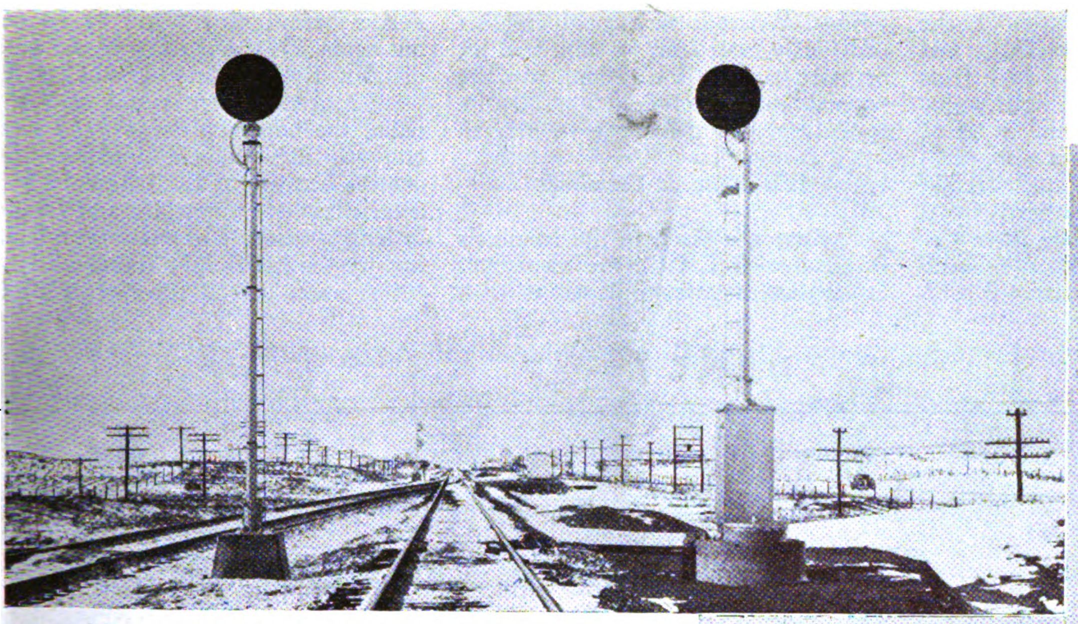
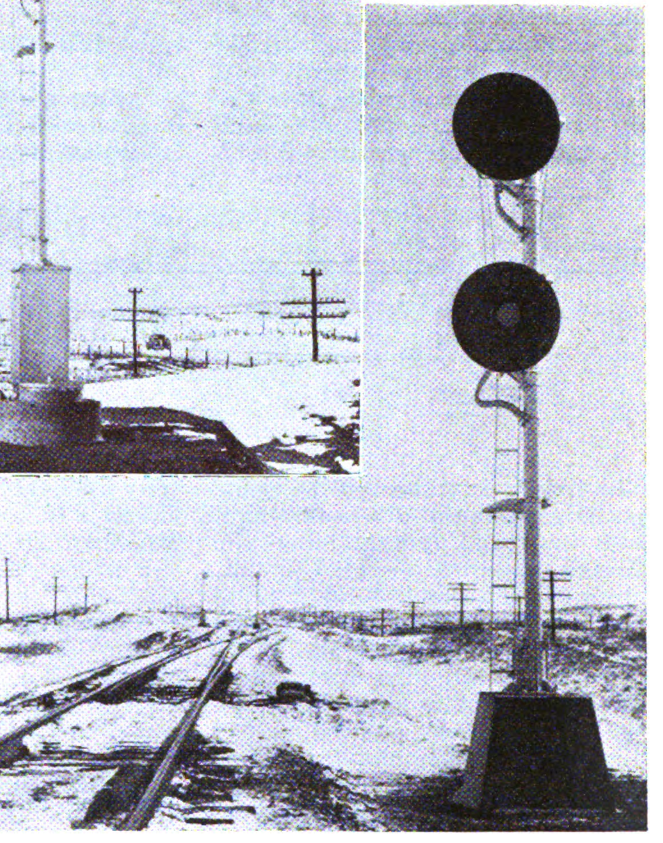




Above—Signal at left, for directing trains to leave a siding, is a high signal and located between siding and the main track.

Right—The sidings are equipped with track circuits which control aspects of the station entering signal such as shown here.

Signaled sidings nearly two miles long, with aspects to direct efficient utilization of the No. 20 turnouts, are aids in making non-stop meets on a 110-mi. district

C.T.C. Has Long Sidings With Signals on the Santa Fe

The Atchison, Topeka & Santa Fe has installed centralized traffic control on a freight-train district of 110 mi. between Waynoka, Okla., and Canadian, Tex. The power switch machines and signals are controlled by a C.T.C. machine in the dispatcher's office at division headquarters in Amarillo, Tex., which is 98 mi. west of Canadian. Previous to the recent improvements, train movements were authorized by timetable and train orders, automatic block signaling being in service as protection. The siding switches were equipped with spring mechanisms so that trains could depart without stopping. Operators were on duty three tricks at Waynoka and Canadian as well as at seven intermediate stations. Therefore, all the known methods, other than C.T.C., were previously being employed.

The project includes long sidings to permit more meets to be made with neither train being required to stop, and the use of No. 20 turnouts with signal aspects to direct trains to enter and leave the sidings at the speeds for which the turnouts are designed. With allowances for the effects of ascending grades, the sidings and signals are located as nearly as practicable on a time-distance basis. Extra approach signals, on curves, give trains the benefit of improved circumstances ahead.

With the former timetable and train-order operation, the dispatcher could not secure enough information concerning the locations of and the progress being made by the trains, and the enginemen and conductors were similarly handicapped in receiving information that superior trains were on time or running late. When trains were delayed unexpectedly in yards, terminals or other points on the line, there was no practical means for the dispatcher to get this information and change orders quickly enough to advance other trains. On the other hand, with the C.T.C., the lamps on the control panel indicate the location and progress of each train, so that the dispatcher controls signals at the proper time and place to authorize trains to keep moving for close meets. Approximately 80 per cent of the meets between opposing trains are being made with neither train being required to stop. On March 11, the westbound passenger train No. 23 met eastbound passenger train No. 2, as well as five eastbound freight trains on the 110-mi. district, and in all of the six meets neither train stopped.

On March 2, eastbound freight train 5035E was authorized by a C.T.C. controlled signal to leave Coburn at 9:00 a.m., just 10 min. ahead of eastbound passenger train No. 2.

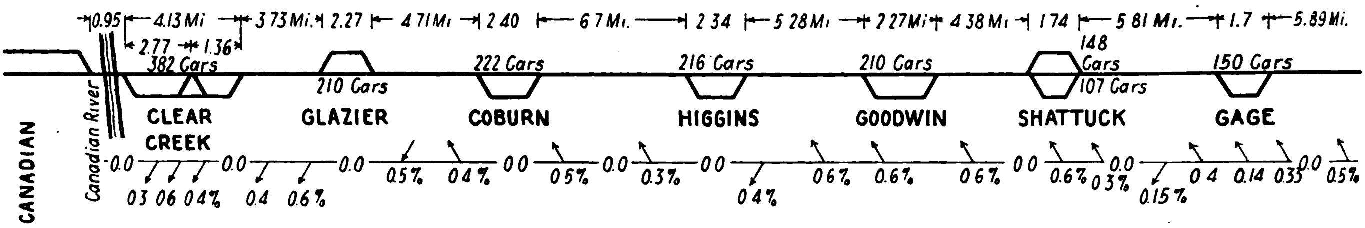


Fig. 1—Track and signal plan of the entire 110-mi. engine district equipped

The freight went through the siding at Fargo to make a non-stop meet with westbound passenger train No. 23 and proceeded east at 9:45 a.m., about 17 min. ahead of No. 2. Also freight 5035E made a non-stop meet with westbound freight train 5017W at Heman, with the latter going through the siding, and 5035E continued to Waynoka, arriving there at 10:55 a.m., 17 min. ahead of No. 2. If 5035E had stayed at Coburn for No. 2, which it would have done under timetable and train orders, it would have stayed at Shattuck for No. 23, and most likely would not have arrived at Waynoka until about 1 hr. later than it did. The reduction in overall running time is an accumulation of savings in delays on sidings, as well as by the elimination of train stops formerly required to operate hand-throw switches when entering sidings. Whereas the through freights previously took 7 hr. 30 min. to 8 hr. or more to make the 110-mi. run, the normal time now is about 3 hr. 30 min. to 4 hr. from departure to arrival.

Less Time at Terminals

Savings are made in the terminals because, with C.T.C., the dispatcher can authorize trains to depart without delay when they are ready to go. Previously a train in a yard might have until a certain time to depart and get to a certain siding. If delayed in the yard longer than anticipated, new orders would be required, thus entailing further delay. Thus the ability to move a train out of Canadian or Waynoka as soon as it is ready to depart, not only reduces initial terminal time, but also helps to keep the tracks in these terminal layouts clear so that other trains can pull in without delay.

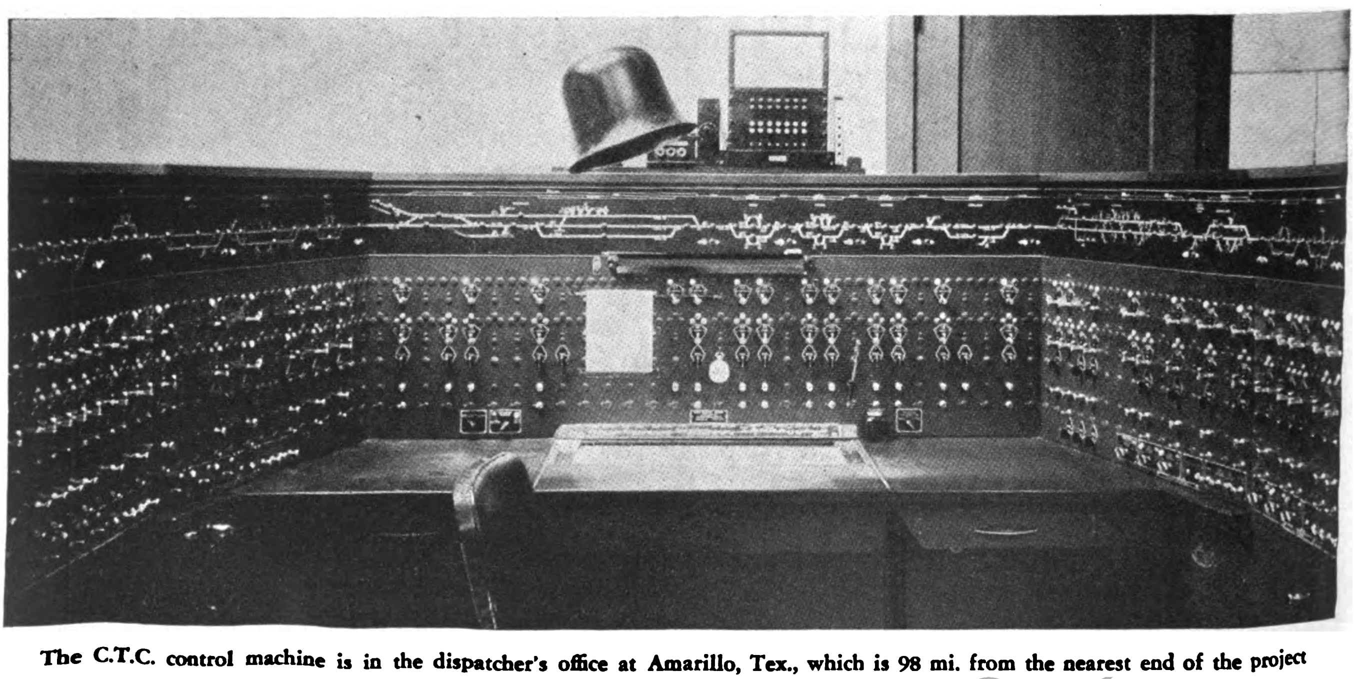
Less Bunching

Formerly with timetables and train orders, there was a tendency for trains to bunch up towards the far end of the district, and then pull into Canadian, for example, one after another to block the yards and thus hamper terminal work, thereby causing further delays before they could be spaced out again when departing on the next district. Even when westbound trains were spaced uniformly out of Waynoka, the bunching toward the west end was inevitable in numerous instances because of the inherent characteristics of timetable and train-order operation. For example, a leading westbound freight train, with no information that a superior train is running late, enters a siding to wait for the meet.

In the meantime, the following westbound freight, with run-late information on the superior train, keeps going, and thereby reduces the spacing between the two freights before taking siding. With several following trains on the district, they would bunch on numerous days, and there was not much that the dispatcher could do about it, certainly he could not run one train around another. With C.T.C., the dispatcher can keep the trains spaced over the district, and bring them into Canadian or Waynoka at intervals, so that the yards or station layouts will not be congested.

Fewer Break-In-Twos

The reduction in the train stops has minimized the number of instances in



The C.T.C. control machine is in the dispatcher's office at Amarillo, Tex., which is 98 mi. from the nearest end of the project which trains break in two. For the division as a whole, there were 56 break-in-twos in November, 1943, before C.T.C., as compared with 9 break-in-twos in November, 1946, after the C.T.C. was in service. Figured on the number of trains operated, there was a break-in-two for 56 trains in November, 1943, as compared with a reduction to 257 trains per break-in-two in November, 1946. These totals were for the division as a whole, but the reductions were for the most part accomplished on the Canadian-Waynoka C.T.C. territory, therefore, as a matter of fact the proportions of benefits in this respect are greater than indicated by the totals. On the average, a break-in-two not only delays the train involved about 1 hr., but also delays other trains as much as 5 to 6 hr. With train orders, several hours were required to get all the trains moving again, but, with C.T.C., the signal aspects, which are the modern equivalent of an order, can be controlled at numerous places by the dispatcher instantaneously, and, therefore, all the trains are on their way soon after the train with the break-in-two has corrected its trouble.

Fewer Helper Locomotives

The helper locomotives, used on tonnage trains westward from Waynoka to Curtis, formerly lost time in returning to Waynoka under timetable and train-order operation. Four such crews worked 12 to 16 hr. daily. Now with the C.T.C. these helpers can be moved back to Waynoka promptly, and, as a result, only three such crews are needed and they seldom work more than 8 hr. Previously helpers were used on certain trains eastbound out of Canadian to Glazier on the long 0.6 per cent grade. With the power switches and signals under the control of the dispatcher he can give preference to any heavy eastbound train so that it can go all the way up the grade without stopping.

Location of the Project

On the overall route between Chicago and cities in California, the Santa Fe has alternate routes between Newton, Kan., and Dalies, N. M., roughly 730 mi. The original line built in 1880 via La Junta, Colo., is a high-speed route except for certain short sections of heavy grades and curves over two mountain ranges. The southern route, completed in 1908 via Amarillo, Tex., is at lower grades. Accordingly the passenger trains on short schedules, such as the Chief, El Capitan, the Super Chief and the California Limited, are routed via La Junta, and the other two passenger trains, the Grand Canyon Limited and the Scout, as well as all the through freight traffic, are routed over the southern line through Amarillo. The district between Waynoka and Canadian, on which the C.T.C. was installed, is a part of the route via Amarillo.

Eighteen to Twenty Trains

The traffic on the Waynoka-Canadian district includes two passenger trains and about seven to nine through freight trains each way daily. A local freight is operated westward on Monday, Wednesday and Friday, and eastward on Tuesday, Thursday and Saturday. Thus the number of trains operated on this single track may range from about 18 to 22 on normal days, with peaks of 30 or more on some days.

Waynoka is on the Cimarron river at an elevation of 1,475 ft. above sea level, and Canadian, 110 mi. further west, is on the Canadian river at 2,344 ft. elevation. As the line rises from the valley of the Cimarron river, there is an ascending grade westbound of about 0.8 to 1.0 per cent for about 11 mi. between Belva and Curtis. In this section, helper locomotives are used on westward trains which have more than a certain tonnage. As the line rises from the Canadian river there is a steady ascending grade eastward for about 10 mi. from the bridge to Glazier. Between Woodward and Tangier, about 10 mi., the grade ascends westward at 0.5 to 0.6 per cent. On the remaining portions of the district the grades are rolling but not to exceed 0.6 per cent.

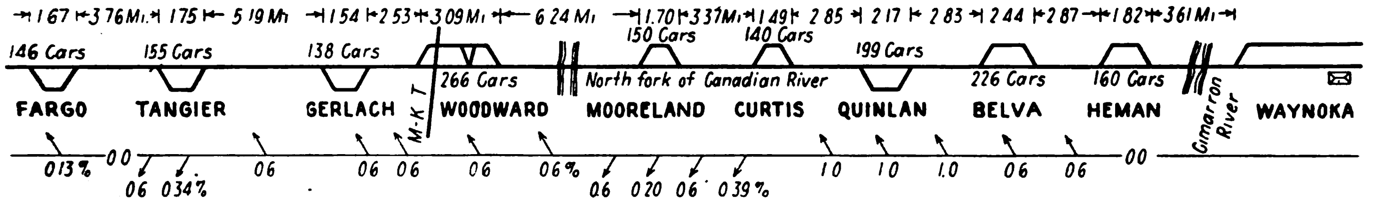
Thus by providing helpers on the 11 mi. of 1 per cent westward between Belva and Curtis, the tonnage ratings are based on a ruling grade of only 0.6 per cent. The rating for the 5,000 Class locomotives between Waynoka and Canadian is 3,650 tons westbound and 5,500 tons eastbound. Heavy wheat traffic is brought in on a branch which connects with the main line at Shattuck. This grain moves east, and the grades are such that eastbound trains can fill out to 6,800 tons at Shattuck and take it to Waynoka. The through traffic ranges from 650 to 750 cars each way daily. Traffic originating on this district, such as wheat and stock, varies in volume during different seasons.

The curves are relatively few and far between, and most of them are 2 deg. or less, with only two 3-deg. and one 4-deg. curves, this being the maximum. The maximum permissible speed for freight trains is 50 m.p.h. with restrictions on account of the 4-deg. curve to 45 m.p.h. at one location. The track is well maintained, using 131-lb. rail, good ties and crushed rock ballast.

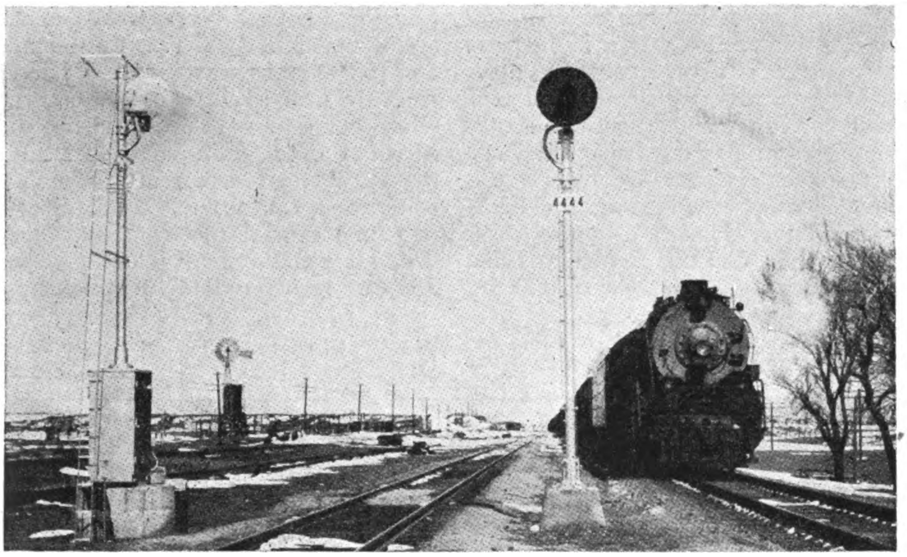
Sidings Lengthened

In the previous arrangement there was a siding, long enough for one freight train, located at each of 15 towns, and with two sidings at Shattuck. An important feature of the project was to lengthen all these sidings except the one at Curtis. In general, each siding was extended to a length of about 1.5 to 2.0 mi., the principal purpose being to allow trains to make running meets with neither train stopping, and also, when necessary, to place more than one train on a siding. The locations and car capacities of the sidings are shown on the accompanying plan. Some sidings are longer than two miles, as for example the siding up the grade east of the Canadian river bridge to Clear Creek is 4.15 mi. long. About 1.36 mi. east of the east end of this siding there is a set of two crossovers connecting to the main track so that trains can enter or leave the siding. These crossovers as well as the switches at the ends of all the sidings are equipped with electric switch machines controlled by the dispatcher as a part of the C.T.C. system.

New No. 20 turnouts with 30-ft. points were installed at the ends of the sidings and the intermediate cross-



with centralized traffic control between Canadian, Tex., and Waynoka, Okla.



View showing train on the main track, and the intermediate automatic signals on the siding at Glazier

overs, thereby permitting trains to enter and leave at medium speed. Each siding is long enough that an engineer can pull his entire train into the siding at medium speed and then have plenty of track length remaining in which to stop. This operation is possible because the sidings are equipped with track circuits which enter into the control of signal aspects to direct trains to enter as well as to depart from the sidings at medium speed.

Signaling on Sidings

At the middle of each siding there is an automatic signal location with a signal for each direction, as for example signals 4203 and 4204 on the siding at Goodwin, as shown in Fig. 2. Normally the eastward leave-siding signal 56RB displays the Stop aspect, and the eastward intermediate automatic signal 4204 on the siding displays the Approach aspect, yellow. When the dispatcher sends out a control for an eastbound train to enter the siding, switch 51 is reversed and eastward signal 52R is controlled to display the Medium-Clear aspect, red-over-green, and distant signal 4232 displays the Advance aspect, yellow-over-yellow, indication "Proceed: Approach next signal at medium speed." Accordingly the engineman brings his train up to and through the turnout at medium speed, and he pulls to stop short of leave-siding signal 56RB, with the rear of his train east of signal 4204, which then displays the red aspect. Under these circumstances, if the dispatcher wants to run another eastbound train into the siding he sends out a control that places switch 51 in the reverse position, and signal 52R is controlled to display the Medium-Approach aspect, red-over-flashing-yellow, which indicates "Proceed at medium speed prepared to stop at next signal", which in this instance is signal 4204, which is displaying the red aspect. Accordingly an engineman enters the siding at medium speed prepared to stop his train short of signal 4204.

If the first train stopped with the rear west of signal 4204, the dispatcher cannot clear signal 52R for a second train to pull into the siding. If such an instance occurs, the second train would stop at signal 52R, and the head brakeman or conductor would go to the telephone at the switch to get information from the dispatcher concerning the emergency. If necessary, directions can be given for the train to be pulled into the siding at restricted speed. Circuits are interconnected so that signals cannot be cleared for opposing movements on the siding.

Some of the signal aspects discussed above are new, and this is the first C.T.C, project on the Santa Fe on which they have been applied. These aspects use only the three basic colors, red, yellow and green. Ordinarily a signal displays only one lamp, such as green for Clear, yellow for Approach or red for Stop. The second lamp appears only when needed to form a part of some aspect other than the three just named. In a yellow-over-yellow aspect, if one yellow lamp burns out, the remaining single yellow is more restrictive, and thus on the safe side. In the red-over-flashing-yellow aspect, if the flasher fails to operate, the red-over-steady-yellow is more restrictive. In the red-over-green and red-over-yellow aspects, if the red lamp burns out, a relay operates to extinguish also the green or the yellow.

Extra Approach Signals

As a general rule a block extends from the signals at one switch to the signals at the other switch of a siding, as for example from signal 56L to signal 52L in Fig. 2. At some locations there are curves in the tracks and high banks which reduce the range at which the engineman of an approaching train can see a signal. Referring to the layout at Glazier, as shown in Fig. 3, assuming that an eastbound train is entering the siding for a meet with a westbound train which gets an Approach aspect on signal 28L at the east end and then proceeds at reduced speed down the main track prepared to stop at signal 24LA at the west end. In the meantime the eastbound train gets in on the siding, and the dispatcher clears signal 24LA for the westbound train but the engineer of the westbound train cannot see the signal on account of the curve, and, therefore, cannot increase his speed. To save train time in such an instance, an additional signal, 4441, as shown in Fig. 3, was installed at a location where it can be seen on the tangent track as the westbound train approaches.

Accordingly, as soon as the aspect on this signal 4441 changes from yellow to green, an engineman knows that the other train is in the clear, the switch has been placed normal and signal 24LA has been cleared for him

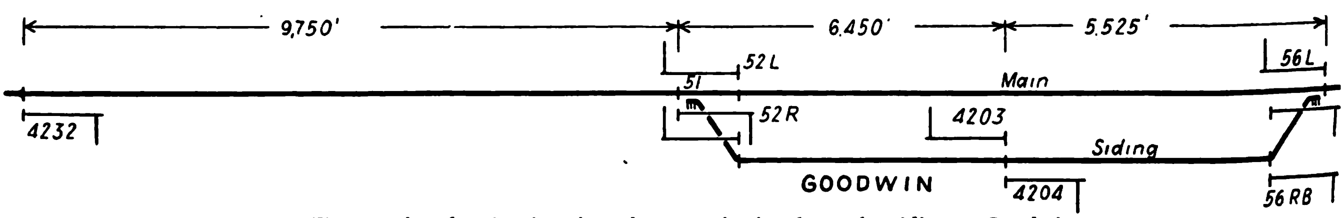


Fig. 2—Plan showing location of automatic signals on the siding at Goodwin

so that he can at once accelerate his train. In some instances this saves several minutes or perhaps also a stop for the westbound train, and, furthermore, by getting the rear of this train past the east end of the siding, the dispatcher can reverse that switch and clear the signal for the eastbound train on the siding to depart, thus keeping it rolling without a stop. Of interest is the fact that this arrangement operates quite often exactly as planned, as for example about 3 p.m. on March 12. The controls are such that, with the main track unoccupied, signal 28L cannot display an aspect better than that on signal 4441. Therefore, as applying to aspects less restrictive than green, the block is from signal 24LA back to signal 28L. Accordingly, the additional signal 4441 does not introduce a short block, with respect to braking distance for stopping trains.

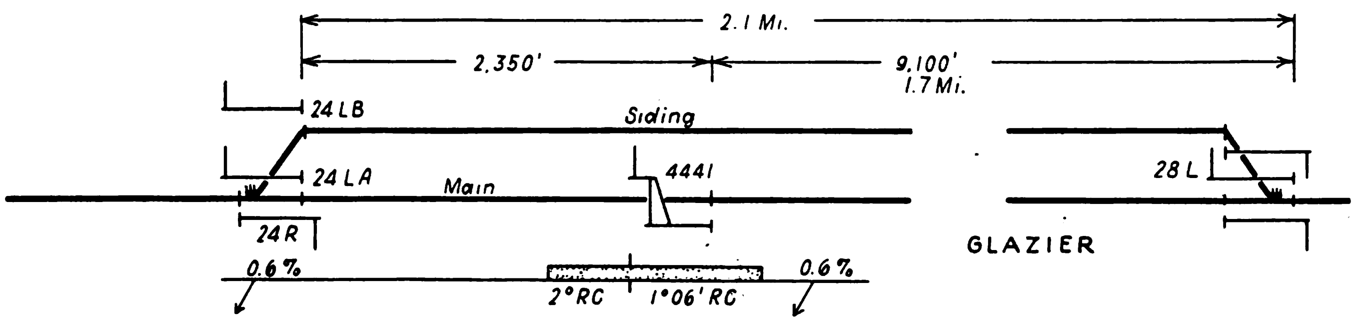


Fig. 3—Extra approach signal on main track within station limits

Extra Approach Signal on Main Track

Likewise to eliminate train stops, an extra approach signal is provided at some locations on main track approaching a siding. Referring to Fig. 4, for a westward train the grade is ascending at about 0.53 per cent for several miles. On account of a 1-deg. curve and a high bank, the engineman of a westbound train gets only a short approach view of signal 108L at the east end of the siding. Therefore, if he gets a yellow aspect on signal 3911, which is 6,350 ft. from signal 108L, he would have to drag up the grade prepared to stop short of signal 108L. In the meantime, the eastbound train may get into the siding, and the dispatcher clears signal 108L, but the westbound train would be going so slow that chances are the engineman would have to stop the train short of signal 108L even if it is clear. To correct this situation, an extra signal, 3921, was installed 1,450 ft. east of signal 108L at a location where the engineman of a westbound train can see it a long distance. Thus, if the dispatcher clears signal 108L after the westbound engineer passes signal 3911, signal 3921 will clear so that the engineer can see it and keep his train at normal speed up the grade and over the crest. As compared with stopping on the ascending grade short of signal 108L, this saves considerable time for the westbound train as well as improves the chances for a close meet so that the eastbound train may not need to stop.

The distance between two signals such as 108L and 3921 may or may not be adequate train stopping distance, but this does not introduce a short block because when the track is unoccupied, signal 3911 cannot display a more favorable aspect than 3921. In other words, when signal 108L displays the Stop aspect, both the signals 3921 and 3911 display the Approach aspect. Therefore, as applying to aspects less restrictive than green, the block is from signal 108L back to signal 3911.

Time-Distance Spacing Between Sidings

The possibility of making non-stop meets between opposing trains depends not only on long sidings but also on comparatively short train time between sidings, so that with an even break, a train can be directed to move on over to the next siding and enter, on short time for a meet, rather than being held back at the previous siding. The running time between sidings is governed by the distance and train speed. On this project the distances between sidings are comparatively short, ranging, with certain exceptions, from 3.3 mi. to 6.7 mi., as shown in Fig. 1. The spacings are shorter, 2.8 mi. between Heman and Belva, and 2.8 mi. between Belva and Quinlan, because this is heavy ascending grade westbound, thus westbound trains take more time. Between Mooreland and Woodward, 6.24 mi., and between Gage and Shattuck, 5.8 mi., the grades are light, and therefore the running time is short.

Spacings of Intermediate Signals

In instances where the distance from one siding to the next varies up to about 4 mi. there is one double location of intermediate signals. Where curves and high banks reduce the sighting distance, the two signals are located separately so that each can be seen further. Where the distance between sidings varies from about 4.4 mi. to about 5 mi., there are two double locations. Between Gerlach and Tangier, where the grade is 0.5 per cent ascending westward, there are three double locations in 5.19 mi. thus shortening the blocks where train speeds are reduced and thereby increasing the capacity for following trains. On the other hand, between Woodward and Mooreland, 6.24 mi.,

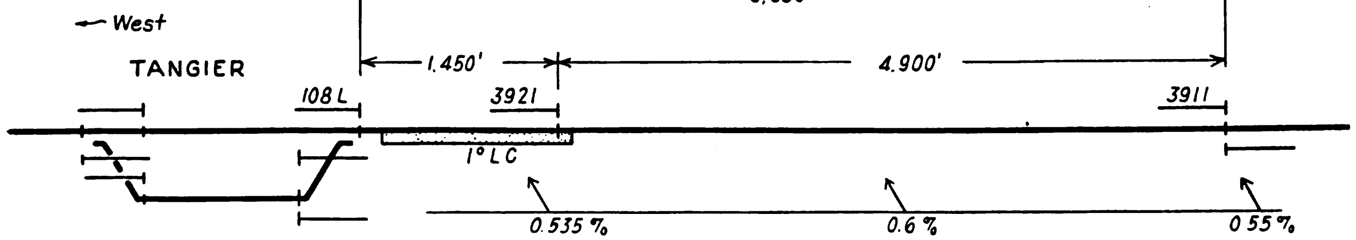
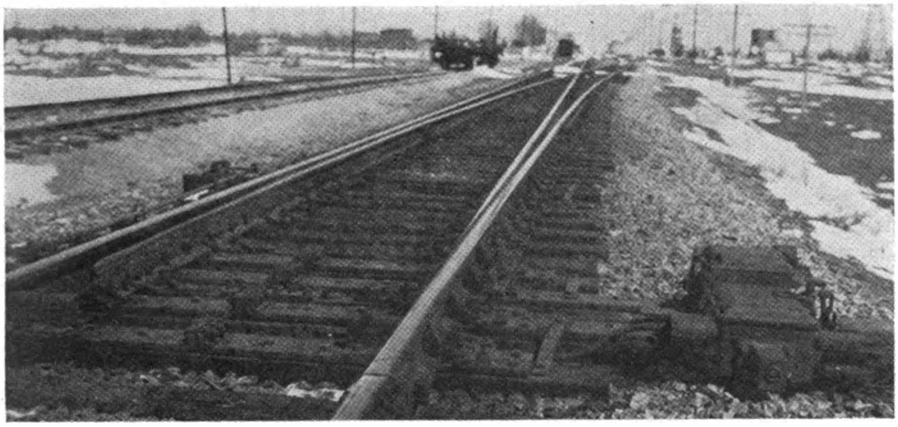


Fig. 4—Extra signal approaching a siding



The switch layouts include heavy gage plates and adjustable braces

the grades are light and train speeds are faster, therefore the blocks can be longer. Accordingly only two double locations are required. Thus, as nearly as practicable, the intermediate signals are arranged on the basis of time-distance for trains.

Operation of Switches

The siding switches and certain crossovers between sidings and the main track are now equipped with M-22A d.c. electric switch machines which operate in about 14 sec. with 20 volts on the motor. These machines are equipped with dual control so they can be operated by hand when making special switching movements. The switch points are 30 ft. long and, although they are reinforced, they are flexible, and, therefore, to be sure that the points go over to fit against the stock rails, a second operating connection is attached to the No. 5 switch rod, and is pipe connected to the operating connection on the No. 1 rod. All of these turnouts are new, and were installed with insulated gage plates 1 in. thick, 8 in. wide on four ties, one ahead of the points and three under the point. Adjustable rail braces are used on these four ties. The plates on two ties extend and are bolted to the switch machines, thus preventing lost motion between the rail and machine.

At the main-track switches connecting to house tracks or spurs, the old hand-throw stands were replaced with Union T-21 stands which in effect are hand-throw, switch-and-lock movements, including lock rods and plungers which lock a switch the same as an interlocked switch, in the normal position. Each of these T-21 mechanisms is equipped with a Style SL-21A electric lock which is controlled as a part of the C.T.C. system.

When a local freight train on a house track is ready to move to the main track the conductor telephones to the dispatcher. If the dispatcher is ready for the train to go, he tells the conductor that he will let him out. The dispatcher positions his lever for the control of that lock and sends out a code. In the meantime, the conductor unlocks the padlock and removes it. If no train is occupying any part of the entire traffic block on the main track, the electric lock on the switch stand is released at once.

When a train on the main track is to make a switching move into a spur, its occupancy of the approach track circuit, together with the removal of the switch padlock, completes circuits locally which release the electric lock on the switch stand after a time delay, which depends upon the length of the circuit. Independent of other controls, the removal of the padlock from the switch stand holds the protecting signals in each direction at the red aspect, and then starts the operation of a five-minute automatic time-measuring relay. At the end of this safety period, the electric lock on the switch is released.

Also on Sidings

In view of the fact that trains enter sidings at medium speed, electric locks were installed also on the hand-throw switches which lead from sidings to spurs. In general, these switch stands are the Pettibone-Mulliken hub type, to which the Style SL-21A electric locks were applied. The locks on these switches are not controlled by levers on the C.T.C. machine. When a train on a spur is ready to enter the siding, the conductor telephones the dispatcher. If the movement is to be made, the conductor removes the padlock from the switch, which holds the entering signals at Stop and starts a two-minute time-release relay. At the end of this period, the electric lock is released.

New Light Signals

The semaphore signals used in the previous automatic block signal system were removed and discarded, light signals being installed throughout on the C.T.C. project. The H-5 searchlight signals are used for all single-unit signals and for the top unit of all two-unit signals. On two-unit signals where the lower unit can display either of two colors (yellow or green), this unit is the H-2 searchlight type. This unit never shows red, and, therefore, a metal blind is used instead of the red roundel in the spectacle. This blind is black and shaped like a cone so that it cannot reflect light. On two-unit signals capable of displaying no color but yellow in the lower unit, this unit is an HC-33 lamp case with a yellow glass.

In the signals at the sidings, the lamps are the single-filament type, rated at 10 volts, 18 watts. In the intermediate signals the lamps are the double-filament type, rated at 8 volts, 13.0 + 3.5 watts. The lamps on all signals are normally dark, being lighted automatically when trains approach. The lamps are fed normally on a.c. from transformers, but if the a.c. fails, a relay transfers the lamp

ASPECT	NAME	INDICATION
G	Clear signal	Proceed
Y / Y	Advance signal	Proceed Approach next signal at medium speed
R / G	Medium-clear signal	Proceed at medium speed
Y	Approach signal	Proceed preparing to stop at next signal. Train exceeding medium speed must at once reduce to that speed
R / Y (Flashing)	Medium approach signal	Proceed at medium speed preparing to stop at next signal
R / Y	Restricting signal	Proceed at restricted speed
R (Number plate)	Stop and proceed signal	Stop – Then proceed in accordance with rule 509
R	Stop signal	Stop

Some of the signal aspects are new and this is the first installation on the Santa Fe on which they have been used

circuits to feed from batteries.

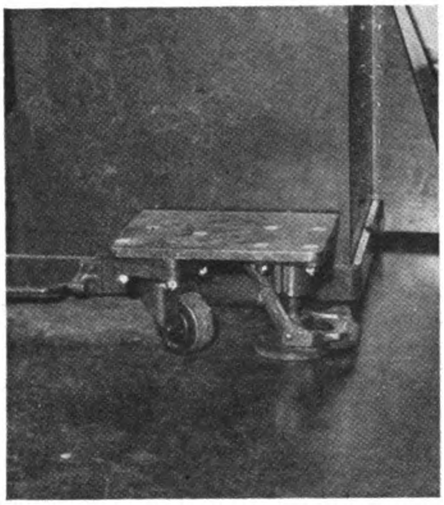
In a signal which can display red-over-yellow, red-over- flashing-yellow, or red-over-green, an 0.08-ohm DN-22L relay is connected in series with the filament of the lamp in the upper unit when red, so that, if this filament fails, the relay releases and opens the circuit for the lower unit. Also the lamp circuit in the upper unit when green or yellow is checked through a back contact in this relay. Thus the failure of a lamp cannot result in the display of a less restrictive aspect, and a failure of the series relay to release would prevent normal operation of the signal.

As a general standard each signal is mounted over or to the right of the track governed. Where signals are between the main track and a siding, the siding was thrown over to 18-ft. centers, which provides standard clearance for a mast and ladder, but, in order to get clearance for the searchlight signal with the circular background, the masts are 17 ft. 11 in. high to bring the center of the lens 19 ft. 8 in. above the level of the rail. On further projects now under construction the track is being thrown over to 20-ft. centers, permitting the use of standard signals in which the top unit is 15 ft. 8 in. above rail. This results in much better indication for the engineman in the cab. Where local conditions are such that too much grading or filling would be required to throw the track, a cantilever half-bridge is installed on which the signals are mounted above the track.

The C.T.C. Control Machine

The C.T.C. machine in the dispatcher's office at Amarillo has a center panel 5 ft. long and at each side there are two 2.5-ft. panels which are set at angles to form a "U" shape, the total length of the five panels being 15 ft. Another 5-ft. C.T.C. control machine in this same room is for the control of the 40-mi. section from Canadian west to Pampa, from which point double track extends 56 mi. into Amarillo and beyond for 18 mi. to Canyon. Another C.T.C. project on the 77 mi. of single track west from Canyon to Texico is now being planned, and is to be controlled by a second 15-ft. machine arranged in a "U" shape with the open end facing the open end of the Waynoka-Canadian machine.

Between the two "U"-shaped machines will be the one 5-ft. machine for the Canadian-Pampa section. The 5-ft. machine is on four large casters which are equipped with toe-operated jacks by means of which the weight of the machine can be raised up on pads



Caster and toe jack on C.T.C. machine

which lock the machine from rolling. The floor is covered with sheet iron, on which the machine can be pushed about readily. By this means the 5-ft. machine, for the Canadian-Pampa 40-mi. section, can be operated by a separate dispatcher or, in periods of light traffic, it can be turned to face the open "U" end of either the Waynoka-Canadian or the Canyon-Texico machine, and accordingly operated by the dispatcher in charge of either of those larger machines. The wires entering the 5-ft. machine come through a flexible metal conduit from the rear to a pipe extending up from the floor, with slack in the length of the conduit and wire to allow the machine to be moved either way as far as may be required.

The illuminated track diagram on the machine has lamps in the lines representing tracks which are lighted to indicate track occupancy of all sections of main track and the sidings. Also traffic-direction indicators show the direction in which traffic is lined up on the single track between sidings. Thus the track-occupancy lamps report the location of a train, and the traffic indicators show the direction in which it is moving.

The C.T.C. machine is equipped with an automatic graphic train recorder with the mechanism geared to move the graphic sheet 3 in. per hour, which is two minutes for each division between lines. These recorders have pens which indicate when trains enter and leave the OS track circuits at siding switches in the customary manner, and in addition a new feature is that the clearing of the C.T.C. signals at each end of every siding is also recorded by the pen which provides the OS in the following manner:

The recorder pens are three position and are normally on center. Clearing a signal in either direction at the end of a siding deflects the pen to the left if the switch is normal or to the right if the switch is reversed. When a train occupies the OS section the pen travels to the other extreme position. Thus a record of a clear signal, an OS time and the position of a switch for the train movement is automatically recorded graphically on the record sheet.

If the dispatcher has cleared a signal and later he decides to take that signal away, he can cause it to again display the Stop aspect by setting his lever to normal and sending out a code which causes the signal aspect to change back to red, but he cannot clear any conflicting signal or operate the power switch at that location until after the expiration of a time-locking interval which is long enough that any train at normal speed which had passed the distant signal would have time to pass the switch and lock it by

Intermediate signal with second unit to display the yellow-over-yellow aspect

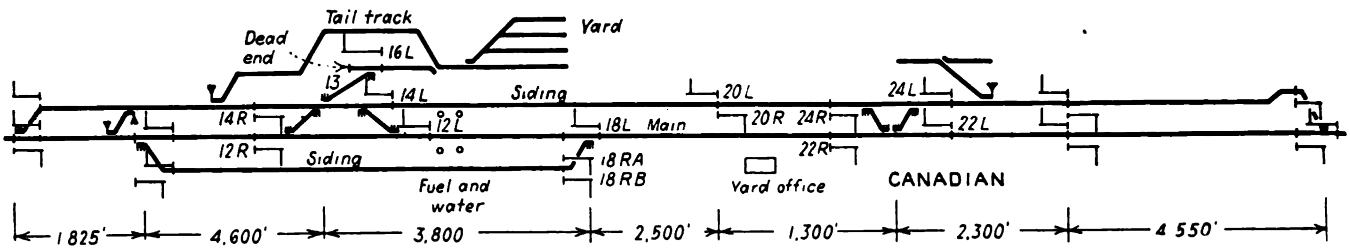


Fig 5—Track and signal plan of layout at Canadian terminal

detector locking, or a train at slower speed would have time to stop short of the signal at the switch. When time locking is in effect, the indication lamps above the signal lever are extinguished when the signal goes to Stop, but the red lamp above the normal position of the lever is not lighted until the time-locking interval has expired. This informs the dispatcher so that he can send out new controls just as soon as they would be effective in moving the switch or clearing another signal.

When the a.c. power supply fails at any layout including a power-operated siding switch, the dispatcher is informed accordingly by the fact that the OS track-indication lamp for the corresponding layout on his machine becomes lighted when he knows there is no train there. If a signal at that layout is clear, the power-off indication is held out, otherwise the dispatcher might conclude that a train had entered. After the train has gone, the power-off indication comes in and lights the OS lamp. The dispatcher takes what action may be required to restore the a.c. power and then he sends out a maintainer's call code which restores the power-off indication circuit at the field location. By these means the power-off indication is transmitted without requiring an extra code step.

Local Controls at Canadian

The train and engine crews on through freight trains are changed at Canadian. The locomotives stay coupled to the trains while taking fuel and water, and while being lubricated. In the meantime, the cabooses are changed by a switch engine. In order to do this work without running the trains in and out of the yard, certain changes and additions were made in the track layout, and an interlocking was installed with the control machine in the Canadian yard office, to control the power switches and signals, as shown in the track and signal plan herewith in Fig. 5. With this arrangement, trains can take fuel, oil and water on either of the two main tracks or on the siding. These three tracks are signaled for both directions, and train movements are directed by signal indication. The various crossovers and signals are located so that trains can make run-around moves, thus increasing the flexibility of operations. With these improvements, the time between arrival and departure of through freight trains has been reduced to about 20 min. as compared wih 50 min. or more when trains were pulled into and departed from the yard.

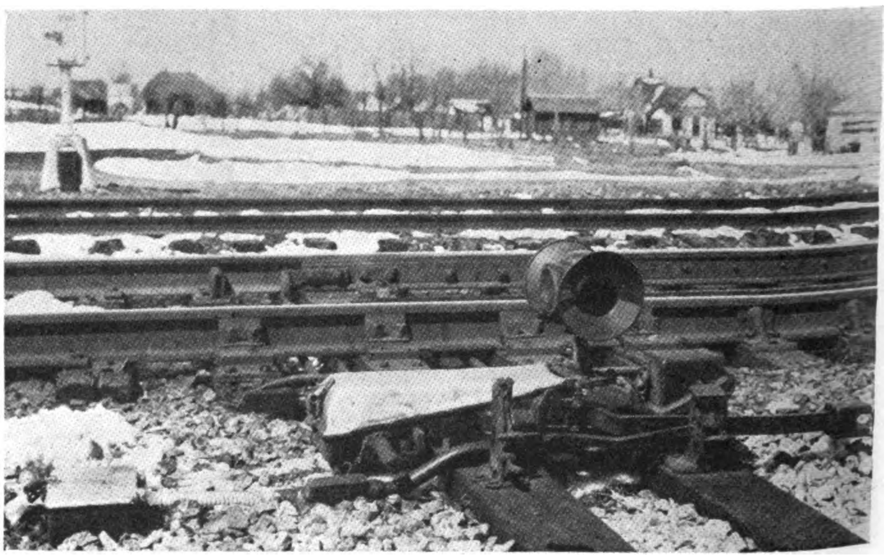
When arriving at Canadian, a westbound train may be stopped for fuel and water with the rear end just west of signal 24L. In such an instance, the problem was to authorize a switch engine to pass the signal so it could take off the caboose. A short track circuit about 100 ft. long, located in approach to the signal, is known as the clearing section. With the lever 24L thrown to the clear position, when the switch engine occupies the clearing section, the signal 24L displays the Restricting aspect, red-over-yellow, which authorizes the switch engine to pass the signal and proceed at restricted speed to couple to the caboose.

Previously when a switch engine was working at the west end of the yard it had to pull out on a main track when switching cars from one track to another. In order to keep these switching moves off the main track, a tail track was extended west along the north side of the main, and the yard switches were arranged so that all yard tracks normally lead into this tail track. The connection from the main track to the yard is crossover No. 13, the west switch of which connects with the main track, and the east switch in reality forms a derail which, when normal, diverts to a dead-end any cars which may drift westward out of the yard, thus protecting trains on the main track from being side-swiped.

Control of Katy Crossing

A mechanical interlocking under the control of a leverman was formerly in service to protect a crossing of the Santa Fe and a branch line of the Missouri-Kansas-Texas just west of Woodward. As a part of the C.T.C. project, this mechanical interlocking was removed, and electric signals and electric switch machines for operating derails on the Katy are now controlled as part of the C.T.C. system. Normally the home signals on both roads are at Stop, and the derails on the Katy are in the derailing position.

The dispatcher's illuminated diagram includes lamps to indicate the approach of trains on the Katy as well as on the Santa Fe. When a train approaches on either road, he lines the route and clears the signal in the same manner as for a move at the end of



Hand-throw switch stand with an electric lock

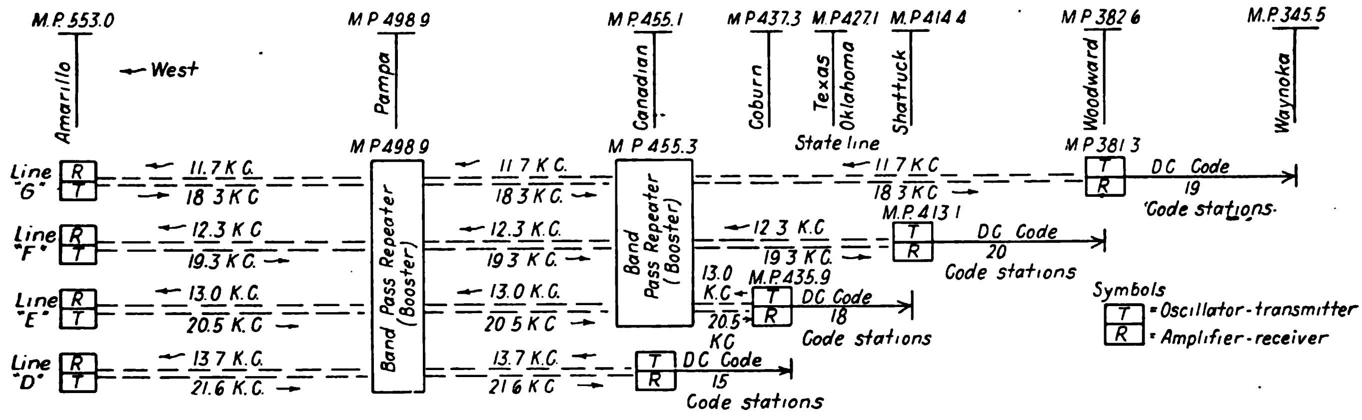


Fig. 6—Diagram of the coded carrier sections for the C.T.C. control line

any of the sidings. A complete record of the approach and passing of trains as well as the clearing of signals and operations of the crossing is maintained by an automatic Esterline graphic recorder at the crossing.

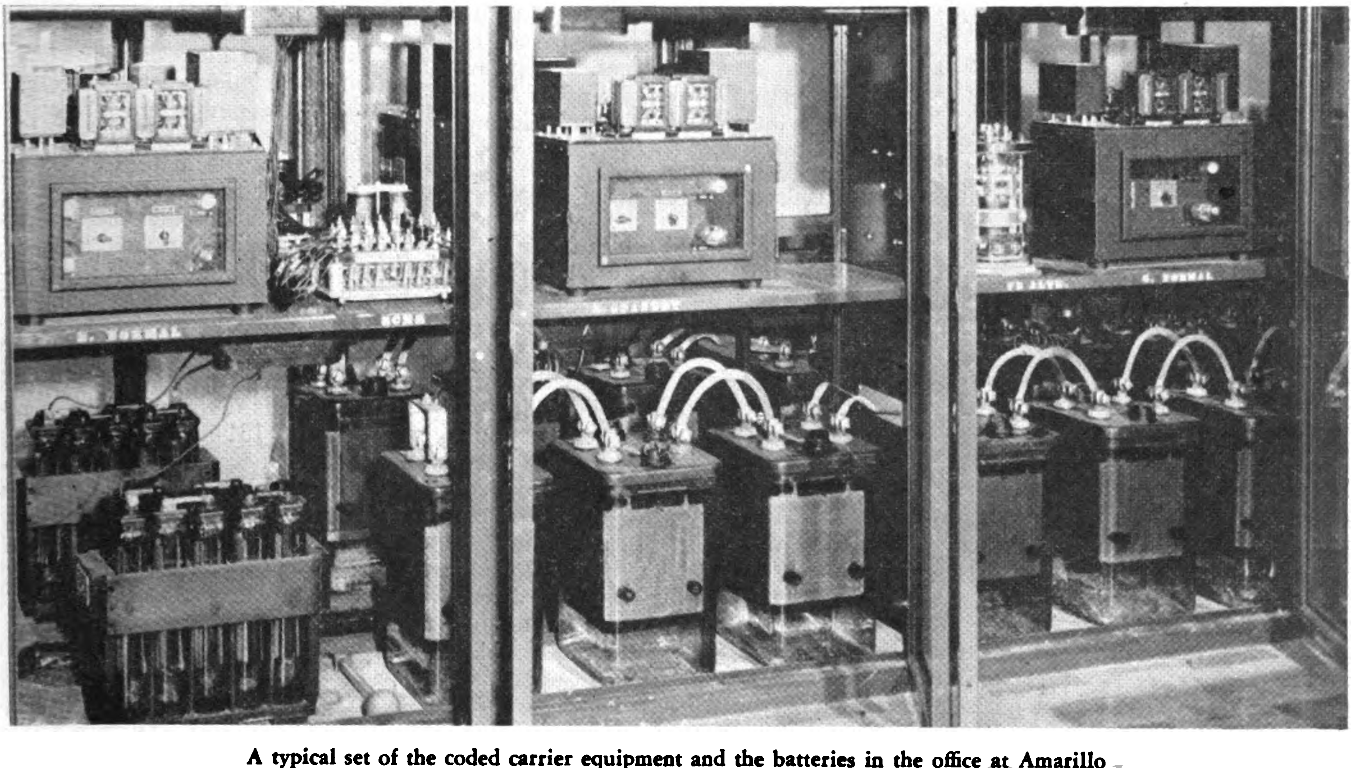
Coded Carrier C.T.C.

The C.T.C. system is the Union Switch & Signal Company's Type L, form 506A time code for multiple-line application, using biased-polar line and starting relays. Each such arrangement has a capacity to handle 35 field stations. The transmission of control codes and the return of indication codes are handled on two line wires. These wires start at the control office in Amarillo and extend east for 98 mi. before they get to the C.T.C. territory at Canadian, and then these two wires extend on through the C.T.C. to Waynoka.

The 110 mi. of C.T.C. is cut into four sections, each of which utilizes separate coding equipment and conventional d.c. codes for outgoing controls and incoming indications, for example between Canadian and Coburn, between Coburn and Shattuck, between Shattuck and Woodward, and between Woodward and Waynoka, as shown in the diagram in Fig. 6. Between the west end of each such section and the office at Amarillo, high-frequency carrier codes, ranging from 11.7 k.c. to 21.6 k.c. applied to the same two lines wires, are used to handle the outgoing control codes from the office and the incoming indication codes from the field. Thus in effect the C.T.C. territory is operated as four separate sections so that controls can go out to or indications can be received from any one or all four sections simultaneously.

A special carrier booster equipped with band-pass filters, located at Canadian, is normally in service to boost the carriers on the three sections other than the one starting at Canadian. Another booster at Pampa applies to all four sets of carrier. Standby duplicate equipment is provided at both locations and is automatically transferred in case a line wire breaks, or it may be transferred manually by the control station at Amarillo in case of failure. The standby equipment is set at a slightly higher operating margin so that, in event adverse weather conditions cause high line losses, the transfer to standby will operate the system until necessary adjustments can be made.

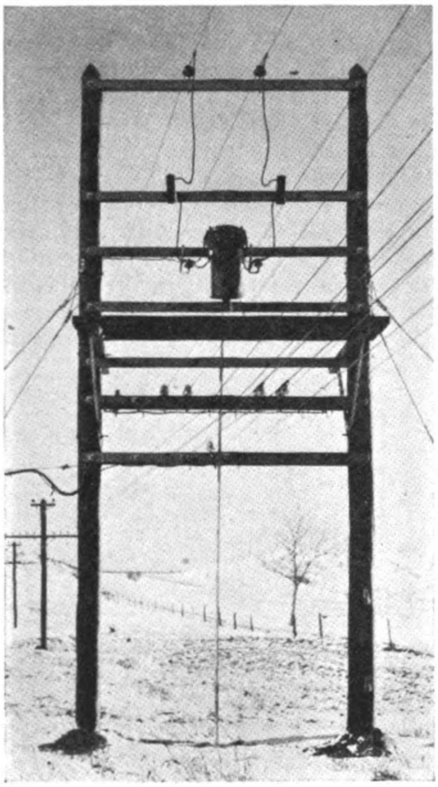
The use of coded carrier apparatus on this C.T.C. project accomplishes two important results: (1) it permits the 110-mi. of C.T.C. to be cut into four sections so that even with numerous trains there will be no delays to



A typical set of the coded carrier equipment and the batteries in the office at Amarillo trains on account of codes waiting for their turn; and (2) the control station need not be on the C.T.C. territory but rather is located in the dispatcher's office in division headquarters at Amarillo, 98 mi. away.

New Signal Pole Line

No space was available for additional wires on the previously existing pole line. Furthermore, on account of heavy sleet storms every few years in this territory, a separate pole line was necessary in order to insure reliable operation of the C.T.C. A new pole line was constructed from Amarillo east to Waynoka, 207 mi. This line was built with Southern pine poles treated with creosote full length. Except where higher poles were required at crossings, the poles are 25 ft. with a minimum of a 7-in. top, and are spaced 117 ft., which is 45 to the mile. The holes were dug by a pole-hole digger, and the poles were set by a power derrick, both these machines being mounted on the rear of a truck.



An H-fixture in the new pole line

The terrain is such that all the holes were dug by this machine, although in some instances a caterpillar type tractor was required to tow the truck through soft ground. The crossarms, pins and insulators were installed on the poles before being set. Where circumstances were fair to favorable, about 75 holes were dug and poles set in an 8-hr. day.

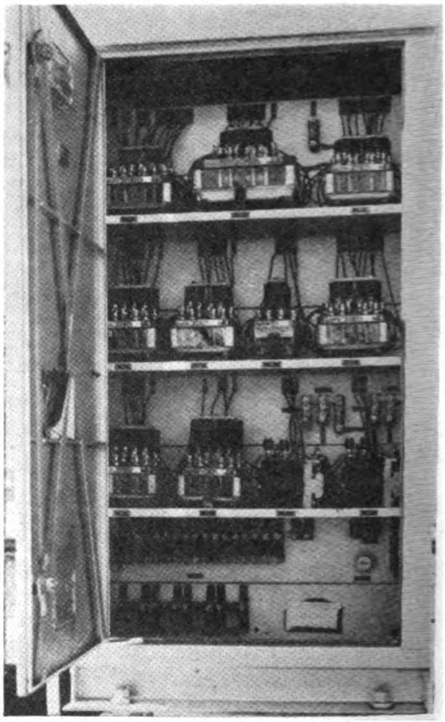
The gains are spaced 2 ft. A two-pin arm 38 in. long, in the top gain, carries the two No. 6 bare copper wires for the single-phase 60-cycle 4,600-volt a.c. power distribution circuit. A 10-ft., 10-pin arm in the third gain carries the two No. 6 Copperweld weatherproof wires for the C.T.C. code, the two No. 8 bare Copperweld wires for the new signaling telephone circuit from the office at Amarillo to Waynoka, and the two No. 8 Copperweld weatherproof wires for the local automatic signal line controls, as well as two or more No. 8 galvanized-iron line wires for the control of motor-car indicators. In some sections the new pole line also carries additional two-wire line circuits for control of additional aspects such as yellow-over-yellow. Insulators with top grooves were used on the power, code, telephone and signal control circuits as an aid in minimizing damage caused by high winds whipping the wires. To strengthen the line against sleet and wind, an H fixture guyed four ways was placed at each power switch location and at each intermediate signal as well as at other places spaced about three to the mile.

Line transformers to reduce the voltage from 4,600 to 115 volts, and rated at 1.5 kva., are located at each power switch and intermediate signal location. These transformers are the new CSP or "Completely Self Protecting" type furnished by Westinghouse. A local 115-volt line circuit extends from certain signal locations to cut section locations as may be required to feed the automatic rectifiers across the two cells of primary on the track circuits. Where only one track circuit feed is involved at a cut section, the 115-volt line circuit is omitted in some instances, and if so, the track circuits are fed directly from four cells of 500 a.h. Edison primary battery.

Insulated Wires and Cables

The underground cables from each instrument house to the switch machine include a 7-conductor No. 9 and a 12-conductor No. 14. A 12-conductor No. 14 cable runs from the house to each signal for control circuits, and the lamps are fed by a 4-conductor No. 9 cable. The track connections from the house or cases are single-conductor No. 9 to the Raco bootleg outlets. At the top of these outlets the cable wire is soldered to stranded conductor which extends to a 3/8-in. plug driven in the rail. The line drops from the line poles to the houses or cases are in manufactured No. 14 aerial cable, run in rings supported from a galvanized iron messenger.

The sheet-metal instrument houses at the switches are 5 ft. by 7 ft., except at crossovers where more equipment requires larger houses, 8 ft. by 10 ft. In the entrance door to each of the houses there is a small door 1 ft. square which gives access to a telephone. This door is locked with a switch padlock so that trainmen, trackmen or other employees can use the telephones. This practice eliminates the need for separate telephone booths.



Relay case at an intermediate signal

At the switch locations the batteries are in the sheet-metal houses with the relays and other equipment. At intermediate signal locations, one of the signals is mounted on one of the combination foundation - battery - cellars which were used on the previous automatic block signaling. At such locations the battery is in the cellar. In order to mount the new masts or instrument cases on the old cellars which have a different bolt spacing, adapters were made of 3-in. angle-iron with holes to fit the spacing of the cellars below and the cases or masts above.

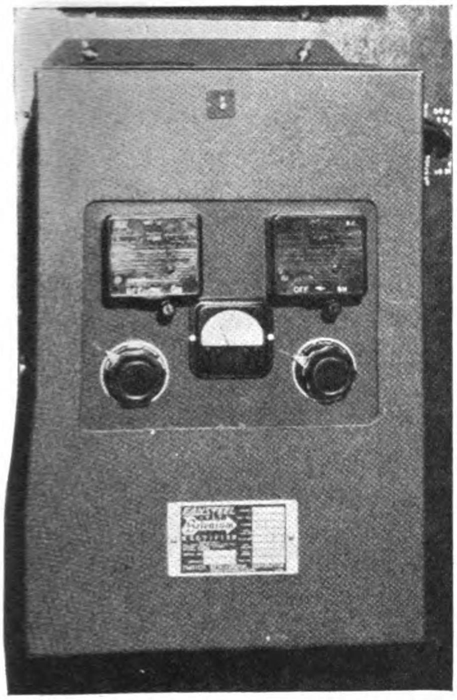
During the last year or two the rail throughout this division has been relaid with new 131-lb. rail, and as this rail was laid it was bonded with mechanically applied rail-head bonds which are of several makes such as Raco, Ohio Brass and American Steel & Wire.

Primary and Storage Battery

Each track circuit is fed by two cells of Edison 500-a.h. primary battery, and at all locations where a.c. is available an automatic rectifier is connected across the battery to take all but about 10 m.a. of the load. At this rate a set of these batteries should have a life of about 5 years.

Batteries at Switch

At each power switch location there is a set of 15 cells of 80-a.h. Gould storage battery which feeds the switch machine and the C.T.C. code equipment. At each switch location and at each intermediate signal location there is a set of 5 cells of the same type of storage battery to feed the line circuits and to act as standby for the lamps if the a.c. fails. In the office at Amarillo there are two sets of 8 cells of 250-a.h. storage battery which feed the code equipment and other office equipment. If the local a.c. supply fails, these batteries feed the lamps on the C.T.C. machine, and operate tuned alternators to feed the motor on the graphic train sheet, and to feed the a.c. for the C.T.C. carrier apparatus. Thus the C.T.C. system can be continued in service until a.c. power is restored.



One of the rectifiers for charging batteries in the office

Two-Wire Either-Direction Local Line Circuit

In the new installation one two-wire line circuit is used for the control of signals for one direction or the other, depending on the direction of traffic being established in a station-to-station block when a C.T.C. code is sent out from the office to clear a signal. The two-wire either-direction circuit is similar to that explained on page 420 of the August, 1943 issue of *Railway Signaling*. A difference is that the Santa Fe positively controls switching to connect "battery" or "relay" at the two ends of the two-wire circuit. The positive control uses C.T.C. function relays (polar stick Style KP) to provide the directional selection, which is determined by the interpanel wiring on the C.T.C. machine. When clearing a station-leaving signal, codes are sent from the office to both ends of the station-to-station block if a traffic reversal is being effected. The operating units of the intermediate signals for the direction of traffic established then become energized. The lamp, however, is normally out, being approach lighted by a 40-ohm series line relay in the two-wire line circuit.

Track Circuits

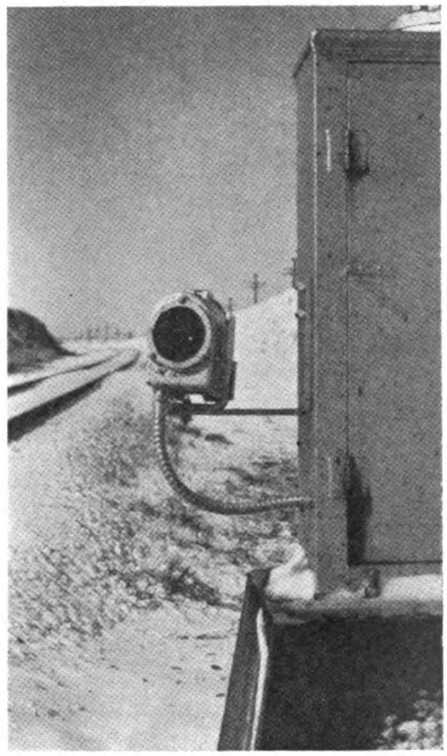
The previous automatic block signaling included d.c. neutral track circuits and two two-wire polarized line circuits, one for the control of signals in each direction. Automatic signals were normally clear and the line circuits were arranged on the overlap principle. In the C.T.C. the direction of traffic is set up manually by the control office before a train arrives on the circuit. Only one of two opposing station-leaving signals can be cleared at the same time and this is also true of intermediate signals so that no signal can clear unless its opposing signal is at Stop. The number of intermediate signals was reduced and the locations of these signals as well as the track cut sections are practically all different than before.

The new C.T.C. includes d.c. neutral track circuits, the same as previously. The relays are rated at 4 ohms except where ballast conditions are adverse, and then 2-ohm relays are used. Ordinarily the circuits range up to about 3,500 ft. in length with a few up to 4,000 ft. On passing tracks where the ballast is not clear the circuits may be limited to about 3,000 ft.

Motor-Car Indicators

In sections where sighting distances are short, motor-car indicators are provided by means of which men on motor cars can be warned of the approach of trains. Where a.c. power is available the indicators are of the electric lamp type, each indicator consisting of an electric lamp previously used on the old semaphore signals. These indicators are mounted on signal cases, the lamps being directed at an angle across the track so that, as a man approaches on a motor car, the indicator he sees applies to the territory into which he is going to proceed.

Each indicator has a 3.5-watt, 13.5-volt lamp which is normally lighted. The relay which controls each indicator is normally energized by a line circuit which breaks through front contacts of the track or line relays for the limits of the control of the indicator. The indicator line circuits are taken through contacts in the directional-stick relays so that the indicators will clear for a man on a motor car to follow a train. At locations where a.c. is not available to feed a lamp, the indicators are the semaphore type with 500-ohm coils which are normally energized by the line circuit. In most instances the line circuits are fed from the d.c. side of rectifiers. When the a.c. power fails, the line circuit is deenergized but this is of no consequence because with the a.c. off, the lamp in the indicator would not be lighted. These motor-car circuits are entirely independent from the signal circuits, so that any grounds or crosses will not interfere with the signaling. An important part of the improvements was to provide a motor-car set-off, built of old ties, at every power switch and every intermediate signal as well as at others placed not more than an average of ¼ mi. apart.



Typical motor-car indicator

The track changes and centralized traffic control on this project were planned and constructed by the forces of the Atchison, Topeka & Santa Fe, the major items of the signaling equipment being furnished by the Union Switch & Signal Company.