Signaling In War

Railroad Signals Go to War

C.T.C. on main track and car retarders in yards are an effective means for increasing capacity of existing track facilities, locomotives and cars

By Joseph B. Eastman

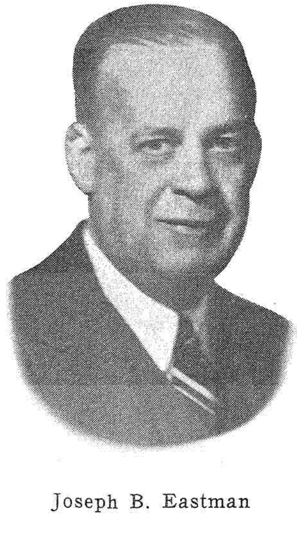
Director of Defense Transportation
Washington, D.C.

WHEN the Axis nations declared war upon the United States, they attempted to reassure their worried peoples by telling them that "A democracy is wasteful, inefficient and bumbling. The United States will never be able to strop itself down to the hard cutting edge of war."

Today the railroads of this nation are proving how utterly wrong those Axis mouthpieces were. They are now carrying loads which a year ago, even six months ago, were thought impossible. Freight and passenger business over some lines has increased more than 150 per cent. Gross ton-miles for the first eight months of 1942 rose to approximately 26 per cent over the same period of 1941. For the year 1942, the figure is expected to be 76 per cent greater than the gross ton-miles handled in 1938.

Back in the 1920's, the railroads were faced with a rapidly expanding volume of business. They met it then by construction of additional main tracks and by reducing grades and curves to speed up traffic. Today this method is impossible.

The railroads are being forced to use such facilities as they have already available; to take these facilities and use them better and more efficiently. It is a tribute to the American way of life, which the railroads exemplify, that they have been able to do this so well.



Joseph B. Eastman

One very important way in which the railroads have increased the efficiency of their equipment is through the use of railway signaling devices. Automatic block signals, centralized traffic control, car retarders, yard train communications and train operation by signal indication without train orders, etc., have played an important role in increasing track capacity and reducing traffic hazards, at a minimum expenditure of critical materials.

Congestion Relieved by C.T.C.

While local operating conditions have determined the type of signaling most adequate for a particular operating problem, the Office of Defense Transportation has found that traffic congestion on single and multiple-track lines has often been relieved by the installation of centralized traffic control by means of which train movements are authorized and directed by signal indications without the use of train orders or train superiority.

Centralized traffic control practically eliminates the time lag in the transmission of orders, and results in more efficient train dispatching, as the trains are directed by signal indications at the time and place required by traffic conditions. This results in the elimination of one of the main reasons for traffic congestion on single-track lines, or on multiple-track lines where trains are operated in either direction on one or more tracks.

These devices, as well as many others which space does not permit mentioning here, have enabled the railroads of the nation to assume the tremendous transport burden that has been placed upon them. With every indication that freight and passenger movements will increase, rather than decrease, during the course of the war, the efficiency of railroad operations will be subject to continual and increasing strain. We in the Office of Defense Transportation have not the slightest doubt but that the railroads, with the help of the government, will be able to meet this challenge as they have met the one placed upon them at the outbreak of the war—successfully.

Manufacturers' War Problems

In spite of shortages of materials and workers, the supply companies will continue to aid the railroads

By R. H. Weber

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AMERICAN history is studded with periods during which the nation wrestled with the age-old problem of supply and demand. However, this is probably the first time a prompt, successful solution was so vitally important to the Nation's very existence. No person or group can or has escaped the far-reaching effects of this crisis. That includes members of the Signal Appliance Association.

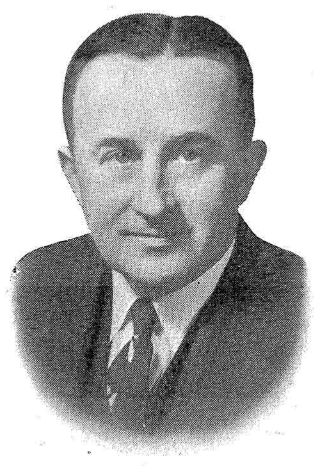
No one questions the importance of rail transportation to our national economy and to the successful prosecution of the war. The general public and the press are loud in their praise of the magnificent way the American railroads are meeting the current unprecedented demands on their services and facilities. So are government spokesmen and leaders of our armed forces. There is not, to my knowledge, any official of the War Production Board who does not fully recognize that safe and uninterrupted operation of our railroads is a vital part of the war program and that adequate, efficiently maintained signaling systems make possible maximum safety and the maximum utilization of existing railroad facilities.

Materials Must Go Farther And Do More

Notwithstanding this completely favorable attitude towards the railroads and the importance of supplying their needs, the fact still remains there are critical materials and just not enough of these critical materials to go around. Bad as the situation is now, it is certain to get worse, so all of us, suppliers and users alike, have the common problem of making a drastically limited and constantly shrinking supply of materials go further and do more than ever before.

Some of Our Problems

With respect to operating and operating personnel, our problems are probably no different than those confronting all producers today. Many of us have lost experienced key men to the armed forces of our country. Executives, engineers and service men have been requisitioned by Washington to aid in the non-combat prosecution of the war. Many of our draft-age employees have gone to help meet State draft quotas. Those of us whose plants are located in heavily congested "war contract" areas constantly face raids, aimed to relieve us of skilled and semi-skilled help. Replacements in such areas are practically unobtainable.



R. H. Weber

Many of us are producing munitions and other war materials. Sometimes this means plant and personnel expansion. Often promised equipment is not delivered, or the raw materials, to meet production quotas, are simply not obtainable regardless of priority ratings. Very often, contract production quotas are doubled or tripled over night, and a few days later explanations for being behind in shipments are in order. These expansions, with resulting influx of new employees, usually lead to additional facilities, thinly spread supervision, transportation jams, and other complications.

Traveling personnel are finding it difficult to get adequate hotel and pullman accommodations. Day coaches are crowded, messages delayed, and average traveling time schedules seriously disrupted.

Some of us have donated the use of available machine-shop equipment for training enlisted personnel of the armed forces twenty-four hours a day. With this arrangement goes the responsibility for housing, feeding and transporting the trainees from quarters to plant and return. Then there are the air-raid drills, provisions for blackouts, armed guards, joint management and labor committees. Also payroll allotment, war bond, salvage, group riding and various other kinds of drives. These are busy times.

A Personal Challenge

The whole situation presents a challenge which calls for every bit of resourcefulness, ingenuity, skill, patience, and sacrifice that all concerned can muster. It puts a new intensity on conservation, maintenance, getting the most out of existing facilities, simplification, substitution, salvage, and the limiting of purchases to absolute necessities.

Most of the foregoing has to do with the dark side—shortages of one kind or another. On the brighter side, there is not now or likely to be, I am sure, any shortage of American genius, imagination, will to work, power of adjustment, and the traditional spirit of the signal fraternity to freely cooperate on mutual problems.

Member companies of the Signal Appliance Association fully recognize their duty and share in the important task of keeping them rolling safely and on time. Coupled with this, is the always present sincere and earnest desire to serve the railroads faithfully and well, through thick and thin. As long as these combined forces are fully applied, there can be no doubt as to the ultimate outcome.

Signaling as Considered by W.P.B.

Suggestions for information needed by the War Production Board when determining the allotments of materials

By Eugene Moore
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Transportation Equipment Branch
War Production Board, Washington, D. C.

THE Transportation Branch of the War Production Board appreciates this opportunity to outline some of the problems which come before it in the handling of applications for priority assistance involving materials required for maintenance of signal and communication systems and for the installation of additional devices and systems of this character.

Use of Signaling In Peace and War

The railroads have been called upon to produce maximum transportation output with a minimum of facilities and equipment. This calls for extreme alertness and ingenuity on the part of railway operating officers. The signal engineer should be in an especially good position to assist in these efforts, inasmuch as the basis of his profession is improvement of the "use factor" or capacity of track facilities, and in expediting the movement of motive power and rolling stock. Intelligent use of signaling in peace time avoids capital expenditures for additional tracks and makes it possible to do the transportation job with fewer units of equipment, thus keeping capital accounts and operating expenses at a minimum.

In time of war, when materials are critically scarce, it is even more essential that an improvement which will use the least critical material should be given preference. No track expansion program should be advanced today without careful consideration being given to improvement of the capacity of the existing tracks, where this can be done with use of smaller quantities of critical materials, just as

Eugene Moore

no new factory expansion should be made until existing plants and machines are worked on an around-the-clock basis.

Everyone's Job

The principal job at W.P.B. is to conserve materials and to see that the restricted amounts made available are put to work where they contribute the most to the war effort. This should also be the job of members of the signal engineering profession, because they are in a position to use critically scarce materials wisely in the light of current requirements or to divert some of them into projects which could well be deferred until the situation improves. The co-operation received from the signal, as well as the telegraph and telephone departments, when the gravity of the situation was fully appreciated, has been heartening. The work of the Conservation Committees of the Signal Section and the T. & T. Section of the A.A.R. have resulted in recommended practice which will bring about substantial savings, particularly in copper and copper alloys, but individual railroads are in a position to do even more by revision of standards, deferment of maintenance which goes beyond absolute minimum requirements, repair and reclamation of materials, and careful check of all new projects in order to cut them to irreducible minimum of material.

Maintenance as Compared with Extensive Replacements

Generally speaking, the limited amount of material available for railway signaling facilities must first take care of minimum normal maintenance requirements. The importance attached to this is evidenced by the procedure set forth under Preference Rating Order P-88, wherein the railroad is empowered to extend ratings for materials and supplies required. Attention is called to the fact that this order is intended to take care of ordinary maintenance only which, in general, means the replacement in kind at existing locations of various items of signal equipment. This does not mean that it would be necessary to replace a worn-out device of obsolete design with an identical device if the standard of the railroad has been changed, and if the modern device uses less critical material. However, it is expected that each railroad will examine its requirements to avoid making extensive changes at this time unless it is absolutely imperative that they be made. Any maintenance program which involves changes over an extended area, or out of face replacement amounting to complete rebuilding of a signaling facility should be submitted for a project rating or for ruling as to whether the particular case may be undertaken under the provisions of Order P-88. In other words, P-88 is intended to take care of ordinary maintenance and not maintenance projects which amount to complete renewal of extensive installations.

Each railroad should examine its major maintenance projects with a view to determining if all or part of the project can be deferred or if repairs can be made which will extend the useful life of the installation. This is a patriotic duty which will conserve critical materials at the present time when they are so urgently needed in the production of direct munitions of war. Such an approach to the maintenance situation would ordinarily not be considered economical over a long period of time, but it is a *must* now. Nothing should be retired that can be repaired sufficiently to give reasonably satisfactory service. Careful attention to and supervision of signal and interlocking installations will frequently make it possible to secure a few more years service out of what is in service and release materials for vital expansion programs necessitated by the load of war-time traffic.

Consideration of New Projects

As to these new projects—probably every reader of *Railway Signaling* has been directly or indirectly involved in the question of whether the War Production Board will approve one or more of these on his particular railroad. What yardstick can be applied to the approval of these expansions of signal systems? The details are many and varied, but the general basic analysis may be stated simply by an answer to the following question: Will the project contribute directly to the successful prosecution of the war to an extent sufficient to warrant allocation of the quantity of material it consumes? If it does not, the project must be deferred even though it would ordinarily be considered to involve a wise expenditure of funds.

The signal installations reviewed by this branch almost invariably provide a facility which constitutes a permanent improvement which will provide for economical operation after the war, but this reason alone cannot be given weight in the analysis of the project. The branch must consider what the direct and relatively immediate effect in handling of trains will be. We at W.P.B. are dealing primarily with the present and the immediate future, and it is only incidental from our point of view that signal projects ordinarily happen to be of a character that will continue to render valuable service long after the present emergency, which necessitated the installations.

It is appreciated that there is a great temptation for railroad managements to authorize the improvements which have been curtailed in the past for lack of available funds, and that there might, in some cases, be a tendency to apply less exacting standards to requests for new projects because some officials have not as yet become material-minded. Today it is not a question of funds, but a question of expanding vital resources of material, production facilities and skilled labor badly needed in the prosecution of the war. No less rigid standards of establishing the essentiality of a project should be applied by management today, with respect to these materials, than has been applied in the past with regard to the cash resources of the railroad. In fact, the duty to conserve today is more solemn and vital than ever before in the history of our railroads. It is expected that railroad management has given such consideration to every project which comes before this board for review, and that its essentiality has been passed on before the project is submitted.

No project should be submitted for approval unless the management firmly believes it to be urgent for the proper operation of the railroad, undeferrable and cut to barest essentials. If a project has undergone this test, the railroad management should have little difficulty in presenting the data required for analysis of the project by this Branch of the War Production Board.

Information Needed by W.P.B.

It should be remembered that basically the information needed for the analysis of a project by this branch is not much different from the statement ordinarily presented to management to secure approval of the improvement. The difference, in this instance, is that a little more detail should be furnished, because local facts or circumstances surrounding the need for the project many not be known to this branch of the W.P.B. In addition to the information required on the project application Form PD-200, a sufficient description and summary of the merits of the proposed project should be furnished the branch to give the analysts the full picture. In analyzing a project, it is first necessary to determine its essentiality, after which a detailed analysis of the material list is made. The supporting data should include plans, description of project, details of traffic, train charts, data outlining expected benefits, and any other information which would tend to show the importance of the project to the war effort.

With regard to materials and specifications, the branch analysts will review the railroad's requirements along the following lines:

(1) To bring them into conformity with the recommendations of the Conservation Committees, Signal Section and T. & T. Section of the A.A.R.

(2) To suggest substitutions where practicable.

(3) To suggest reductions possible through use of fit or second-hand materials.

(4) To inquire if any reductions in quantities can be made by furnishing materials from stock on hand, salvage or transfer of equipment from other points on the system.

The list submitted with an application can show all of these things, which will expedite handling.

Every Man Is His Own Game Warden

To repeat, each officer and employee engaged in signal work has a personal responsibility for the efficient use of material. It is obviously impossible for the War Production Board to do more than set the general policies regarding the utilization of materials, the details of such policies being carried out into the field. Only by the active co-operation of all concerned can the limited quantities of materials available be made to do the work which in ordinary times would require much larger amounts.

Every reader of this magazine, engaged in the railway signal field, can do his part to conserve material. The maintainer can avoid wasteful practices, and refrain from requisitioning materials he can possibly get along without. Circuit designers can exercise their ingenuity to avoid use of excessive quantities of material. Estimators can sharpen their pencils to avoid ordering more than is needed. Signal shop employees can use materials formerly scrapped. Storekeepers can control materials better.

Too much emphasis cannot be laid on the conservation of materials. We can all try to do our jobs just a little better, and remember that everything we waste, whether it be in maintenance or expansion not vitally necessary, is taking something away from an essential war activity. Nothing is more important than the conservation of vital materials today. It is important to take no more than is actually needed, and to tighten our belts so that we do not need so much. It is up to the individual who has to do with authorization, design, installation or maintenance, regardless of how lofty or humble his position may be, to determine whether he is doing his job in conserving material and using it wisely. To a large extent, every man is his own game warden.

In closing, attention is called to a poster of the A.A.R. which sets forth the following slogans:

(1) Conserve
(2) Convert
(3) Use it up
(4) Make it do
(5) Save the pieces

That about tells the story which should be constantly on display not only in every maintainer's shanty but in the shop or office of all those who use or authorize the use of materials.

Utilization of Signaling In War

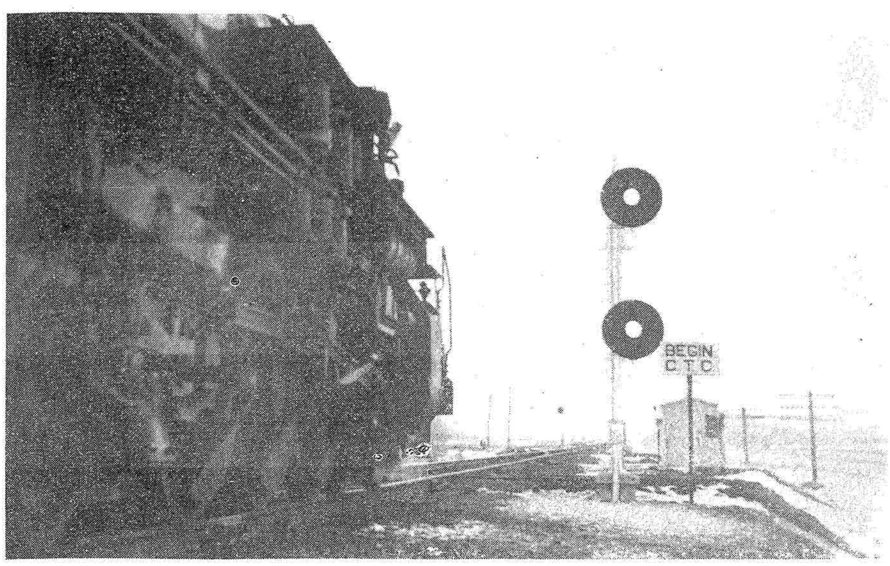
A discussion of the manner in which modern signal facilities save train time under war conditions

In 1918, under the stress of war, the excessive time required to move freight shipment between shippers and consignees was due not so much to the fact that the maximum train speeds were less than they are today, but rather to the fact that delays en route increased the road time of trains between terminals to such an extent that the overall speed *including delays* was much lower than the maximum running speed. Furthermore, delays in yards were excessive, as measured by today's operations. Obviously, a most practical means for reducing the time required by freight shipments or passengers to move between points of origin and destination is to minimize these delays; in other words, to increase the average overall speed more nearly to that for which the locomotives and tracks are designed. This is the function now being performed by the numerous extensive installations of modern signaling that have been placed in service since 1918, with the result that trains are now being operated at higher speeds for a greater percentage of the time when in motion, many stops previously required are eliminated, and standing delays are minimized. Throughout the discussion which follows, information is presented concerning the time saved by specific signaling projects, this information having been furnished recently by the railroads. The discussion does not, however, disclose the names of the roads or the locations of the projects, although this information can be secured by writing to the editor.

Locomotives, Cars, and Tracks Decrease

With approximately 63,890 locomotives in service during 1918, this total was reduced about 30 per cent, to approximately 40,275 locomotives as of January 1, 1942. The new locomotives have more power, so that the average tractive effort increased from about 35,000 lb. to approximately 52,000 lb. The total tractive effort of all locomotives increased from 2,024,118,700 lb. in 1918 to 2,611,273,975 lb. in 1926, and then gradually decreased so that at the present time the total is approximately 2,121,000,000 lb. As shown in the accompanying table, the revenue ton miles per freight locomotive mile increased from 6,102,998, during the first six months of 1918, to 13,242,837 for the corresponding period of 1942.

The railroads owned 2,397,943



Since 1925, centralized traffic control has been installed on a total of 2,703 track miles in the U.S.A.

freight cars in 1918, which was increased to 2,348,679 in 1926; then the total number decreased gradually to 1,731,096 in 1940, with an increase to about 1,800,000 cars as of August 1, 1942. The average revenue capacity of freight cars increased from about 40 tons in 1918 to about 50 tons in 1942, so that the total car capacity decreased from approximately 95,917,700 tons in 1918 to about 90,000,000 tons at the present time. The revenue ton miles per freight car mile increased from 77,436, for the first six months of 1918, to 145,172, for the corresponding period of 1942. Whereas the railroads owned 56,611 passenger cars in 1918, this total has been decreased to about 39,000 cars in service now.

Revenue Ton Miles
First Six Months

	1918	1929	1940	1941	1942
Per Mile of Line	733,121	826,266	700,251	857,556	1,251,342
Per Mile of Main Track	645,909	710,548	599,609	733,982	1,063,086
Per Freight Locomotive	6,102,998	7,312,265	7,714,260	9,676,524	13,242,837
Per Freight Car	77,436	87,507	92,969	112,339	145,172

Revenue Passenger Miles
First Six Months

	1918	1929	1940	1941	1942
Per Mile of Line	78,458	57,562	44,120	54,335	88,548
Per Mile of Main Track	69,124	49,501	37,779	46,506	75,227
Per Passenger Locomotive	1,664,569*	1,220,014	1,420,724	1,822,349	2,889,629
Per Passenger Carrying Car	486,905	370,742	366,991	458,418	702,076

(*) Estimate

Increases in Traffic

As of January 1, 1918, the railroads of the United States had 253,626 miles of road, including 284,227 miles of main tracks, whereas on January 1, 1942, these totals had been reduced to 232,336 miles of road, including 267,416 miles of main tracks. Thus the railroads entered the present war with 16,861 less miles of main tracks than were in service in 1918.

With fewer locomotives, cars and miles of main tracks than were in service in 1918, the railroads are now producing more ton miles and passenger miles each day than in 1918, or at any other time in their history. Reference to the accompanying table shows how the signaling, in part, aided the railroads to increase the utilization of tracks, locomotives and cars. The ton miles per mile of line were 733,121 for the first six months of 1918, as compared with 1,251,342 for the same period of 1942. Based on miles of main track, the corresponding increase in ton miles was from 645,909 to 1,063,086. The revenue passenger miles per mile of track increased from 78,458, for the first six months of 1918, to 88,548 during the same period of 1942.

Increases in Previously Known Signaling Since 1918

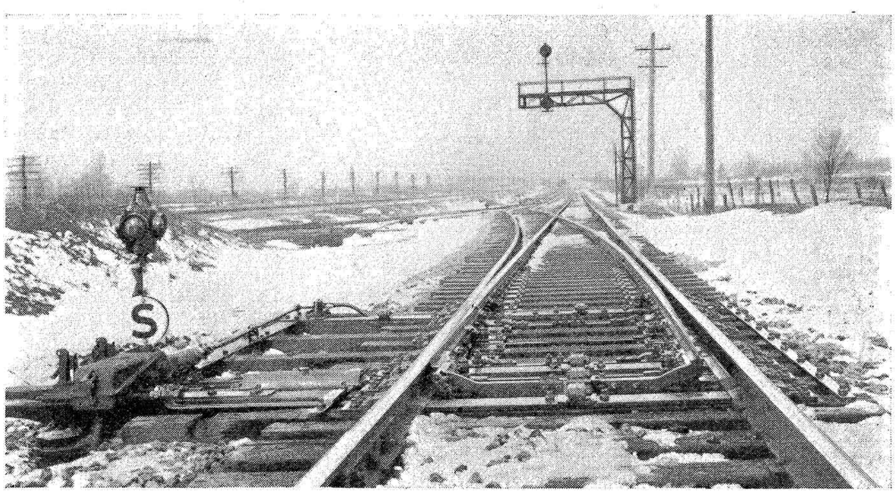
Giving due credit to modern locomotives and track, the principal difference between railroading in 1918 and 1942 is the more extensive facilities for keeping trains in motion, which in a large part has been brought about by the signaling facilities installed in the intervening 25 years. An important fact about this signaling is not only that previously known systems, such as automatic block and interlocking, were improved and installed extensively, but also new systems of signaling were invented, developed and installed on large mileages.

In 1918, the railroads of the United States had 35,193 miles of road, including 57,084 miles of main tracks, equipped with automatic block signaling, this total having been increased, as of January 1, 1942, to 66,423 miles of road including 97,361 miles of main tracks.

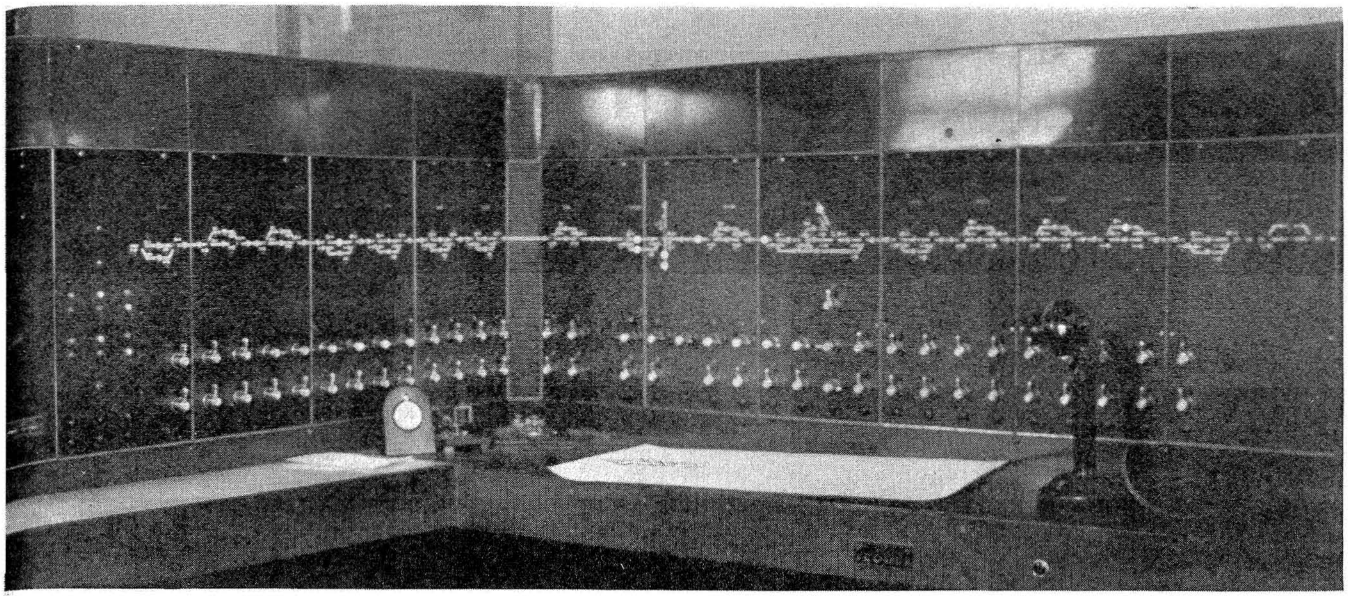
No data are available concerning the number of interlockings in service during 1918, and the field has changed so much that such a figure would be of no value. In 1918, practically all the interlockings were controlled locally; i.e., the plant limits extended only a few hundred feet either direction from the tower. The idea of installing a power switch machine and signals at an outlying location and controlling such a plant from a remote point, i.e., several miles away, was actively developed in the early 1920's, although a few early applications of this idea antedate this period.

Interest was shown in the development of circuits to accomplish the automatic control of interlockings at railroad crossings based on the approach and departure of trains on track circuits. Also, as applied to manually-controlled power plants, methods were developed to accomplish locking by interconnections of electrical circuits rather than by mechanical locking between levers.

As a result of all these developments, interlockings were installed at many locations where such facilities had not previously been in service. In other instances, a single new power interlocking has been installed to consolidate the controls of layouts formerly included in two or more plants. For example, the modern all-relay power interlocking at Dayton, Ohio, includes all the functions previously handled by four separate plants, as well as two layouts formerly handled by switch-tenders. Adaptation of the code control features of centralized traffic control to the remote operation of an interlocking has further extended the distance from which interlocking facilities may be operated. Thus, today, there is no reason, from the engineering point of view, why



A spring switch with an oil buffer saves train stops when a trailing move is to be made from a passing siding or yard



This C. T. C. machine controls the power switches and semi-automatic signals on 89.7 miles of single track

an interlocking of considerable size could not be operated from a point 100 miles away. The net result of all the various developments was that, as of January 1, 1942, there were a total of 6,742 interlockings in service in the United States, of which 4,094 were controlled locally, 438 were controlled remotely and 393 were controlled automatically.

New Systems Developed

In addition to extensive additions to previously known systems of signaling, such as automatic block and interlocking, the period between the two great wars included the invention, development and extensive installation of new signaling systems such as continuous train control, cab signaling, and centralized traffic control for train operation on main tracks entirely by signal indication, as well as car retarders power switches and communication systems for use in classification yards.

Automatic train stop or train control, including apparatus for applying the brakes automatically, was installed and is now in service on 7,953 miles of road, including 14,335 miles of track and 6,570 units of motive power. Also, continuous cab signaling, without means for applying the brakes automatically, is now in serivce on 2,776 miles of road, including 6,243 miles of track and 3,936 locomotives. These facilities improve safety, and those which incorporate the continuous cab signal also save train time by permitting increased speed as quickly as a more favorable track condition is encountered. During fogs, the cab signals permit trains to maintain normal speeds with safety and without the necessity of reducing speed to enable enginemen to see the aspects displayed by wayside signals.

As traffic has increased during 1942, so that more locomotives were required on cab signal territories, the apparatus required has been added to additional locomotives, the new apparatus being in such small quantities, as compared with the signaling system as a whole, that no serious handicaps have been encountered in securing the materials.

Spring Switches Installed

Between 1920 and 1925, buffers were developed for use with spring switches as a means for preventing the slapping of the points between the time of the passing of the wheels of cars when a train is trailing through a switch. This combination of a spring with a buffer was adopted and installed extensively as a means for eliminating train stops to permit manual operation of a switch stand when departing from a passing track.

As a means for locking the switch points during train movements over the switch when in the normal position, automatically-operated mechanical facing-point locks were developed to provide protection equivalent to that at interlocked switches. When a train starts to trail out from a passing track to the main track, the facing-point lock is automatically unlocked.

Coded Track Circuits New

A basic feature of signaling systems is the use of electrical circuits which include the rails, thereby permitting trains automatically to control signals and locking equipment. For many years steady flowing energy was used to operate track relays, which were normally energized except when trains occupied the track circuits. As a part of the development of continuous train control and cab signaling, in the early 1920's a method was devised for interrupting the feed to track circuits at the rates of 75, 120, 180, etc. per minute, as a means for controlling the equipment on locomotives. In more recent years, this idea of coded track circuits has been applied in automatic block signaling and in centralized traffic control to control wayside signals. In order for a signal to display an Approach aspect, the code received at a signal must be at the rate of 75 per minute, or for a Clear aspect, 180 per minute. Other code rates, such as 120 per minute, can be used to control other Proceed aspects, such as Approach-Medium. The Stop aspect is displayed due to absence of current when a train shunts the track circuit. Likewise, a Stop aspect is displayed if the relays fail to follow code, or if foreign current causes the relays to be energized constantly.

Line Wire Eliminated

Thus all the aspects required are controlled by circuits on the rails, thereby eliminating line wire circuits which are used ordinarily in connection with conventional track circuits. In addition, codes which operate in both directions on rails can be used to control approach locking and highway crossing protection, thus further minimizing the line wires required. Coded track circuits provide improved shunting protection because the shunt depends on the pick-up rather than the release of a relay. A further advantage is that coded track circuits can be operated successfully up to 11,000 ft. in length which, in general, is approximately twice the length of steady-energy direct-current track circuits of the conventional normally-energized type.

Superseding Time Table and Train Orders

On lines with two or more tracks, with each track signaled for train operation in one direction and with all switches at junctions, crossovers and passing tracks included in interlockings, very few, if any, train orders are required for authorization and government of train movements. For many years, trains on double and multiple-track lines have been permitted to move with the current of traffic without train-order authorization. Likewise, for many years train movements in either direction have been authorized by signal indications, which supersede time table and train-order authority, on short sections of single track over bridges or through tunnels. Some of these latter installations have been automatic, based on a first-come-first-served basis, while others have been controlled by interlocking or block offices.

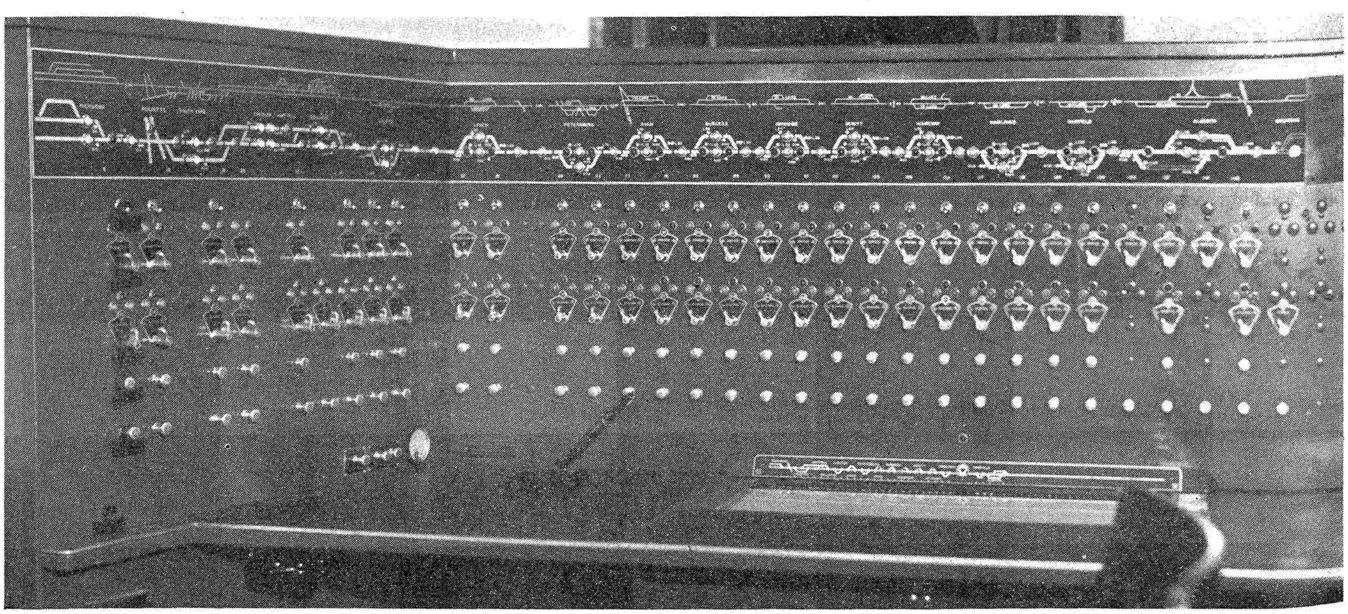
Using the practice of remote control of power switch machines at the outlying ends of passing tracks, and track circuit controlled manual block between interlockings at passing tracks, the Missouri Pacific, in 1925, first installed a system for authorizing train movement on 50 miles of single track by signal indication without train orders, including the directions to trains to enter or leave sidings, as well as to proceed from station to station. Following the development of direct-wire circuits to each location to control the power switches and semi-automatic signals from a central point, the New York Central, in 1927, made the first project of what is now known as centralized traffic control, on 3 miles of double track and 37 miles of single track. The first installation of a system employing only two wires, extending throughout an entire territory was made on the Pere Marquette in 1928. The ability to control a series of locations over an extended area, by means of code impulses, very materially extended the scope of C.T.C. by reducing the number of wires required. All of the C.T.C. systems extensively installed today rely upon some variation of the basic code system, and the very latest installations go a step farther by employing carrier codes which make it possible to control a series of entirely separate C.T.C. areas over one control line. On numerous centralized traffic control projects, the line wire circuit for the centralized traffic control code system is used also for telephone communciation, special apparatus being provided so that there is no interference between the C.T.C. codes and the telephone conversation.

Train Operation by Signal Indication

From the standpoint of train operation, centralized traffic control includes all the advantages of power-operated interlocked switches at all junctions and passing tracks, together with semi-automatic signals at all such points for authorizing train movements by signal indications which supersede time tables and train orders. The advantages of centralized traffic control are most effective where trains are operated in either direction on a track, which applies not only on single-track lines but also for either-direction train operation on one or more tracks of a multiple-track line. Centralized traffic control is used also for single-direction train operation on tracks of multiple-track lines, the control of switches at outlying crossovers and junctions being included as parts of the C.T.C. system, and the basic features of code control, which characterizes all C.T.C. systems installed today, may be used to operate entire interlockings from a distant point as previously mentioned. Up to January 1, 1942, centralized traffic control had been installed on 229 sections, totaling 2,163 miles of road including 2,703 miles of track, thus on 540 miles of road more than one track is equipped. These projects include 1,676 power switches and 4,285 semi-automatic signals.

Other Than C.T.C.

The term centralized traffic control applies only to those projects in which the semi-automatic signals at two or more points are controlled from one office, and thus does not include territories on which train movements are authorized by signal indications between interlockings, each of which is controlled locally, although from the standpoint of train operation there is no essential difference. Data with reference to such operation show that, on other than C.T.C. territories, train movements are authorized by signal indication without train orders in one-direction operation on 12,262 miles of road, including 30,000 miles of track, and in either-direction operation on

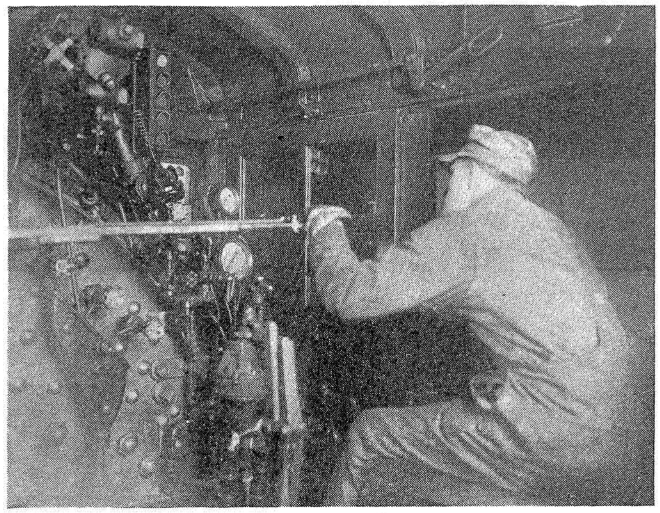


Typical C. T. C. control machine including an automatic train graph recorder

2,485 miles of road, including 3,270 miles of track. Controlled manual block and traffic locking installations are included in these figures, but manual block is excluded.

The benefits effected by the installation of an interlocking at a junction or crossing, where trains were formerly required to stop, can be based on the train time and fuel saved by the elimination of train stops and delays. Data applicable to various classes of locomotives and weights of trains are available. On the average, however, the elimination of a stop for a tonnage freight train will save from 8 to 10 min., and from 250 lb. to 600 lb. of coal.

The installation of automatic-block signaling on 20,278 additional miles of track between 1918 and 1942 is now aiding train operation because, as compared with manual block, the automatic block permits following trains to be operated at closer spacings and at higher speeds with safety, and meets or passes can be made on closer time with safety. The train time saved by automatic signaling depends on local conditions and the volume of traffic. As compared with operation by manual block, one installation of automatic block cab-signaling on 50 miles of double-track line, that is used almost exclusively by freight trains, has saved an average of 9 minutes for ore trains, 8 minutes for preference trains eastbound, 20 minutes for preference trains westbound and 36 minutes for coal and empty trains.



During fogs and storms, cab signals insure on-time performance of trains

Time Saved by C.T.C.

THE train time saved by centralized traffic control should be separated into two catagories. The power-operated switches, as compared with hand-thrown stands, permit an average freight train to save from 5 to 6 minutes when entering a passing track and from 8 to 10 minutes or more when departing. Based on actual field tests, as well as statements of dispatchers, the use of power switches permits a train on a siding to pull out, proceed to some other siding and enter, in a period which is approximately 15 minutes less time than was possible with hand-thrown switch stands. This fact, in numerous instances, makes it possible to advance a train one or more stations beyond, when otherwise it would have been held for a delay.

The use of spring switch mechanisms at the ends of a passing track does not effect any time saving when a train is entering a siding because the switch must still be opened and closed by hand. When departing, however, a spring switch permits a train to pull out without stopping, thus saving 8 to 10 minutes for each such operation of a freight train.

If a freight train holds the main line and proceeds over an engine district without delay, the overall time will be the minimum. In actual operation, this minimum time is increased by the time lost in taking siding for meets. For a train that otherwise would be required to take siding for three meets, the time saved by C.T.C. on the first two meets may permit that train to arrive at its terminal before the departure of the third opposing train, thus obviating the delay which would have been occasioned by the third meet, as well as the running time between the meeting point and the end of the territory.

Second Category of Saving

The second category of time saved by C.T.C. is accomplished by the semi-automatic signals, the indications of which authorize trains to (1) proceed to the next station, (2) enter the siding or (3) depart from the siding and proceed to the next station. These signals, which are controlled by the man in charge of the C.T.C. machine, are, in each instance, located at the point where the enginemen are to take action. Therefore, the enginemen operate in accordance with aspects displayed by the signals with no need for checking time tables and train orders.

By means of the automatic train-graph and track-occupancy indications on the control machine, the man in charge is informed of the location of and the progress being made by each train. Therefore, he knows in each instance whether time is available to advance an eastbound train, for example, past siding A to siding B for a meet with a westbound train, rather than holding the eastbound train at siding A. Thus with C.T.C., the meeting points need not be established until the circumstances contributing to the most efficient operation are known, whereas with other means of operation, the meeting points must be established by train orders which must be issued considerably ahead of the time they are to be acted on, frequently without a means for changing orders fast enough to take advantage of changing conditions. On some of the more extensive C.T.C. projects where the passing tracks are one and one-half to two times the length of a train, approximately 90 per cent of the meets are timed so closely that neither train is required to stop.

By thus progressively advancing a train with C.T.C., rather than allowing it to incur delays on sidings, a freight train completes its run in a shorter overall time, the reduction in time averaging from 0.8 to 1.6 minutes for each mile, a good average for numerous projects being about 1 minute per mile. After the installation of C.T.C. on a subdivision of more than 100 miles, the overall average train time was reduced 29 per cent, notwithstanding the fact that the number of trains increased 13 per cent and the number of cars increased 18 per cent over previous peak periods.

An important factor in improved operation is that with C.T.C. trains can be accepted promptly when they are ready to go, and need not be planned so far in advance, whereas, when movements are authorized by train orders and restricted by time table, the orders must be established so far in advance of actual planned departure, that close dispatching is impossible. Extensive delays are then incurred by the issuance of new orders. In some instances, the traffic is now so heavy that, even with short districts, the dispatchers cannot issue orders fast enough under the train order system and, as a consequence, trains are actually delayed in yards waiting for orders when the main track is actually available for use. With C.T.C., the control of signals to authorize train movement is accomplished as readily as the operation of a cigarette lighter.

Increased Track Capacity

Centralized traffic control should also be considered from the standpoint of the increase in track capacity accomplished. In many instances the need for increased track capacity is measured not by the total number of trains in a 24-hour period, but rather by the number of trains which should be kept moving during certain peak hours. The operation of each and every train over a division in minimum overall time during peak hours, as well as during slack periods, is the objective obtainable by C.T.C., but impossible with the train-order system because of physical limitations of the train dispatching system. It may be that on some single-track engine districts as many as 50 to 60 trains are being dispatched in some 24-hour periods, without C.T.C., but no one would have the temerity to say that it is done easily. Traffic of this density constitutes a constant drain on the efficiency of dispatching, and leads to many delays, including 16-hour tieups which create almost an impossible situation, in so far as train delays are concerned. Thus a single-track division may have the capacity to "hold" 60 trains, but railroading in war time requires that we "Keep 'Em Rolling."

In brief, results of studies made on existing projects prove that the installation of C.T.C. on a busy single-track line will increase the track capacity 50 per cent during peak periods; or in other words, 50 per cent more trains can be *kept moving*. Thus the centralized traffic control now in service on many single-track lines has been the means whereby unprecedented numbers of trains, occasioned by war traffic, are being handled without delays. On one 60-mile single-track territory, where the normal traffic included 12 to 15 trains daily, the total suddenly increased to an average of 55 trains, with peaks of 60 to 65 trains daily, and the point of importance is that the C.T.C. permits each of these trains to be moved over the territory in an average time not exceeding that required previously with a normal volume of traffic. On another railroad, a 30-mile section of C.T.C. on single track normally handled about 35 trains daily, but within recent months has handled from 65 to 72 trains daily, which is taxing the capacity of double-track sections extending in either direction from the two ends of the C.T.C. territory.

On a centralized traffic control territory, including 27 miles of double track and 75 miles of single track, the traffic in February, 1940, included 472 passenger trains and 859 freight trains. The traffic on this territory increased to 473 passenger trains and 971 freight trains during February, 1941, to 538 passenger trains and 1,585 freights in February, 1942, and to 571 passenger trains and 1,811 freight trains in September, 1942. Records show that the passenger trains are being handled in schedule time and that the freight traffic is being moved without delay.

On another C.T.C. territory, including 89 miles of single track, the traffic during past years ranged from 21 to 32 trains daily, but, with the addition of war business, the number of trains now being handled daily ranges from 45 to as high as 60. An analysis of the train sheets for several days in October proves that trains are being handled efficiently, without delays in this territory. The operating officers agree that the traffic could not be so handled if the C.T.C. had not been provided.

Centralized traffic control, including two passing-track switches in interlockings, and the remainder of the passing tracks, used by through trains, equipped with spring mechanisms, was placed in service in January, 1942, on a certain 69-mile section of single track. Comparing operations during August, 1941, with those for August, 1942, the average time saved for each passenger train was 8 minutes. The schedules of trains were not changed; therefore, savings in train time are effected only when scheduled trains are behind time or when extra trains are operated. One of the scheduled through freight trains reduced its time for this territory by 20 minutes each trip on the average. The average time of westbound extra freight trains was reduced 22 minutes, but the average time for eastbound extra freight trains increased 7 minutes. The average time for the local freight was reduced 3 hours.

As Compared With Second Track

On double-track, trains of opposing direction meet without delay, but time is lost by slower trains which must take siding and wait for faster trains in the same direction to pass. In certain instances, merchandise freight trains and fast over-night passenger trains, as well as passenger trains on slower schedules, are all timed to arrive at a terminal within a short period in the morning. Under such circumstances, numerous passes must be made, whereas but few meets are required. The installation of C.T.C. on an existing single track permits the passes to be made on close timing, whereas the addition of a second track with the usual arrangements of passing tracks operated by hand-throw stands and with operation by time table and train orders would not solve the particular problem or improve train operation unless arrangements were made to operate trains against the direction of traffic. Thus the problem on a single track is one of both meets and passes, while the problem of double-track operation is solely one of passes. However, it is conceivable that the passing moves may be just as serious as that of meets. While it would be possible to install C.T.C. on either track of a double-track line with sidings for passing moves, a much better alternate is to equip both tracks for operation in either direction, which results in a very small need for sidings.

The circumstances discussed above may not apply generally, but, taking train operation under the average flow of traffic, an executive of one railroad, with 165 track miles of C.T.C. in service, stated that such facilities on single track increased the capacity to 75 per cent of that afforded by double track on which conventional operation is in use. In another case, centralized traffic control on single track was stated to afford a better solution of the operating problem than would have been obtainable through the installation of double track.

A C.T.C. Policy

On another large railroad, when increased track capacity is needed on an existing single-track section, the management applies a fixed policy of installing C.T.C. rather than adding second track. This policy is based on experience gained on 22 installations on this road, totaling 418 miles of track, including 204 power switches and 762 C.T.C. controlled signals. On this railroad, a section of single track about 28 miles long, including four passing track layouts equipped with C.T.C., normally handled 35 trains daily, but, with the addition of war traffic, this line is now handling 70 to 75 trains daily.

A certain section of single track, about 22 miles long, handled 601 trains in August, 1940. Since that time, centralized traffic control was installed, and in August, 1942, the

Centralized traffic control saves at least 15 minutes for each train movement from one passing track to another siding

traffic increased to a total of 731 trains. In spite of this increase in the number of train movements, the passenger trains were operated on schedule and each freight train saved an average of approximately 15 minutes. On a C.T.C. territory on another road, comparing February, 1933, with September, 1942, the number of trains increased 113 per cent, from 24.6 to 52.6 daily, while on a second C.T.C. territory on the same road the number of trains increased 115 per cent, from 44.3 to 95.3 trains daily.

About 23 miles of third track were removed when a certain C.T.C. project was installed in 1940. Although the number of train movements increased from an average of 48 daily in August, 1941, to an average of 56 in August, 1942, track capacity is adequate not only to handle this traffic without delay, but, furthermore, additional trains can be so handled.

Better Utilization of Power and Track Forces

Getting a train over an engine district in 40 minutes to 1 hour 30 minutes less time, by means of the centralized traffic control, is of advantage in many ways aside from the fact that the overall time of cars between points of origin and destination is thus shortened. By getting trains over an engine district in less time, the locomotives can be turned and assigned to return trips. In one instance, the installation of C.T.C. on an engine district permitted eight locomotives to be released for use on other divisions. On another road, where the engine pool for a division included a certain number of large locomotives and a few older ones of less capacity, practically all trains can now be handled by the larger locomotives, thus reducing the number of trains as well as increasing the speed. In another instance, the installation of C.T.C. facilitated train operations to the extent that engine runs could be changed so that it was possible to close a roundhouse at an intermediate point.

In some instances, the tonnage ratings of locomotives were limited by the ability to start a train on an ascending grade after stopping to permit operation of hand-thrown stands before entering or after leaving a passing track. With power switches, these stops are eliminated, and in certain instances this has permitted an increase in the tonnage rating without decreasing the speed.

Also As Information

By means of the automatic train graph and track-occupancy indication lamps, the man in charge of the control machine knows the locations of all trains on the territory, and this information can be given by telephone to track foremen whenever they call from the telephones provided at each switch as well as at intermediate points.

Thus now the track foremen have exact information of the time available for moving their crews or performing certain track work and, in special cases, can be protected in movements they may have to make. Comparing the work done this summer with that done last year before C.T.C. was installed, the chief engineer of one railroad estimates that the efficiency of the track forces has been increased at least 15 per cent.

Retarders and Yard Communication

Strenuous efforts to get freight trains over the road are oftentimes defeated by extended delays in yards. A serious difficulty arose during the World War I because of the delays to freight cars when in classification yards, as well as in delivery to connecting lines. The capacity of a classification yard is limited by the speed at which cars can be pushed over the hump, which in turn is limited by the time required to operate the yard switches and to control the speed of cars when passing down the hump and through the turnouts to a stop on the classification tracks. In 1918, the practice was for a man to ride each cut of cars, using the hand brakes to control the speed and to stop the cars. Power switch machines were in service in a few yards, but, for the most part, the switches were hand-operated by switch tenders.

Retarders In 1924

Following the invention and development of car retarders in 1924, power switches and retarders were installed in 40 of the more important classification yards in the United States, one project having been completed early in 1942 and another as recent as October 15. Included in many of these projects are the various forms of communication, as, for example, the newly developed yard communication system by means of which telephone conversation is possible between the yard master's office, the humpmaster's cabin, and the various locomotives used in yard operation. Using such a system, the yardmaster telephones directly to the engineman of a yard locomotive to alter assignments or give additional instructions, thus improving operations as a whole, especially the utilization of the locomotives. The humpmaster talks directly by telephone to the engineman of the locomotive, which is pushing cars over the hump, so that the pushing speed is varied, depending on the number of cars in various cuts, and also depending on whether the cars are loaded heavily or are empty. For this purpose, telephone communication is more direct than wayside signals, and,