CHAPTER II

CENTRALIZED TRAFFIC CONTROL

C.T.C. Aids Train Movement on Union Pacific

William "Bill" Jeffers and the Union Pacific. Those names are synonymous, and will live forever in American Railroad history. They stand for progress, for foresight, for courage.

When the final chapter of World War II has been written and the green lights glimmer for a clear track ahead, Bill Jeffers and the Union Pacific can proudly point to their page in the record book where it is written that the U.P. exerted every effort toward the efficient and safe transportation of troops and war materials, along with old John Q. Public and his family.

And right there at the top of the page it will be set forth that Centralized Traffic Control was one of the stout cogs that helped keep the wheels rolling. A 171-mile installation in the wild vastness of the Mohave Desert between Las Vegas, Nevada, and Yermo, California, is providing the most efficient and effective method of train dispatching ever developed.

Here is an excellent example of how Centralized Traffic Control affords the extra track capacity needed to handle unprecedented increases in war traffic. Immediately after Pearl Harbor, the Union Pacific's Salt Lake City–Los Angeles line, of which the C.T.C. territory is a part, became an especially strategic transportation artery.

Factors contributing to its importance were the great steel mill Henry Kaiser built near San Bernardino, California, another that sprang up at Provo, Utah, and the world's greatest basic magnesium plant just outside of Las Vegas, Nevada. The latter was located at this point to take advantage of the enormous amount of power generated at Boulder Dam. This dam in itself has added significantly to the importance of the line.

Let us consider a few tonnage figures before we start poking into the vitals of this thing called Centralized Traffic Control. The tonnage handled between Las Vegas and Yermo during the first quarter of 1942 was 35.5 per cent greater than in the same period of 1941, and 60.5 per cent greater than the first three months of 1940..

Now we're thinking in big numbers, so hold your hat. Stated in gross tons the increase represented from the first quarter of 1940 to the same period in 1943 was 149,402,929 gross tons. In other words, the jump was from 246,956,665 gross tons in the first quarter of 1940 to 396,359,594 gross tons in the first quarter of 1943.

This is a lot of tonnage to handle over a single-track line, particularly inasmuch as heavy mountain grades limit the tonnage of each freight train to 2,500 tons for both eastbound and westbound drags. At the time the first C.T.C. studies were made, it required each day an average of 9.33 passenger trains, 19.33 freight trains, 16 helper engines, and 2.34 light engines, or a total of 47 movements to handle the tremendous volume of business.

West of Las Vegas the C.T.C. territory climbs out of the great Las Vegas Valley and tips over into that enormous hinterland, the Mohave Desert. Many people associate any desert with a vast, flat expanse of sand and nothing else, a place where a man who is lost walks in circles and meets himself coming back. True, there is a lot of flat country in the western deserts; there are, also, a lot of mountains—he-mountains with mountain sheep on them; mountains with snow on them in winter. Mountains predominate in the Mohave Desert.

Leaving Las Vegas on the Union Pacific, the line lifts sharply to the summit of a sprawling mountain range about fourteen miles to the westward, and subsequently follows the contours of this range. Curves are necessarily sharp, some having a six-degree curvature, but prevailing grades are held to a maximum of one per cent for the eighty miles to Cima, California, which is the highest point on the Las Vegas–Yermo subdivision.

Beyond Cima, the line descends sharply for eighteen miles to Kelso at a continuous gradient of 2.2 per cent. Because of this steep grade it is necessary to use as many as three helper engines on all eastbound trains between Kelso and Cima. Before the installation of Centralized Traffic Control an especially serious bottleneck existed in this section because of the difficulties arising in handling light helper engines against such dense traffic.

West of Kelso the line descends at a gradient not exceeding one per cent to Cork, California, which is approximately twenty-eight miles west of Kelso. The remaining forty-four miles of the territory is a continuously ascending westward grade of one per cent or less. Here the track skirts the weird, sandy reaches of the Devil's Playground, crosses the Mohave Sink, and comes finally to Yermo, on the flats under the gay-colored Calico Mountains.

This, then, is a brief word relief map of the Union Pacific's Centralized Traffic Control district.

The Union Pacific, the pioneer, the road that drove the golden spike at Promontory, Utah, in mid-spring of 1869, has established another milestone in the bright history of railroading by completing the *longest* stretch of Centralized Traffic Control in the world to be controlled from one location.

During 1942 traffic in the Las Vegas–Yermo territory had closely approached the saturation point. Delays were frequent, congestion had assumed alarming proportions, and, as a result, equipment could not be utilized efficiently. For this reason construction work on the C.T.C. project was rushed to the greatest possible extent. Portions of the territory over which the greatest delays were occurring were hurried to completion first. As the various portions were placed in service, the congestion began to ease, and by the time the entire installation was operating congestion had disappeared entirely.

Not only have delays ceased, but trains can now actually make up an almost unbelievable amount of time while they are in C.T.C. territory. Freight trains can save approximately a minute a mile. Fast passenger trains, when late, can make up twenty minutes over the entire C.T.C. district.

Let us go back now and see what makes this C.T.C. thing tick.

With Centralized Traffic Control, the train dispatcher can virtually do everything but shake hands with the engineer and conductor. One little machine does it—one little machine crammed with gadgets born of American ingenuity. Oh, yes; there are some wires strung out along the line, but they were there anyway.

A quarter of a century ago the man attempting to dream up a scheme whereby the engineer of a heavy-tonnage freight on single track might be directed to slip his train into a passing track a few scant seconds ahead of a speeding limited coming against him, without the use of train order tissues, would have promptly been thrown in the pokey, being regarded as far too dangerous a character to be on the loose.

"Smoke orders," they would have termed such a meet, and somebody would have sure been hauled onto the carpet.

Yet today these same paint-scorching meets are merely a part of the scheme of things on many of the Nation's most vital rail lines, and they are accomplished with an unsurpassed degree of safety.

Long ago, operating officers visualized as the ultimate in signaling a centralized system of train dispatching whereby one man would have under his hand complete control of the switches and signals over extended distances of track. He would, they foresaw, authorize the movement of trains by signal indications rather than by written train orders on concise, up-to-the-minute knowledge of train progress, which would be furnished by indications on a track model on the wall before him.

Such a system, using direct wire circuits, was installed. However, to control the vast and intricate functions over long distances required enormous quantities of line wire, which prohibited the economical and feasible application of such a method.

But the Union Switch and Signal Company soon proved that there is more than one way to get over a mountain, and it came up with what was called the "Time Code System." It reduced to two the number of line wires required to provide centralized control of traffic over extensive territories. And Centralized Traffic Control was on its way.

The earlier C.T.C. systems were relatively short, but there followed a trend toward longer installations. By the end of 1937, the silver Denver Zephyrs of the Burlington were flashing across an entire subdivision of 105 miles, guided and protected by Centralized Traffic Control all the way.

Under the written train order method of operation, the dispatcher must rely upon train reports (OSes) from the various telegraph operators along the line for information concerning the location of trains under his jurisdiction. Since some operators may allow considerable time to elapse after a train passes or leaves a station before they send their "OS," and since there is always a variance in the time the different operators require to report a train, the dispatcher does not have a true picture of the train's progress. He must therefore arrange for meeting points according to the rather incomplete and inaccurate information he has available. In addition, he must make allowances for the time consumed in issuing, transmitting, and delivering written train orders.

Under the best conditions, the written train order method of operation is inefficient compared to the C.T.C. Where traffic is heavy, the delays occurring in the issuance, transmission, and delivery of your "19" or "31" order can alone create serious bottlenecks. Add to this delay those caused by the necessity of stopping trains, throwing switches, starting heavy drags again, and a busy main line can soon make a mess of schedules.

With Centralized Traffic Control, information concerning the progress of a train is transmitted to the control office automatically as the train passes through a certain designated track section. This information is conveyed to the dispatcher by means of small but brilliant lights, which are inserted in a track model replica of the controlled territory at points representing the "OS" sections. These "OS" sections are usually located at the ends of passing tracks, or at any other point where such information is desirable. Since it is practicable to have many more "OS" points than would be possible under the written train order method of operation, the dispatcher is afforded more comprehensive knowledge of train progress at all times.

With the information furnished by the lights on the track model, the dispatcher is enabled to arrange meeting points on the most efficient possible basis. When a meeting point is decided upon, the dispatcher merely flips a miniature switch lever and signal lever on the control machine; then presses a code-starting button. Immediately things begin to happen, five, ten, twenty, or one hundred or more miles away.

The switch at the desired end of the selected passing track moves to the reverse position and the signal displays the proper indication for a movement into the siding. As soon as the train designated for the passing track is in the clear, this information is transmitted to the dispatcher. He immediately restores the switch lever to its normal position, moves the signal lever to clear the signal for the train that is to proceed on the main line, and again presses the code-starting button. Upon completion of the code, the switch returns to the normal position, the signal clears, and the train on the main line is on its way.

The switch at the opposite end of the passing track is reversed by the dispatcher now, and the train "in the hole" is directed to re-enter the main track by signal indication.

Tremendous savings in train time result from the fact that the switches at the ends of passing tracks in C.T.C. territory are controlled by the dispatcher, thus eliminating the necessity of stopping trains while trainmen throw the switches by hand. Studies of actual installations disclose that power switches save a tonnage freight about six to eight minutes when entering a passing track and some eight minutes when departing.

A tonnage freight can be advanced from one station and into the passing track at the next station in approximately ten minutes less time than is required where switches are operated by hand. A train can pull out of one passing track, proceed to the next station and get in the clear approximately fifteen to eighteen minutes quicker than if it was required to stop at both stations so that switches could be operated by a trainman.

Proper meeting points in Centralized Traffic Control territory can be selected so accurately, and the switches and signals controlled so swiftly that a high percentage of the meets are accomplished without stopping either train. Trains can be advanced one or two or more stations farther than would be possible if their movements were authorized by written train orders.

The benefits of C.T.C. are especially evident during peak traffic hours. Since the dispatcher knows the exact location of all trains in the territory at all times, and since he is not delayed transmitting train orders, he can accept additional trains into the district whenever they are made up and ready to go.

Serious traffic congestion, under the written train order method, may result from such unforeseen incidents as a journal running hot, a draw-bar pulling out, or a locomotive stalling on a grade. For example, a capable dispatcher may have established a meeting point; he knows the crews, the tonnage of the trains, the characteristics of the engines. Everything is moving smoothly. But after the meeting point is selected, a storm hits the Mohave, let us say—a wind storm. It is a cross wind, and blows the sand the engineer is applying to the rail into the next county. The locomotive is on a heavy grade and the big drivers are fighting for traction. Without sand, the engine "slips badly"—the drivers spin. It becomes necessary to "double the hill"—cut the train in half and move each section to the summit separately.

Perhaps a number of passing tracks intervene between this grade and the established meeting point. The opposing train is "in the hole" miles away. There is nothing to do but wait, and precious time is lost. Both trains now are running late.

That is what happens when unforeseen delays occur to one of the trains involved in a meet under the written train order method of operation. This is single track, you understand, and other hurrying trains are bound to be affected, for traffic is dense. Since the dispatcher is unable to communicate promptly with the crew of the train in difficulty, he cannot immediately change the order in such a manner as to advance the other train beyond the meeting point already established.

Now let us see what happens when a similar situation arises in Centralized Traffic Control territory. C.T.C. cannot, of course, prevent hot boxes, broken draw-bars, or sand storms, but it can minimize the effects of such occurrences.

Here we have this freight drag doubling the hill. The lights on the track model in front of him convey to the dispatcher the information that this train is delayed. It is not necessary now for him to hold the opposing train at that previously selected meeting point. Instead, the dispatcher immediately directs it to proceed under signal indications.

This train, the *Challenger*, say, continues to advance during the time the freight is doubling the hill, with the result that the delay to the *Challenger* has been minimized; perhaps not even delayed at all. The freight clears in the siding at the top of the grade; the meet is consummated and both trains proceed.

The advantage of Centralized Traffic Control adds up to greater over-all train speeds and vastly increased capacity of existing trackage, with consequent intensified utilization of existing cars and locomotives.

Since the outbreak of the war, serious restrictions have been placed upon the purchase of new rail, cars, and locomotives. For this reason, the railroads have turned to C.T.C. for at least a partial solution to their problems.

Centralized Traffic Control has proved to be just what the doctor ordered, and the slightly groggy railroad patient gets a new lease on life.

C.T.C. can be installed in an exceptionally short time, and, considering the results obtained, with a justifiable expenditure of critical materials. In territory where Centralized Traffic Control has been put in operation, it has postponed indefinitely the need for additional trackage; in some cases it has actually made it possible to eliminate extra tracks. In several instances where C.T.C. has been installed on single track between sections of double track, it has been found that trains can be operated more efficiently in the single-track than the double-track territory equipped with only straight automatic signaling.

The advantages of Centralized Traffic Control are not, however, limited to single track. Where traffic is dense on multiple-track lines it has been demonstrated that greatly improved operation results by signaling each track for reverse running and authorized train movements by C.T.C.

In view of the tremendous amount of work accomplished by a C.T.C. control machine, the reader might assume that it is a massive affair. Actually it is surprisingly small, as for instance all the levers on the machine controlling the 171-mile Union Pacific installation are within easy reach of the dispatcher from a sitting position.

The switches and signals at the ends of thirty-three passing tracks are controlled by the dispatchers at the C.T.C. machine at Las Vegas. In addition, movements to and from the passing tracks at less frequently used sidings are made on signal indications, although the switches are hand thrown.

The C.T.C. machine at Las Vegas consists of a five-foot center section, with two two-and-one-half-foot wing sections at either end, arranged in semi-octangular fashion. Although under the load of present wartime traffic two men are employed on each trick to operate the control panel, under normal conditions it is considered that one man will be sufficient.

With its maze of brilliantly colored lights and rows of tiny levers and push buttons, the Centralized Traffic Control machine may appear complicated to the casual observer. But to a dispatcher who for years has been working under the time-consuming and complex method of issuing written train orders, it represents a phenomenally simplified means of directing train movements.

The track model, control levers, and code-starting buttons are arranged in a vertical panel on the front of the cabinet. The track model, which is located at the top of the panel, is a miniature representation of the actual track and signal layout within the controlled territory. Small red lights inserted in the lines of the track model indicate to the dispatcher the progress of each train. Beneath each point on the track model designating a switch is located a switch lever, and under the switch lever is a signal lever. Lights are inserted in plates behind each lever to indicate the position of the controlled function. Usually a red light indicates a switch in the reverse position, and an amber light shows that the switch is in normal position. When a signal is at stop this fact is indicated by a red light. When it is clear a green lamp is lighted. If a particular location is furnished with a maintainer's call signal, a toggle switch is provided for its control below the switch and signal levers. A code-starting button is placed under each group of switch and signal levers. Other levers and push buttons can also be furnished for mounting on the control panel according to the individual preferences of the railroads.

A horizontal surface, placed directly under the control panel, forms a desk for making out reports. An automatic train graph, protected by plate glass, is made an integral part of the desk. The train-graph mechanism continuously operates a parallel lined chart, which is printed for direct reading of time. This chart passes over a set of inked pens at the rate of three inches an hour. An individual pen is provided to make a recording on the graph paper each time a train occupies a corresponding "OS" section within the territory. By connecting the recordings made by the graph pens, the dispatcher makes a complete train-graph chart of each train that passes through the C.T.C. territory. The completed graph shows the exact time each train passes the different "OS" sections, and, also, where and at what time the various meets are made.

Now we come to the "coding" apparatus, which is contained within the control cabinet. This apparatus is rather complex and will not be discussed at great length. Substantially, it provides a means of sending out a control code to operate the various functions in the field. Likewise, the office coding apparatus receives an indication code from the field which illuminates the indication lamps and informs the dispatcher of the movement and positions of the various controlled functions.

Here, briefly, is how the coding system works.

Normally, the dispatcher retains the signal levers in the center position, which controls all signals to the stop position. The switch levers are placed in the normal position to line the switches for main line movements. Lever lights indicate which signals have been controlled and also the position of the switches.

Now, suppose the dispatcher wishes to direct a train to go into a passing track. He places the desired switch lever in the reverse position, turns the corresponding signal lever to the position controlling the signal governing movements into the passing track and then presses the code-starting button. The latter manipulation immediately sets a sixteen-step control code into operation. The code is composed of a series of long and short impulses, individual character of the code being established by the sequence in which the short and long impulses are arranged.

The first impulse, which is always long, is used to detect that the code line is not already in use, and also locks out the line so that a second coding operation will not be started and interfere with the one already initiated. The next seven impulses, three long and four short, select the station where the switch and signal are to be controlled. This is accomplished by the sequence in which the impulses are transmitted. The following seven impulses, which may be long or short, depending upon the character of the code, are used to control the switch to the desired position and provide the proper indication at the signal. The sixteenth or final impulse, which is long, resets the apparatus to the normal condition.

After the control code is finished and the functions have completed their movement, coding apparatus in the field, which is similar to that in the office, automatically transmits an indication code to indicate to the dispatcher that the functions have responded. The first impulse, always short, checks and locks the code line in the same manner and for the same purpose as was accomplished during the control code. Likewise, the next seven impulses, three long and four short, select the station in the same manner and the following seven impulses are used to indicate that the functions have responded correctly to the control code. As with the control code, these seven impulses may be long or short, depending upon the character of the code. The final impulse restores the apparatus to the normal position. Upon completion of the indication code, the lights on the levers indicate whether or not the functions have responded correctly.

In connection with the C.T.C. code line, it is interesting to note that the same pair of wires can also be utilized for telephone and telegraph circuits. Almost any type, number, or combination of circuits can be superimposed on the code line without interference with each other. In general, if an existing telephone or telegraph line is mechanically strong, it is not necessary to construct a new C.T.C. code line. On the other hand, if such a line does not exist, a new one can be constructed during the installation of the C.T.C., and other desired circuits can be superimposed on the same line later.

It should be emphasized that the code system serves only as a means of communication between the office and the field and also between the field and the office. Actually, a C.T.C. system retains all the features of automatic signaling plus full-circuit interlocking protection at switches.

If a dispatcher should attempt to clear a signal for one train to leave a station while another train is in the block, the automatic field circuits would cause the signal to continue to display a stop indication. However, if a train should advance to the next block the signal would automatically display the proper approach indication for the train leaving the station. A switch cannot be reversed for a movement into a passing track unless opposing signals are at stop and the signal governing the movement into the passing track is displaying the proper restrictive indication for such a movement.

Safety of train operation in C.T.C. territory is further increased because the authorization of train movements by signal indication eliminates the possibility of an error occurring in the issuance, transmission, delivery, or execution of written train orders.

An especially large amount of intricate, precision-built instruments, interconnected by complex electrical circuits, are required for a C.T.C. system such as the Union Pacific installation. The instruments and other equipment required at the ends of passing tracks are contained in metal instrument houses, amply ventilated to assure a free circulation of air. Inasmuch as temperatures in the Mohave frequently reach 120 degrees, sufficient ventilation is of paramount importance to the men whose duties require them to inspect and maintain the apparatus.

A separate compartment containing a telephone is furnished in each house to provide a means of communication between the dispatcher and train and maintenance men.

In order to speed construction work on the Union Pacific, the instrument houses were wired complete at the Union Switch and Signal Company factory, where all the signal apparatus was designed and manufactured. The houses were shipped to the railroad ready to be set on the foundations, whereupon connections to the line wires and rails were made by the railroad construction forces.

The signals at the ends of passing tracks are the type known as searchlight signals. Such signals afford three long-range indications—red, yellow, and green, using only one lamp bulb and signal unit. This is accomplished by a mechanism that places a red, yellow, or green roundel in such a position that a concentrated light beam is reflected upon the roundel by an elliptical reflector. After passing through the roundel, the light is spread upon a lens, which in turn concentrates the light into a beam possessing the color of the roundel. This beam provides an intense, unmistakable day or night indication, even under adverse weather conditions.

The signals used between the various stations are the color-light type. The color-light signal employs a separate unit and optical system for each indication. On the Union Pacific the units are arranged in a vertical fashion.

In order to conserve battery, all signals are normally lighted off an alternating-current line, which parallels the tracks. In the event of a power failure, a relay automatically transfers the source of energy to a "standby battery." Further battery economics are afforded by "approach lighting" the signals. This means that normally the signals are dark, but automatically light upon the approach of a train.

The automatic signal circuits are designed on what is known as the A.P.B. (Absolute Permissive Block) principle. This means that, for the utmost safety, when a train leaves one town all signals governing opposing movements are set at the most restrictive indication all the way to the next town. However, the signals behind a train that govern following movements go to the approach and clear positions as the train progresses through the blocks, in order to afford the greatest possible track capacity.

An important and interesting feature of the installation is that in spite of its length and magnitude, only two code-line wires are required. Until recently, the number of stations that could normally be controlled by one pair of line wires was limited. However, by means of a Union Switch and Signal Company development known as Coded Carrier Control, the flexibility and capacity of the two-wire C.T.C. system were increased to such an extent that now installations of any desired length or station capacity can be controlled over only two code-line wires.

Here, nontechnically, is how Coded Carrier Control works, as applied to the Union Pacific C.T.C. system. The territory is divided into three approximately equal sections. The first section, extending from Las Vegas (site of the control machine) to Calada, is fundamentally the conventional thirty-five-station Union C.T.C. system, and is operated on normal direct-current impulses. The second section, extending between Calada and Flynn, and the third section, between Flynn and Yermo, can quite well be called separate C.T.C. systems. Each section is controlled by separate high-frequency alternating current impulses, known as carrier currents.

These carrier currents, along with the conventional d. c. circuits, are superimposed on the same pair of line wires. However, by means of filters, the apparatus of each section is allowed to respond only to the correct current for that particular section. In this manner, all sections can be controlled simultaneously from only one control machine, with no increase in coding time. In addition, a voice communication circuit is also superimposed on the pair of C.T.C. line wires, filter equipment making it practical to carry on telephone conversation at the same time that C.T.C. codes are on the line.

The use of carrier frequencies for the handling of the two remote sections of the C.T.C. installations and the derivation of a telephone communication circuit from the one pair of line wires resulted in a large saving in critical materials, which would have been required if these facilities had been obtained by the use of additional line wires. Consistent with the general policy of conserving critical materials, the conductors of this C.T.C. line are Copperweld forty per cent conductivity. These conductors contain approximately forty per cent copper and sixty per cent steel.

In conjunction with the Centralized Traffic Control work, the majority of the passing tracks were extended a sufficient distance to accommodate 120-car trains. This not only makes it possible to handle longer trains, but the extended passing tracks increase the possibility of accomplishing nonstop meets. In this, as well as other C.T.C. installations, a considerable percentage of the meets are made on a nonstop basis.

The over-all result is that in spite of the unprecedented volume of traffic moving over single track across the mountains and valleys of the Mohave Desert it is kept moving smoothly, swiftly, and without unnecessary delays.

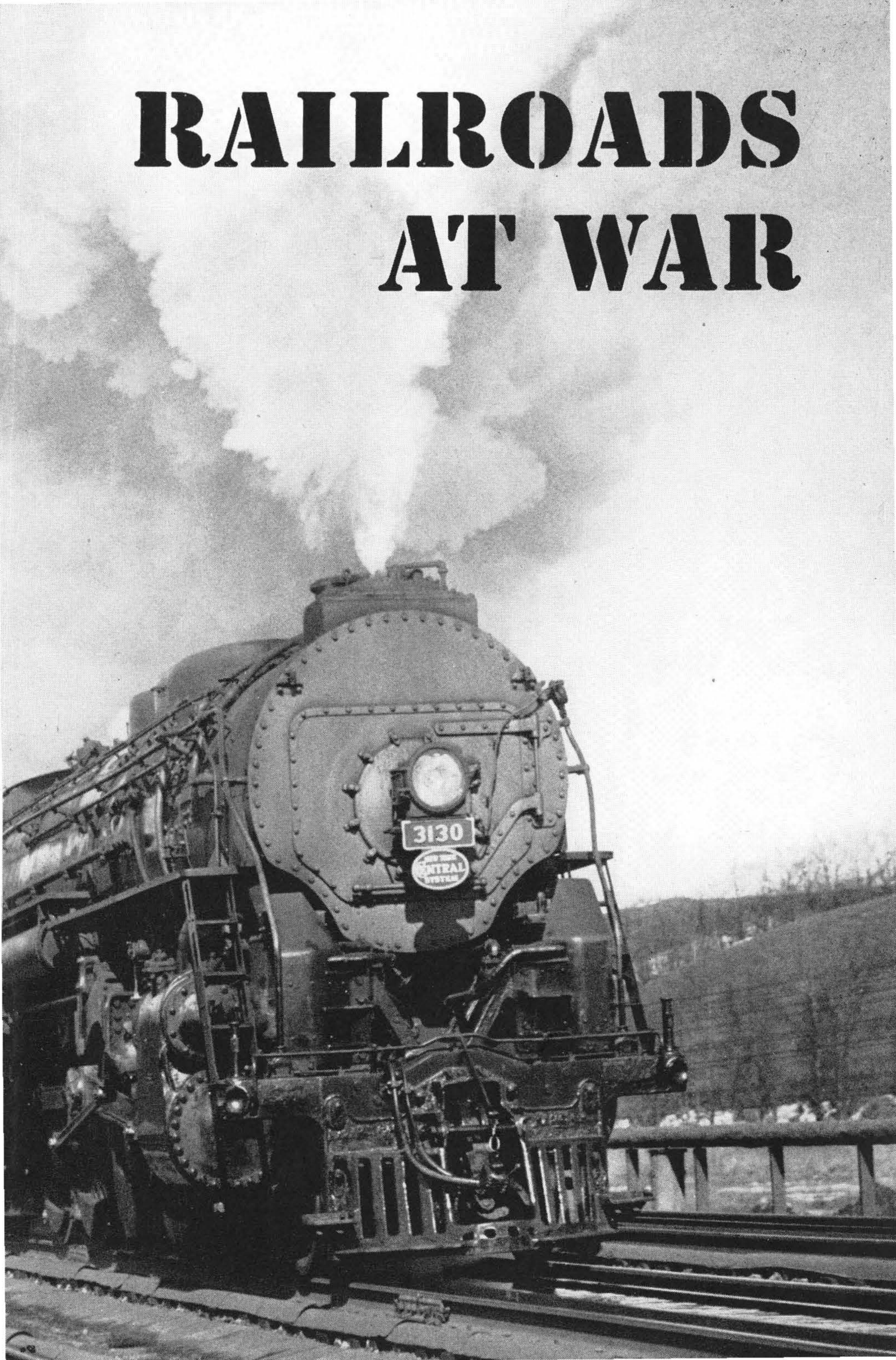
As of March, 1944, the Union Pacific is moving about 1,800 cars daily between Las Vegas and Yermo. The "helper" mileage on this district reaches the rather startling total of 3,600 miles daily. All freight trains are "helped" between Las Vegas and Cima, eighty-one miles, also between Kelso and Cima, eighteen miles.

Before the installation of Centralized Traffic Control, it was necessary to "patch" from four to ten trains daily between Las Vegas and Yermo. In 1942, traffic in this territory had just about reached the saturation point. Now the Union Pacific is handling a traffic increase of better than twenty-five per cent over that of the period prior to the C.T.C. installation. And trains are making the 170-mile run in seven and eight hours.

Centralized Traffic Control stands out as a most important contribution to the war effort by the Union Pacific, as well as the many other railroads of the country, which are today employing this wizard of the main line to keep the supply trains moving.

Yes; C.T.C. and the American Railroads are helping to "pass the ammunition."

RAILROADS AT WAR



Government wartime restrictions on materials have made it essential that the amount of paper used in each book be reduced to a minimum. This volume is printed on lighter paper than would have been used before material limitations became necessary, and the number of words on each page has been substantially increased. The smaller bulk in no way indicates that the text has been shortened.

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