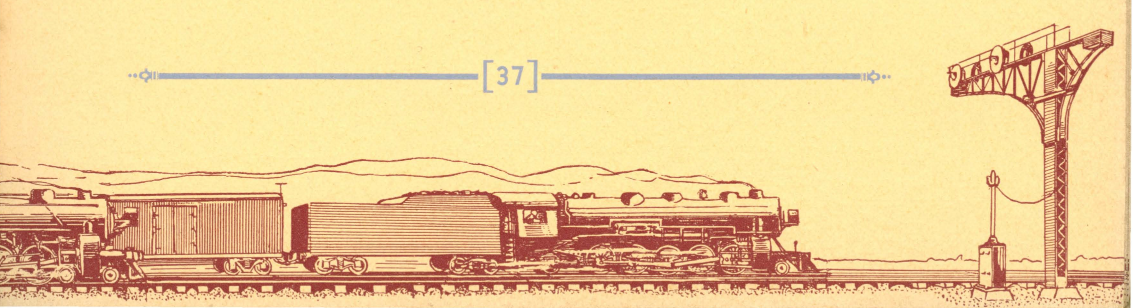
The safety aspects of dispatching trains are transferred from the train dispatcher to the signal system, which forms a part of the installation, and his concern thus is primarily directed toward the movement of trains, rather than the protection of those movements. The following lists some of the causes of accidents that have occurred under train order operation that are directly due to failure on the part of one or more persons to perform their duties as intended.

Errors on the part of the train dispatcher

1. Sending an improper order.
   - (a) One which in and of itself will cause an accident.
   - (b) A potentially dangerous order which is so involved that it is apt to be misinterpreted by those to whom it is addressed.
2. Failure to address copies of the order to all those concerned with its provisions.
3. Failure to properly check repeated orders to insure that operator has correctly copied them.
4. "Completing" an order before receiving proper signatures.
5. Authorizing a clearance card without checking the number of orders.
6. Failure to act properly with respect to orders issued by dispatcher on previous trick.

Errors on the part of the operator

1. Improperly copying, checking, or repeating orders.
2. Failing to deliver all orders addressed to a train.
3. Making an incomplete clearance card.
4. Improper manipulation of the train order signal.
5. Failure to act properly with respect to orders turned over by operator on previous trick.
6. Improper use of block system in manual block territory.



Errors on the part of the train and engine crews

1. Failure of conductor to deliver order to engineman.
2. Failure of train and enginemen to understand orders.
3. Forgetting provisions of orders.
4. Misreading of orders.
5. Failure to perform all the provisions of orders.
6. Disregard of rule requiring all members of crew to read orders.
7. Improper identification of trains.
8. Incorrect check of train register.
9. Running on short time against an opposing superior train.
10. Failure of engineman's watch or improper reading of same.
11. Overlooking a scheduled train.

The principal check upon the safety of the train order system lies in the fact that practically every accident requires the failure of more than one person. The dispatcher has the least chance of having his mistakes corrected by another employee, yet the number of accidents for which a train dispatcher was at fault or contributed to the cause, is a very small portion of the total number of accidents which have resulted from errors or failures under the train order system of operation. With the C.T.C. system, train orders are abolished, hence the additional safety of the system is at once apparent.

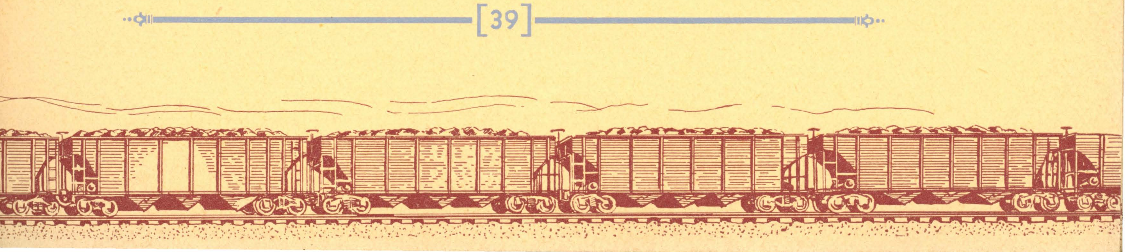
A report by Committee I, Signal Section, A.R.A., on the increased safety and intangible advantages of C.T.C., was presented at the March, 1934, meeting of the Signal Section. Because this report contains an excellent summary of the intangible advantages of C.T.C., it has been reproduced and included as Appendix "B" of this Bulletin.

Advantages of Centralized Traffic Control to Train and Engine Crews

One highly important feature in the C.T.C. method of train operation, a feature which is the groundwork of both economy and safety, is the benificial effect of the method of train operation by signal indication upon the morale of train service employes.

The problems which confront trainmen who are responsible for the safe and expeditious movement of freight trains on single track roads, where trains are moved by means of written orders, are many and varied. They call for the exercise of independent judgment concerning the treatment of emergencies that constantly arise, and which cannot be foreseen. Trainmen are compelled to make quick decisions, with the ever present chance that their decisions may be wrong, leading to a delay for which they will be criticised, or to an accident for which they will be discharged. Whatever action they may decide upon, also usually requires the cooperation of one or more persons upon whom they must depend, and whose actions they cannot control. The result is that from the beginning to the end of a run, trainmen are under a constant nervous strain, which is not fully appreciated by those who have never been subjected to similar experiences.

Under the C.T.C. method trainmen are relieved from all nervous strain. A few simple rules, governing the action required with the display of certain signal indications, take the place of much more complicated rules for operation with train orders. Such decisions as trainmen are called upon to make are based upon accurate knowlledge, and the result cannot fail to produce better morale and a more efficient personnel as well as greater safety.

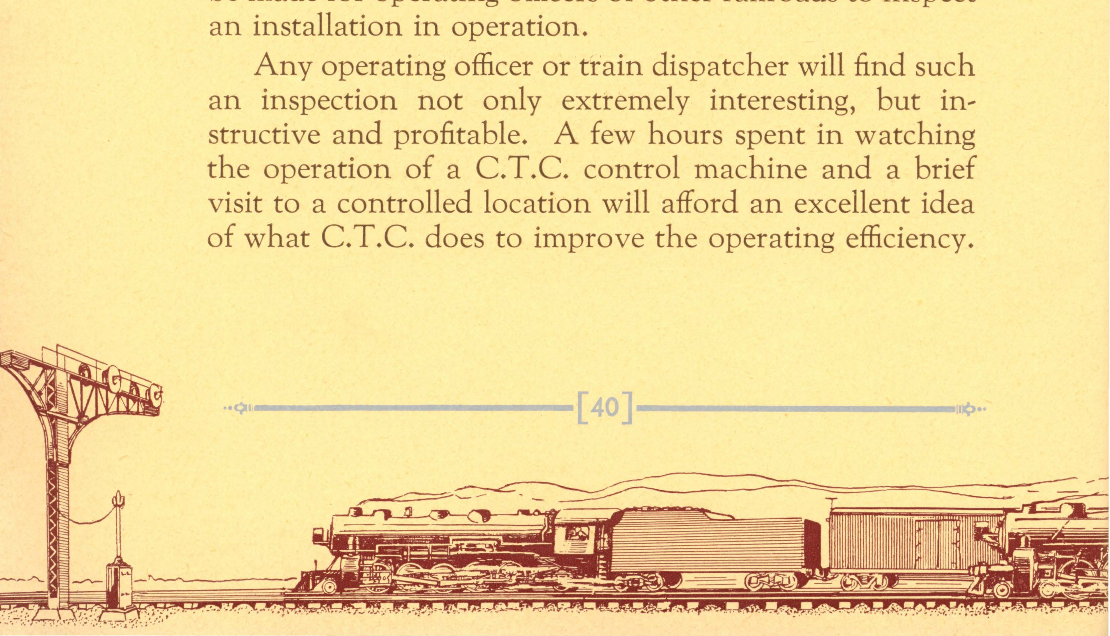


C.T.C. Applied to Junction of Two and Four Track Sections
Central of New Jersey

Location of C.T.C. Installations

As of September 1, 1934, there were 150 C.T.C. installations in service on 43 railroads, as shown in Appendix "E." These installations provide for train movements by signal indication on 1735 miles of track, through the control of 3173 signals and 996 power operated switches. Many of these may be reached conveniently from most sections of the country, and arrangements can ordinarily be made for operating officers of other railroads to inspect an installation in operation.

Any operating officer or train dispatcher will find such an inspection not only extremely interesting, but instructive and profitable. A few hours spent in watching the operation of a C.T.C. control machine and a brief visit to a controlled location will afford an excellent idea of what C.T.C. does to improve the operating efficiency.



APPENDICES

C. T. C. is Applicable to Long as well as Short Sections. This Location, at End of Double Track at State Line, Ind., is Controlled from Peru, 93 Miles away—*Wabash*

Adverse Weather Conditions do not Interfere with Proper Operation. Eastbound freight in C.T.C. Territory at Hoosick Junction, Mass.—*Boston and Maine*

Appendix "A"

Comments of Operating Officers

Train dispatchers and division officers who have had experience with operation under C.T.C. are without exception enthusiastic over the improved performance experienced. The following comments are examples:

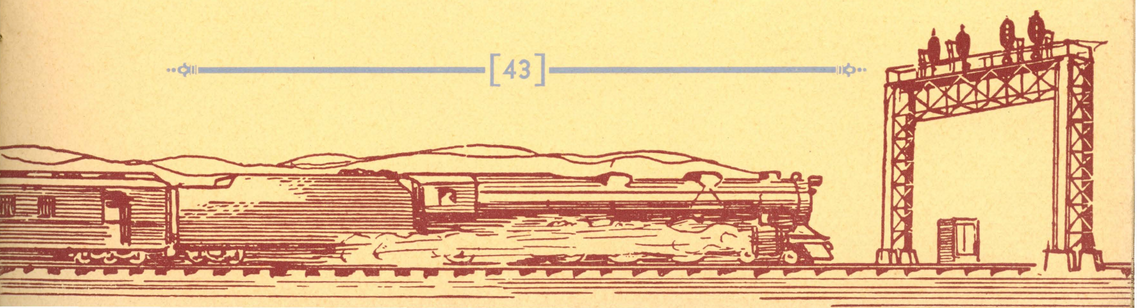
"These installations have more than returned their cost at this time and I can say to you frankly that we are very much interested in signal installations."

"I believe it is the greatest development towards expediting train movements and reducing operating costs that we have seen in the last twenty-five years or more."

"Our men like it very much, they can always go when ready. We haven't had a terminal delay since I don't know when. Crews have nothing to remember—they act at the time and place they are supposed to act, one thing at a time, and in my opinion the movement of trains by the indication of signals is the greatest movement in the safety first program that has yet been devised."

"Our non-stop meets are so regular that they do not attract attention any more. Every engineman seems to think he should make non-stop meets.

"We recently had a day with 55 train movements, which has been our heavy day—although I noticed no excitement about it. You can imagine what it would have been if we were operating under the train order system."



"We are equipped with automatic signals and Centralized Traffic Control, whereby trains are operated by the indication of signals, so can appreciate all the good things these do for the railways.

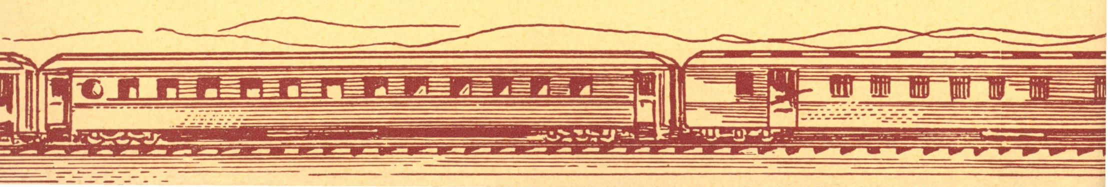
"We haven't issued a train order of any kind or description since December 18, 1929, except last month when we moved our dispatcher's office from one building to another, when it was necessary to put out but one written order.

"Our train and enginemen are enthusiastic about the traffic control.

"In my opinion, moving trains by the indication of signals is the biggest improvement in train operation since the automatic air brake was adopted."

"Aside from the usual safety features peculiar to automatic block signals, and interlocking, this system within an hour after being placed in service demonstrated a new one. It occurred as follows:

"A freight train with approximately 80 cars passed the dispatcher's office on the east main. It was observed that there was a car off center in about the middle of the train, the front trucks being driven back to about the middle of the car. The route had already been lined up for the through movement. The dispatcher restored the signal in advance of the train to the stop position, stopping the train at the end of double track. A member of the crew immediately came to the phone at the stop signal, in accordance with instructions, and was told of the trouble by the dispatcher. The defective car was cut out. Under the old arrangement, it would have been impossible to notify the crew until the next office was reached, approximately four miles away. It is quite probable that the front end of the defective car would have dropped down to the track before reaching that point, thus causing a serious accident."



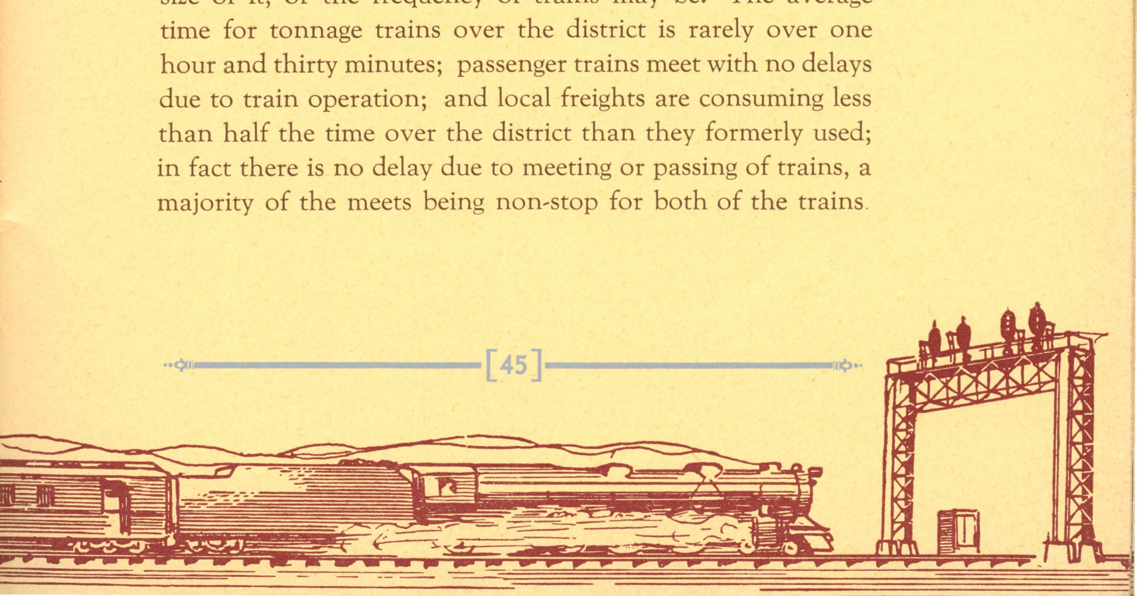
"Since we put our C.T.C. in operation, I have maintained that it was the most efficient and effective method of dispatching trains I had ever seen."

"The advantages of C.T.C. in the operation of trains are many; a few of these advantages are listed below:

"During the peak movement of perishables before the installation of this equipment, freight trains often consumed eight to ten hours over the district, due to the large number of opposing trains to be met, and the number of passenger or more important trains which it was necessary to pass by them. A considerable portion of this delay was due to having to hold such trains back in order to avoid bunching them, and thereby avoid bad saw-bys. It was a daily occurrence for important trains to be held awaiting train orders which would permit them to move, and often times they were moved from one telegraph office to the next, at which point they were again held awaiting further orders.

"Passenger trains, also, frequently met with delays sawing by long freight trains due to inability of the train dispatchers to keep them from bunching.

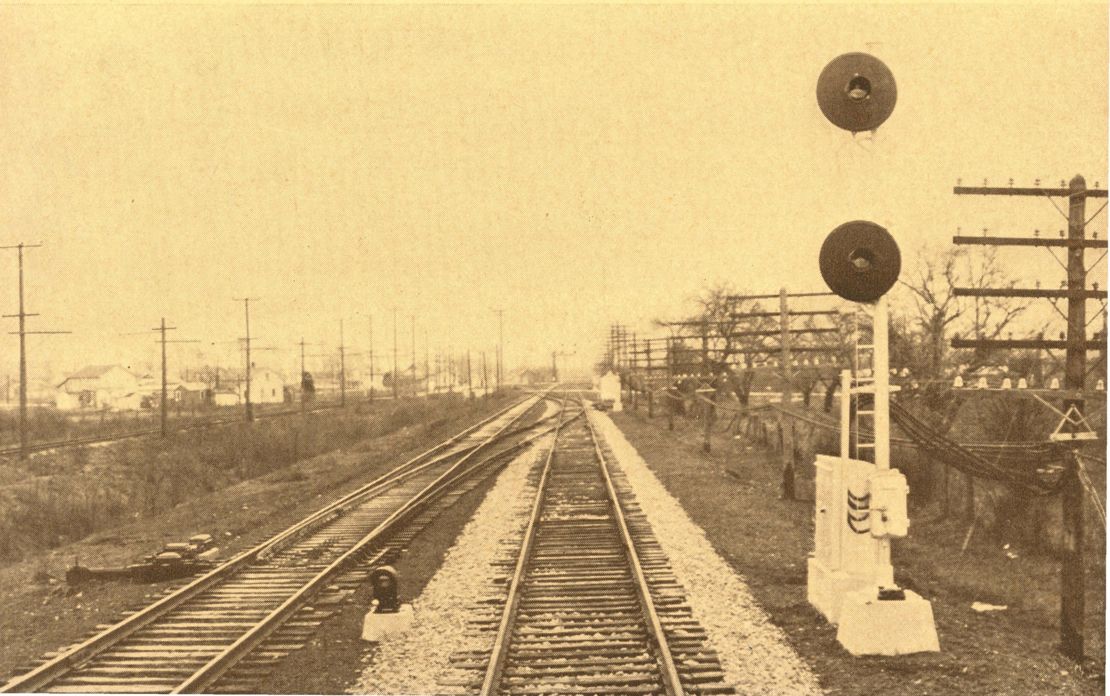
"Since C.T.C. was installed, these delays have all disappeared. The movement, from the moment a train appears at either end of the district, being continuous and with not an instant's delay starting, no matter what the class of train, size of it, or the frequency of trains may be. The average time for tonnage trains over the district is rarely over one hour and thirty minutes; passenger trains meet with no delays due to train operation; and local freights are consuming less than half the time over the district than they formerly used; in fact there is no delay due to meeting or passing of trains, a majority of the meets being non-stop for both of the trains.



"The fact that the train dispatcher controls the switches and signals at each end of each siding enables the dispatcher to instantaneously change a meeting point, so that delays are reduced to the absolute minimum, and changes can be made in an emergency that would be impossible by train order operation.

"I consider C.T.C. installation equal to, and in some respects better than, double track. In fact, several moves can be made with this equipment that are impossible without it. For instance, one train may be headed onto siding, and while this train is drifting to the opposite end of the siding, a fast train may pass it, with neither train being brought to a stop. Also, due to the fact that switches are lined by the dispatcher, a heavy freight may be advanced one or more stations beyond the point where it would have to let a faster train by under ordinary double track operation. This, due to the fact that the dispatcher lines the switches, saving the time necessary to stop train, throw the entering switch, start the train and pull into siding, and throw the switch in order to clear the automatic signal nearly a mile away, then wait for the fast train to pass. Under C.T.C. this twenty or more minutes need not be considered as the entire move is made without bringing the slow drag to a stop."

C.T.C. Location, Maumee, Ohio
Nickel Plate



Appendix "B"

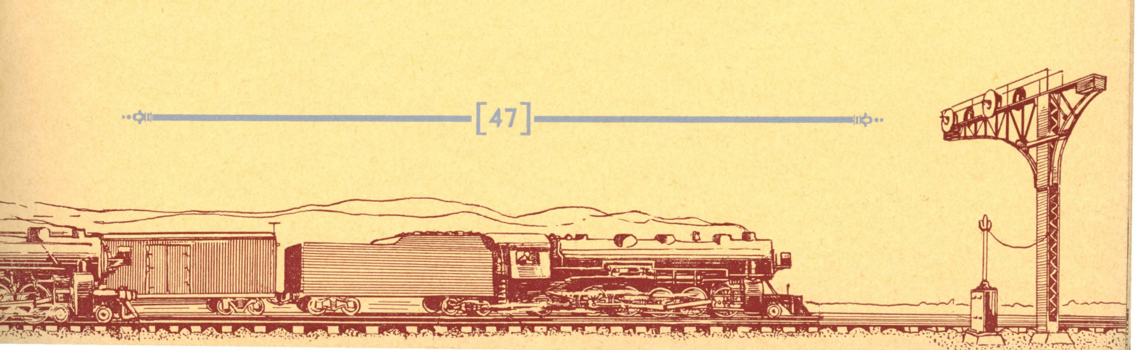
Report on Increased Safety and Intangible Advantages

The following report on the increased safety and intangible advantages of C.T.C. was presented by Committee I, Economics of Railway Signaling, Signal Section, A.R.A., Vol. XXXI., p. 27, at the March 1934 Meeting.

"Centralized Traffic Control (C.T.C.), in addition to providing for economy of train operation as measured by reduced operating expenses, provides increased safety and other intangible advantages, which cannot always be directly measured in dollars, but which, nevertheless, have a true economic value. These intangible advantages add much to the attractiveness of C.T.C. as an investment in operating efficiency even though they do not appear as factors on the economic statement made to justify the installation.

"The advantages listed below represent some of the intangible savings resulting from the increased efficiency of operation and safety as brought about by C.T.C. on five representative installations.

1. It reduces or eliminates the use of written train orders and the possibility of errors in using, transmitting and interpreting train orders.
2. The use of controlled signal indications as authority for the movement of trains permits of immediate control sufficiently flexible to meet changing traffic conditions with increased facility and safety.
3. It provides more frequent and accurate "OS"ing of the passage of trains throughout the 24 hours. This tends to increase safety and the alertness of train and engine crews because the "OS"ing can be used to check the observance of "STOP" signals and the speed between "OS"ing points, and performance at various points along the line.
4. With C.T.C. where power-operated switches are used there is an improvement in safety because:



(a) Reduction in number of stops results in less wear and damage to equipment and, consequently there is less chance of accidents and personal injury.

(b) Power switch may be used to route trains around obstructed track and may serve to give derail protection to train standing on the main track, awaiting a meet.

(c) Eliminates chances of personal injury to trainmen running ahead of train to open switch, or running to catch train after closing switch.

(d) Eliminates danger of improperly opening switch in front of or under trains.

(e) Trains are kept in motion a greater portion of the time and chances of collision are reduced.

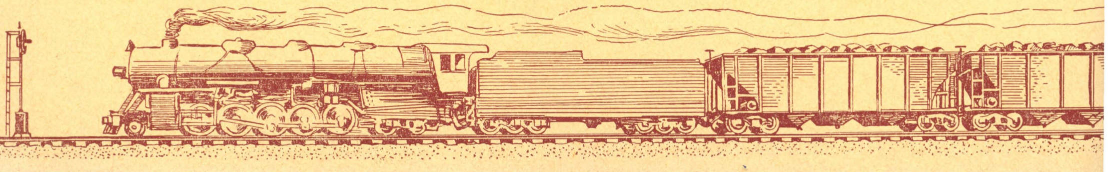
5. Instructions governing the movement of trains are given by signal indications displayed at the point where action is required, by the control operator direct to the engineman, eliminating intermediary action of other employees. This concentration of control of train movements eliminates individual judgment which cannot always coordinate to the best advantage in the most expeditious and safe movement of trains.

6. It eliminates auxiliary signals, such as train order signals, and improves safety because there is less possibility of misinterpreting signal indication.

7. It provides additional protection for trains working between switches at ends of sidings, as often another train can be run around the working train. This form of operation may in many cases, permit the elimination of yard limits at intermediate stations.

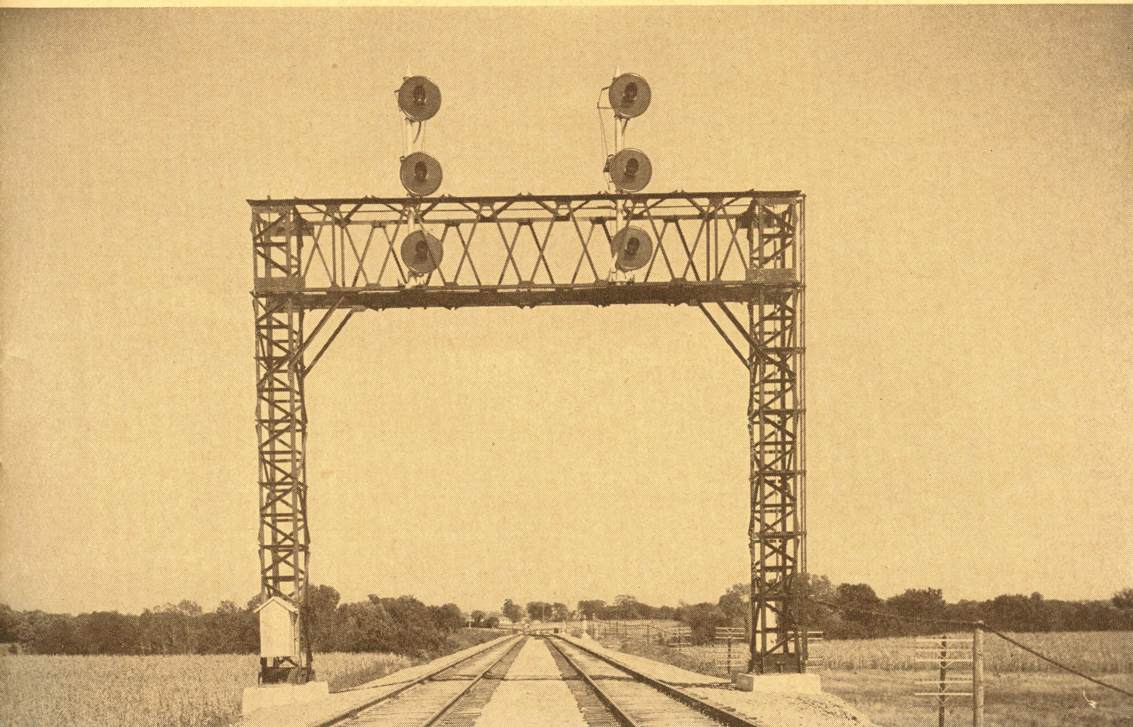
8. It provides controlled signals at many points which may be used by the control operator to stop trains when employees report dragging or defective equipment or other unsafe conditions.

9. Its operation shortens the running time over the territory and, consequently, reduces the number of meets per trip, thereby reducing the possibility of accidents.



10. It has brought about a higher standard of maintenance of switches and sidings, increasing safety of operation.
11. Additional protection can be given for the movement of track cars and other maintenance of way department equipment as the control operator can protect these movements by signals.
12. Because there is less standing time on sidings, the "freezing up" of trains in cold weather is less likely to occur.
13. It provides greater safety at times of peak business as the control operator can efficiently direct increased traffic.
14. A check of the accidents occurring on several roads before and after C.T.C. was installed indicates that with it, notwithstanding the elimination of roadside train inspection by operators, there has been a decrease in accidents due to defective equipment.
15. Non-stop meets are frequently made with C.T.C. On some roads this has amounted to more than 50 percent of the total meets.
16. It increases safety by eliminating the necessity of checking train register and identifying trains at meeting points."

Signals for Either Direction Operation in C.T.C. Territory—*Rock Island-Milwaukee*



Appendix "C"

Published References to Comments on Train Operation by Signal Indication

1. Train Operation by Signal Indication on the Burlington*

The Chicago, Burlington & Quincy Railroad, as early as 1900, began operating trains on double-track between Chicago and Burlington "with the current of traffic by block signals" and without written train orders. The rules were few and simple. After several years' trial the net results were summed up as follows:

"A large saving in the time of getting trains over the road, due to the absence of any necessity for waiting for a train of superior class which may or may not be on time; a simplification in train dispatching, owing to the lack of a necessity on the part of the conductor to state that he has time to make one station farther on and to secure the dispatcher's order to proceed; and a measure of safety due to getting rid of the mathematical and chronological computation above referred to.

"It was formerly required on the Burlington that freight trains should keep out of the time of the fast mail by an interval of 10 minutes; of the time of an ordinary passenger train by an interval of five minutes. Of this responsibility the conductor of the freight is now relieved. On a busy section, as between Chicago and Mendota (83 miles), it is estimated that there is a saving of one-third in delays to trains."

The late F. C. Rice, general inspector of transportation of the Chicago, Burlington & Quincy, the man mainly responsible for the introduction of this method of moving trains, said in 1911: "Our scheme of running trains on double-track has fulfilled our most sanguine expectations. It has saved our company a great many dollars, I am sure, over the delayful

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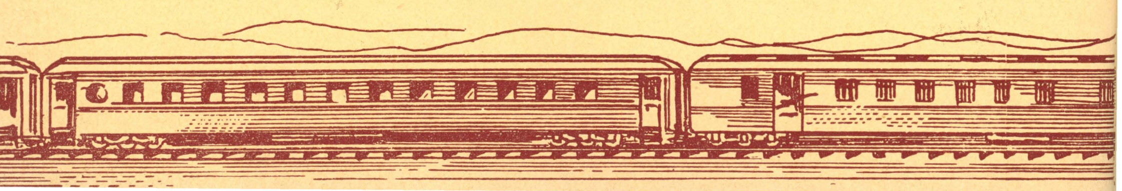
*From "Train Operation by Signal Indication," by Henry M. Sperry, page 17.



practices of train rules and train dispatching. We have not had an accident of any sort resulting from the change in practice, not a lfe lost nor a person injured."

2. An Early Advocate of Train Operation by Signal Indication*

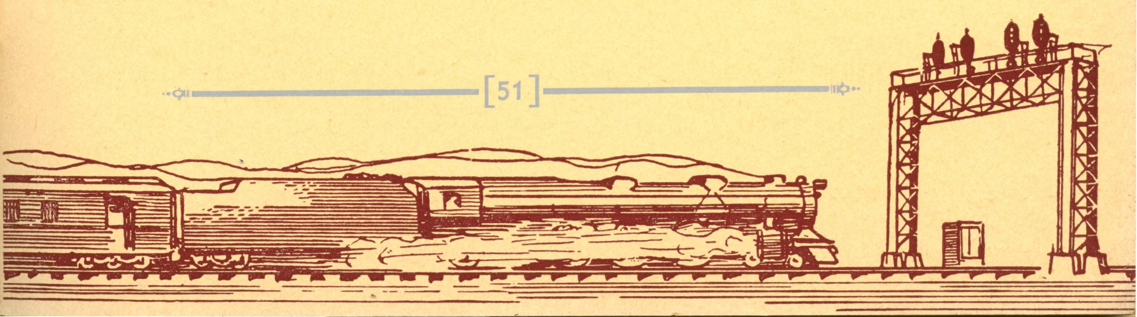
Mr. J. J. Turner (formerly vice-president of the Pennsylvania system) in his book on "The Telegraph as Applied to Train Movement," as early as 1885, set forth the advantages of train operation by signal indication on single track. Mr. Turner quoted an article by E. W. McKenna (formerly vice-president of the Chicago, Milwaukee & St. Paul) on "A New Theory of Train Movement," from which the following is taken:

"What advantages follow this? First, the elimination of the danger of accident connected with the present system. The factors that produce disaster in the handling of train orders have been discussed. They are the dispatcher, the operator, the conductor and the engineer; any one of these four can produce an accident. By eliminating any one or more of these factors you make the responsibility concrete, for an individual responsibility fills its office better than a divided one.

"Accidents have been known where a conductor in doubt as to a point sits in his caboose and depends on "Jim" in the engine to understand it. Jim is befogged on the same question, but depends on "Bill" in the caboose, and the result of this division of responsibility is disaster.

"Under the theory discussed, the thinking is all done by one man, the responsibility all rests upon one man, and he

*From "Train Operation by Signal Indication," by Henry M. Sperry, pages 17 and 19.



has under his absolute control all the appliances for carrying out the system and has only in a small degree to depend upon the intelligence and assistance of the operators and trainmen."

3. **Method Endorsed in Principle by Rules Authority***

A single track railway equipped with the C.T.C. System will fully meet the requirements of the block signal system described in the handbook "Train Operation," written by William Nichols, for many years chairman of the board of rules examiners of the Southern Pacific Company and a recognized authority on operating rules.

Mr. Nichols described this block system as follows:

"With a proper block system, with signals to govern train movements in and out of sidings, trains may be safely moved on single track without train orders and with but few train rules."

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*"Train Operation"—by Wm. Nichols, page 4 (1920 Edition).

C.T.C. Controlled Lap Siding Layout
Baltimore and Ohio

Appendix "D"

Reference to Articles Describing Typical C.T.C. Installations

Railroad	Location	*Railway Signaling* References
A.T.& S.F.	Dodge City—Kinsley, Kans.	April 1931
A.T.& S.F.	Holliday—Olathe, Kans.	Jan. 1932
B.&. O.	Gilkeson—Wheeling, W. Va.	Feb. 1932
B.& O.	N. Lima—Roachton, Ohio	April 1932
B.&.G.	Arthur Jct.—Bingham, Utah	May 1930
B.& M.	Dover, N. H.—Rigby, Me.	June 1932
B.& M.	Hoosac Tunnel—E. Fitchburg, Mass.	Nov. 1931
B.& M.	Lynn—Swampscott, Mass.	May 1931
B.& M.	N. Chelmsford—Ayer, Mass.	July 1929
B.& M.	Winchester—Wilmington, Mass.	Feb. 1931
C.R.R.of N.J.	N. Branch—Whitehouse, N. J.	Mar. 1931
C.B.& Q.	Steward Jct.—Flag Center, Ill.	April 1930
C.B.& Q.	Red Oak—Balfour, Iowa	Sept. 1930
C.B.& Q.	Waverly—Greenwood, Neb..	Feb. 1930
C.G.W.	Rice—Winston, Ill.	June 1931
C.M.St.P.& P.	Beloit—Rockton, Wis.	Feb. 1934
C.M.St.P.& P. C.R.I.& P.	Lawson—Moseby, Mo.	Nov. 1931
D.& H.	Lanesboro, Pa.—Center Village, N. Y	Feb. 1931
D.& R.G.W.	Deen—Tennessee Pass, Colo.	Nov. 1929
D.& R.G.W.	Provo—Midvale, Utah	Feb. 1930
Erie	Tusten—Lackawaxen, N. Y.	Aug. 1931
G.T.W.	Sedley—Valparaiso, Ind.	Feb. 1934
I.C.	Otto—Ashkum, Ill.	Oct. 1930
M.P.	Edgewater Jct.—Atchison, Kans.	Mar. 1930
M.P.	HD Jct.—Rose Hill, Mo.	June 1931
N.Y.C.	Stanley—Berwick, Ohio	Sept. 1927
N.& W.	N. Roanoke—Cloverdale, Va.	Mar. 1929
P.& I.	Metropolis, Ill.—Paducah, Ky.	Jan. 1930
P.R.R.	Ben Davis—Almeda, Ind.	Dec. 1930
P.& P.U.	Peoria—N. Pekin, Ill.	June 1931
P.M.	Mt. Morris—Bridgeport, Mich.	Oct. 1928
S.P.	Stockton—Brighton, Calif.	July 1930
T.& N.O.	Beeville—Skidmore, Tex.	Mar. 1930
T.& P.	Addis—Edwards, La.	April 1930
Wabash	State Line—Lafayette, Ind.	July 1931

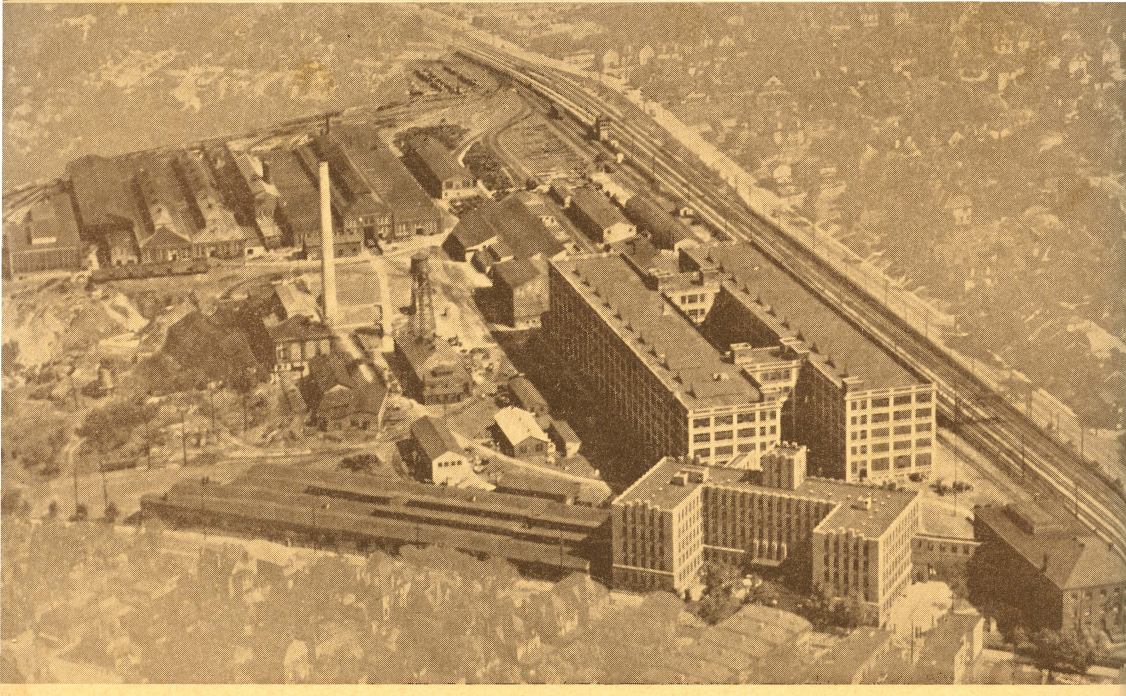
NOTE: Reprints of some articles are available and will be supplied on request.

Appendix "E"

Train Operation by Signal Indication without Train Orders
Centralized Traffic Control Installations in Service Sept. 1. 1934

SUMMARY

Railroads with C.T.C. Installations	Number of Installations	Total Miles of		Switches Controlled	Signals Controlled	Passing Sidings		"OS"ing Points
		Road	Track			Power Operated	Hand Operated	
Alton	2	11.1	11.1	0	10	0	1	4
AT&SF	6	66.4	86.7	47	110	7	4	28
B&O	3	105.3	110.7	64	249	26	4	63
B&G	1	17.2	17.2	2	43	1	6	15
B&M	12	174.1	319.0	342	667	16	13	172
CN	1	.8	.8	3	6	0	0	0
CP	2	7.2	7.2	5	35	0	0	5
CofGa	4	33.1	33.1	6	6	3	8	18
CofNJ	1	4.4	17.6	6	55	0	0	2
C&O	4	20.7	35.3	20	55	3	0	11
C&NW	3	9.7	9.7	6	25	2	3	9
CB&Q	14	106.3	128.3	85	264	8	10	50
CGW	1	1.6	1.6	2	6	0	0	2
CMStP&P	7	15.5	15.5	2	43	0	4	16
CMStP&P—								
CRI&P	1	37.7	75.4	11	28	3	3	5
CRI&P	2	21.9	32.3	6	28	0	2	6
CCC&StL	1	3.4	3.4	0	8	0	0	0
D&H	2	15.4	23.7	9	64	0	0	32
D&RGW	2	38.4	40.9	14	75	8	0	28
Erie	6	19.4	32.1	7	21	0	2	16
GTW	1	5.3	5.3	0	4	0	0	0
IC	5	19.7	32.0	17	69	2	0	15
LV	1	11.1	11.1	2	12	0	0	2
L&N	3	6.4	6.4	0	12	0	6	1
MStP&SSteM	2	4.6	4.6	3	19	0	0	3
MKT	10	23.4	23.4	6	62	8	3	10
MP	22	201.1	267.4	102	468	22	17	144
NC&StL	1	10.1	12.9	5	14	2	1	3
NYC	1	40.2	43.5	32	102	9	2	32
NYC&StL	3	10.9	16.1	25	34	3	1	0
NYO&W	1	2.1	2.1	1	6	0	0	2
N&W	1	5.0	5.0	1	9	1	1	2
NP	1	1.3	1.5	2	12	0	0	2
P&I	1	14.8	14.8	13	30	2	0	7
Pennsylvania	2	41.4	43.5	28	80	7	0	21
P&PU	1	7.1	14.9	20	37	2	0	17
PM	1	20.0	20.0	8	33	3	0	8
Phila.DofCT	1	.5	1.0	4	9	0	0	6
StL—SF	4	15.5	15.5	2	25	0	2	0
SP	1	39.7	42.3	23	96	11	0	24
TCI&RRCo	3	14.0	14.0	6	19	0	0	6
T&NO	6	32.3	32.3	24	107	6	1	22
T&P	2	35.0	66.8	22	60	3	0	18
Wabash	1	37.0	37.0	13	56	6	0	14
43 Railroads	150	1308.1	1735.0	996	3173	164	94	841



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