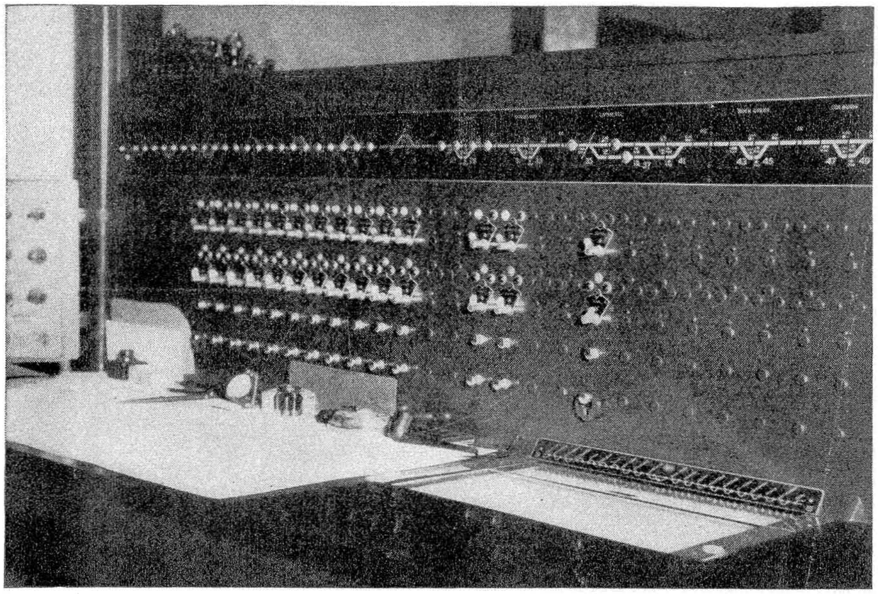
Railway Signaling

Centralized Traffic Control Installed on Wabash



The control machine at Peru

Dispatcher's machine 93 miles from distant end of 37-mile Single-track installation—Operating savings justify cost

SEVERAL features of special interest are included in the installation of centralized traffic control on 37 miles of single track line on the Wabash railway between LaFayette Junction, Ind., and State Line. The control machine in the dispatcher's office at Peru, Ind., is the largest of this type as yet built, being 8.5 ft. long, and containing not only the levers for the State Line-LaFayette section but also spare spaces for additional levers to control the remainder of the division between Danville, Ill., and Peru, Ind.

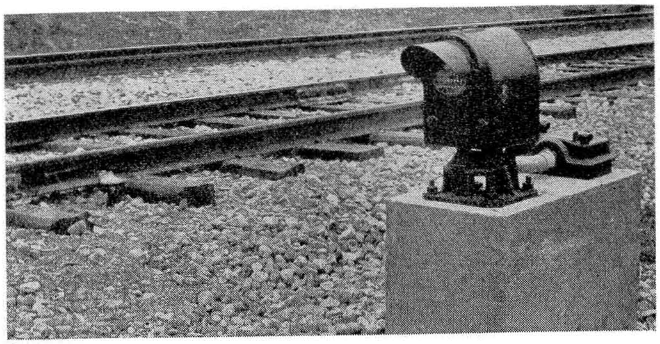
The Track Layout and Traffic

Starting at the west end of the division at Danville, double track extends 7.4 miles to State Line from which point the line is single track for 37 miles to LaFayette Junction where the Big Four crosses at grade, the crossing being protected by an interlocking. Starting in this plant, second track extends for 1.8 miles to a point just west of the LaFayette station, while from LaFayette to Peru, 52.9 miles, the line is single track.

A grade ranging from 0.3 to 1.1 per cent, adverse to westbound trains, extends for about six miles just west of Attica. On the remainder of the State Line-LaFayette territory the grade is rolling with short grades ranging up to 0.8. Near Attica there is a 5 deg. curve requiring a speed limit of 25 m.p.h. but at no other point on this line is the curvature sharp enough to interfere with the normal operation of trains.

In 1928 and 1929, as many as 10 to 14 freight trains, in addition to the 4 passenger trains, were handled each way daily which made a total of from 28 to 36 through train movements daily. Under these conditions, consideration was given to the construction of a second track over certain extensive sections of the division. However, a study showed that a complete installation of centralized traffic control would increase the track capacity so that the present traffic as well as the normal increase could be handled satisfactorily for several years.

Dispatchers' train sheets for five days were selected, and from this information, as well as the conductors' daily time slips, graphic train sheets were prepared showing the movement of trains as they were dispatched by written order. On these same charts, in colored pencil, were plotted lines to show the movement of the same trains as they would have been run by signal indication with the switches and signals power-operated and controlled by the dispatcher. In plotting for train operation under the two methods of operation the same values were used for the running time between stations. Time for station work, taking water and coal, and for other unavoidable delays, was allowed the same in both cases. Therefore, the time savings shown by the centralized control method represented only the avoidable time lost in opening and closing switches, starting and stopping at switches, and waiting for orders or meets—that is, where trains could have been advanced to the next sta-



Searchlight type dwarf—Note Union boot-leg outlet at rail

tion under conditions made possible by the centralized control method of operation. A study of the completed charts for the five days showed an average saving of

CONSOLIDATED STATEMENT OF ESTIMATED SAVING TO BE EFFECTED BY INSTALLATION OF CENTRALIZED TRAFFIC CONTROL SYSTEM OVER ENTIRE DISTRICT, TILTON, ILL., TO PERU, IND.

Miles of road—100.6 freight miles	
Trains per day—(average number, exclusive of local freight, light engines and work trains)	
Through Freight	16.8
Passenger	8.0
Total	24.8
Cost of proposed C. T. C. system superimposed on existing automatic system estimated	$266,000
Interest at 6 per cent per annum on signal system	15,960
Additional maintenance materials, $50 per mile per year	5,000
Additional maintenance labor	none
Estimated Savings per Annum	
Saving by reduction of train hours	38,836
Saving by reducing train stops to open and close switches. Wear and tear on equipment	17,885
Saving by reducing number of block and telegraph operators	21,199
Saving by ability to use same motive power 10 hr. 43 min. more each day	8,150
Saving per diem charges on cars	10,691
Total Gross Saving Annually	$ 96,761
Total Gross Expense Annually	5,000
Net Annual Saving	$ 91,761
Annual return on investment	34.5%
Annual return on investment over and above 6 per cent carrying charges	28.5%

35 min. for each freight train and an increase in average train speed over the division of 1.8 m. p. h. or 11 per cent.

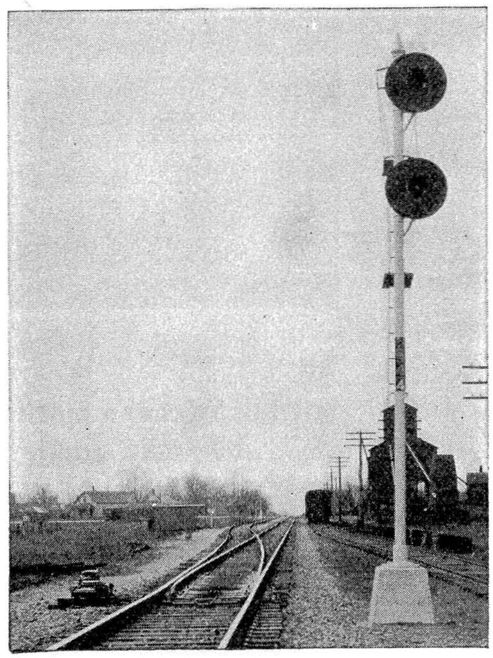
In order to determine the possible benefit which the increased average speed would accomplish in terms of added track capacity, a graphic train sheet was prepared to include the 8 passenger and 22 freight trains operated on a certain date, the lines being drawn to indicate the operation as it could be accomplished under the centralized control system. To this chart were then added the lines for five additional eastbound and six additional westbound through freight trains. Even with this increase of 33 per cent in the number of trains, bringing the total to 41 trains, it was evident that additional capacity was still available to operate more trains without increasing the average elapsed time between terminals.

On this basis, a statement was prepared as shown in the accompanying table, to give the estimated savings to be accomplished by the installation of centralized traffic control on the entire district of 100.6 miles. It should be noted that the estimated annual return on the investment is 34.5 per cent and if an allowance is made for 6 per cent interest, the return is 28.5 per cent over and above 6 per cent carrying charge.

In this tabulation no consideration was given to the cost of extending passing tracks so as to handle longer trains, because the then existing passing tracks were not long enough to hold trains with tonnage equal that of the engine ratings. Therefore, this cost was rightfully chargeable against increased tonnage capacity, rather than a system to be employed to facilitate operation.

Part of System Installed

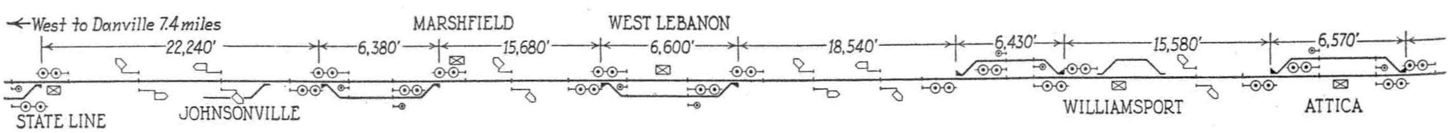
On the basis of the studies made, it was decided to install the centralized traffic control system. However,



End of double track at State Line

about that time traffic was reduced decidedly so that when orders were placed for equipment in September, 1930, it was decided to install only the first section of the field equipment, that is, between State-Line and La-Fayette, at this time. This section was chosen because it permitted the greatest proportionate reduction in operating costs, as eight operators in this territory could be transferred to other points as soon as the system was completed.

As originally planned, the control machine is located in the dispatcher's office at Peru and is large enough to control the entire territory when the remainder of the



Track and signal plan of

district is equipped. Likewise, the three code-control line wires and the control system has adequate capacity. Therefore, additional power-switch layouts with attendent signals for governing train movements at such points can be added at an additional cost of only $7,000 per switch. In fact, in two cases where grade conditions made it desirable to have power switches so as to eliminate train stops at passing tracks, such apparatus was included in the original installations. These switches at Delphi, Ind., and Clymers are between LaFayette and Peru, outside of the centralized control territory as now in service.

The passing tracks at Marshfield, West Lebanon, Williamsport, Attica, Riverside and West Point were each lengthened to hold a train of 125 cars. As a part of the 1931 track program, 110-lb. rails with new crushed rock ballast are to be laid throughout this territory, at which time No. 20 turnouts will replace the present No. 11 turnouts on all passing tracks where power switches are used.

The control system is the code type, all signaling equipment, power switches, control machine, etc., being furnished by the Union Switch & Signal Company, and installed by Wabash signal department forces.

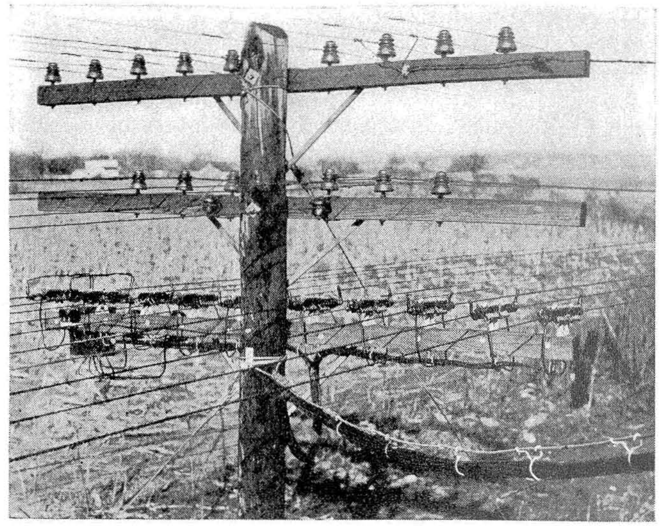
Special Signal Requirements

Three-position semaphore automatic block signals controlled on the overlap system had been in service in this territory since 1916. As a part of the new improvements, the control was changed over to the absolute permissive block system, which necessitated that many of the signals be relocated. These automatic signals had been operated on Edison primary battery with National Carbon cells on the track circuits, and this method of power supply was continued in service for these semaphore signals, as well as all of the track circuits.

New searchlight-type color-light signals were installed at the ends of double track and at passing sidings where such signals direct the movement of trains, for entering a block or for entering or leaving a siding. These main line signals have two units, the same as a home signal at an interlocking. On the entering signal at a siding, the lower unit indicates yellow and the top arm red when the switch is lined for a train to enter the siding. With such a line up, the distant signal indicates caution. When the switch is lined for the main track, the lower unit is red and the top unit is green, yellow or red, depending on conditions ahead. The head-block leaving signal, which authorizes a train to enter a block and proceed to the next station, likewise has two units, but the lower one is inoperative, displaying red at all times. The dwarf signal for directing train movements out of a siding operates to three positions, indicating purple for "stop and stay," yellow for "proceed with caution" and green for "proceed."

As will be noted from the track and signal plan, the head-block signal is located opposite the dwarf signal in line with the clearance point on the siding, thus the head-block signal protects movements being made into or out of the switch. With No. 20 turnouts, these signals are about 400 ft. from the switch point and, therefore, series-type fouling circuits are used to insure proper fouling protection. All signals are located on masts to the right of the track governed, the track being thrown over to allow adequate clearance where necessary.

The power-operated switches are equipped with dual-control switch machines, the entire switch layout being constructed on new ties with adequate adjustable rail bracing as shown in one of the views. All other main-line switches are protected with switch circuit controllers connected to afford signal protection the same as in any automatic block signal system.

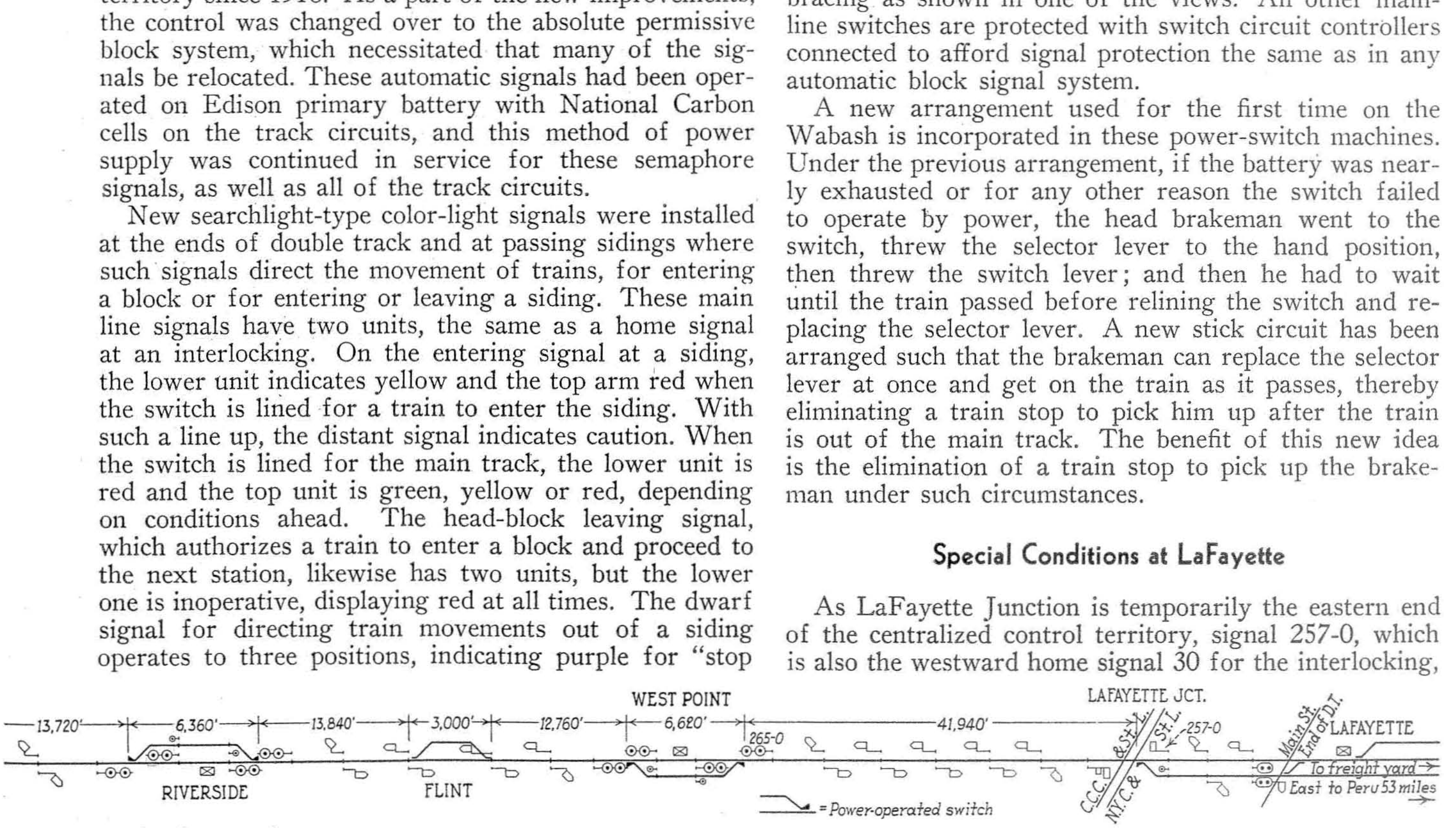


Signal power and control wires on lower crossarm

A new arrangement used for the first time on the Wabash is incorporated in these power-switch machines. Under the previous arrangement, if the battery was nearly exhausted or for any other reason the switch failed to operate by power, the head brakeman went to the switch, threw the selector lever to the hand position, then threw the switch lever; and then he had to wait until the train passed before relining the switch and replacing the selector lever. A new stick circuit has been arranged such that the brakeman can replace the selector lever at once and get on the train as it passes, thereby eliminating a train stop to pick him up after the train is out of the main track. The benefit of this new idea is the elimination of a train stop to pick up the brakeman under such circumstances.

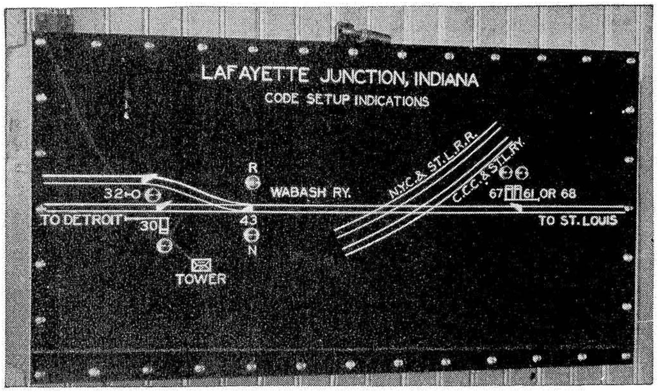
Special Conditions at LaFayette

As LaFayette Junction is temporarily the eastern end of the centralized control territory, signal 257-0, which is also the westward home signal 30 for the interlocking, controls the direction of train movements on to the single track and authorizes a train to move to signal 265-0 at West Point. The problem then arose as to how signal 257-0 could be controlled jointly by the dispatcher at Peru and the leverman at LaFayette Junction. To solve this an illuminated track chart was mounted above the interlocking machine at LaFayette Junction. Small electric lamps are mounted in this board, one at the switch, a second at signal 30, and a third at the dwarf signal



centralized traffic control territory

used to direct reverse movements on the wrong main. The indications on the dispatcher's machine show the position of this switch and the indications of these signals. If he wants the switch moved, he operates the lever on his machine which lights a light on the diagram at LaFayette Junction and also releases an electric lock on the lever. If other conditions at the plant permit, the leverman can then throw the switch. The same procedure is necessary for moving a signal lever; in other words, the leverman actually moves the switch or clears the signal by means of the regular interlocking levers, but the dispatcher has control of the levers by means of



The special panel in the tower at LaFayette Junction

electric locks and, in addition, the dispatcher knows at all times the position of the switch and the indications displayed by the signals.

Another special condition arose because LaFayette is a train order office at which all trains stop and register. As the centralized control system was to eliminate the use of train orders from LaFayette west to State Line, some consideration had to be given to the 1.8 miles of territory between LaFayette Junction and LaFayette. As double track extends from the Junction to Main street, trains could be moved in this territory by automatic signal indication according to rules for double-track operation. However, some means of directing trains over the 500 ft. of single track between Main street (end of double track) and LaFayette block office had to be provided. This problem was solved by installing at Main street an eastbound two-indication color-light-type train-order signal for each track. These signals are controlled by enclosed knife switches on the operator's desk at LaFayette. If he throws a lever up, the corresponding signal displays a green light, which authorizes a train to proceed on the single track to LaFayette block office to pick up orders. On the other hand, if he wants to hold the train on the double track, he leaves the lever down and the signal displays a red indication. The indications displayed by these signals are repeated on the operator's panel so that he can be assured that the signals follow his lever movements. If a lamp in a signal burns out, the corresponding lamp on the panel is likewise extinguished.

Results Satisfactory

The installation was placed in service on February 24, and the resulting benefits in train operation are highly satisfactory, although the present traffic of 20 to 25 trains is not enough to demonstrate the merits with respect to increased track capacity. Non-stop train meets are every-day occurrences. For example, on March 28, two passenger trains No. 28 and No. 29, met at Williamsport; only four minutes elapsed from the time the first train started to enter the passing track until both trains had passed beyond the limits of the passing track neither train having been required to stop. Two freight trains met recently at West Lebanon, and only six minutes elapsed from the time the first train started to enter the passing track until both trains had passed beyond the limits of the passing track. On the same day, such a non-stop meet between a freight train and a passenger train was completed at Williamsport in four minutes.

COMPARISON REPORT TIME CONSUMED BY TRAIN BETWEEN LAFAYETTE JUNCTION AND STATE LINE THROUGH C. T. C. TERRITORY

(Period January 1 to January 10, 1931, Inclusive)

WEST

Class	Number Trains	Total Time	Average Time
Passenger	40	41 hr. 52 min.	1 hr. 3 min.
Manifest	30	39 hr. 29 min.	1 hr. 19 min.
Drags	19	39 hr. 6 min.	2 hr. 4 min.
Total	89	120 hr. 27 min.	1 hr. 21 min.

EAST

Class	Number Trains	Total Time	Average Time
Passenger	41	37 hr. 39 min.	0 hr. 55 min.
Manifest	40	47 hr. 23 min.	1 hr. 11 min.
Drags	10	15 hr. 37 min.	1 hr. 34 min.
Total	91	100 hr. 39 min.	1 hr. 6 min.

Eastward and Westward Combined

180 Trains	221 hr. 6 min. Total Time	1 hr. 14 min. Average Time
99 Freights	141 hr. 35 min. Total Time	1 hr. 26 min. Average Time

Number of train orders issued 502

(Period March 11 to March 20, 1931, Inclusive)

WEST

Class	Number Trains	Total Time	Average Time
Passenger	40	40 hr. 53 min.	1 hr. 1 min.
Manifest	32	38 hr. 46 min.	1 hr. 13 min.
Drags	26	49 hr. 38 min.	1 hr. 55 min.
Total	98	129 hr. 17 min.	1 hr. 19 min.

EAST

Class	Number Trains	Total Time	Average Time
Passenger	40	36 hr. 29 min.	0 hr. 55 min.
Manifest	46	52 hr. 58 min.	1 hr. 9 min.
Drags	11	17 hr. 9 min.	1 hr. 34 min.
Total	97	106 hr. 36 min.	1 hr. 6 min.

Eastward and Westward Combined

193 Trains	235 hr. 53 min. Total Time	1 hr. 13 min. Average Time
125 Freights	158 hr. 31 min. Total Time	1 hr. 16 min. Average Time

Number of train orders issued 375

26 More Trains March 11 to 20
Same Class Motive Power

10 Min. Average Saving per freight train thru territory

A study was made of train movements under the new system of operation in which 10 days were chosen promiscuously, and the totals showed that there were 153 meets on this territory, 34 of which were non-stop, 10 of these being between passenger trains, 14 between passenger and freight trains and 10 between freight trains. This study revealed that of the 269 train stops eliminated in the 10 days, 61 were for passenger and 208 for freight trains. Thus on the average, 6.1 passenger and 20.8 freight train stops were eliminated daily, or a total of 27. In a year this totals 9,855 stops eliminated and, based on a very conservative figure of $1 saved for each stop eliminated, this totals $9,855 annually.

A comparison was made of the running time for trains before and after the centralized traffic control was placed in service, the period from January 1 to 10 being compared with that for March 11 to 20. As shown in one of the accompanying tables the average time for freight trains was reduced from 1 hr. 26 min. to 1 hr. 16 min. in spite of the fact that 26 more trains were operated in the latter period. A second study comparing train operation for the period from April 21 to 30, 1929, with the period from April 21 to 30, 1931, showed an average saving of 24 min. for each freight train. In this case less powerful locomotives were used and 45 more trains were operated in the 1929 period as compared with that in 1931, necessitating certain allowances for these changed circumstances. However, based on the conservative time saving of 10 min. for each of an average of 12.5 freight trains daily, this totals 760 freight train hours annually, which, calculated at $9.69 totals $7,164 annually. This figure of $9.69 for a freight train hour is an estimated average figure for this division on the Wabash, and includes only such items as trainmen and enginemen's straight time wages, fuel and water.

ECONOMIC STATEMENT FOR 37 MILES C. T. C. STATE LINE TO LAFAYETTE JUNCTION AND REMOTE CONTROL SWITCHES AT DELPHI, INDIANA, AND CLYMERS

COSTS	
Centralized traffic control LaFayette Junction to State Line	$145,000
Remote control switch Clymers, Ind.	9,700
Remote control switch Delphi, Ind.	7,300
	$162,000
Additional maintenance materials, $50 per mile per year	1,850
" " labor	None
SAVINGS	
Savings by reduction of train hours 12.5 trains per day, 10 mi. each equal 760 freight train hours at $9.69 per hour	7,364
Saving by reducing train stops to open and close switch, fuel, wear and tear on equipment 27 per day x 365 equal 9,855 no less than $1 per stop	9,855
Saving by reducing number of block and telegraph operators	14,000
(Taking no account of saving in motive power or per diem of cars)	
Total gross saving annually	$ 31,219
Total gross expense annually	1,850
Net Annual Saving	$ 29,369
Annual return on investment	18%
Annual return on investment over and above 6% carrying charge	12%

The saving made possible by the reduction in the number of block and telegraph operators totals $14,000 annually. The three items mentioned make a total savings of $31,019 annually, no consideration being given to the saving in motive power or per diem on cars. No additional labor is required for the maintenance of the new system. However, it is estimated that about $50 per mile or $1,850 annually should be allowed for additional maintenance materials. Thus the direct saving in operating costs is $29,369 annually.

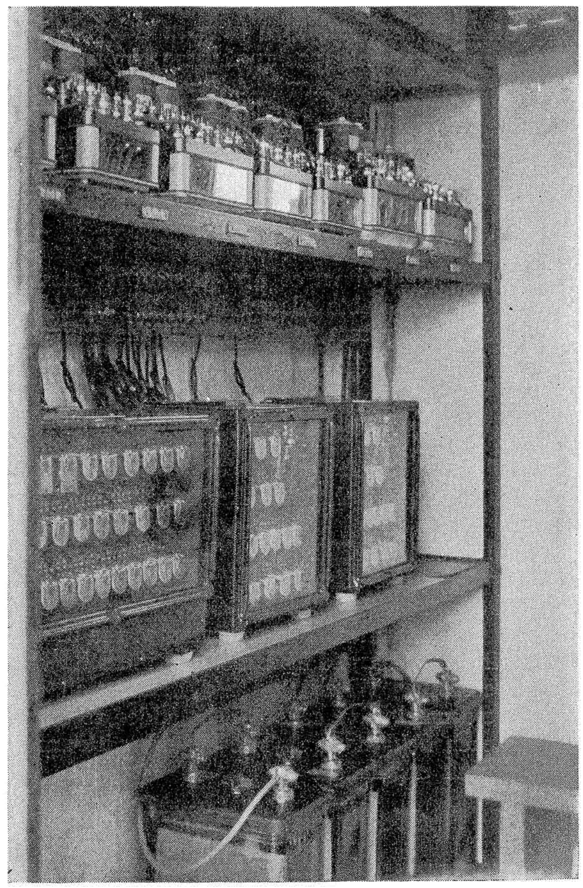
The centralized traffic control system on the territory from LaFayette Junction to State Line cost $145,000, and the remote control layouts at Clymers and Delphi added $17,000, thus totaling $162,000. The annual saving of $29,369 represents a return of 18 per cent of the expenditure.

It should be noted that these figures are based on present traffic of an average of only 12.5 freight trains daily. When traffic returns to the 1929 normal of 20 to 28 freight trains daily the savings on account of elimination of delay and train stop will increase rapidly without any increase in the expense of operating the system. The benefits of the new system and the annual return on the investment will, therefore, increase rapidly as the traffic increases. The point of special note is that even under present minimum traffic, the system justifies itself from both operating and economic standpoints.

The completion of the installation on the territory from LaFayette to Peru will not require as high a proportionate cost as that for the first section because the investment has already been made for the control machine and the line circuits. It is estimated that the system can be completed on the additional 55 miles for approximately $110,000. Therefore, the savings brought about by the elimination of train stops, etc., will be higher in proportion to the investment. On the other hand, not as many operators can be released on the proposed extension as on the installation now in service, and this factor will tend to reduce the proportionate savings. However, based on results now being obtained, it is very evident that the operating benefits and the financial returns will equal or exceed the figures included in the original preliminary estimates.

Power Supply System

A Massey concrete house 6 ft. by 6 ft. is located near each power switch location to house the battery, relays and other instruments. A 12-cell set of Exide EMGO-7 storage battery rated at 168 a.h. is provided for the operation of the switch machine. This battery is split into two groups of 7 and 5 cells each. The 5-cell set is used for the operation of 10-volt control circuits and as a reserve for the operation of the entering signals. The 7-cell set is used as a reserve for the leaving signal. A special 2-point 500-ohm polar relay is so connected as to check the polarity of the battery feed to these circuits so that if a battery connection opened accidentally the feed would be cut off rather than allowing the remaining 7 cells to feed back into these circuits.



Interior of concrete house at State Line

A 440-volt alternating-current feed line extends throughout the territory, this circuit being carried on two No. 8 copper wires protected with double-braid weatherproof covering. The three line wires for the code control are the same type of wire as just described and are carried on the opposite end of the crossarm from the 440-volt circuit. For the signal line control circuits, for controls, Copperweld wire with double-braid weatherproof covering was used, No. 12 being used for the controls and No. 8 for common. Ohio Brass Company No. 14844 line break strain brackets were used at all locations, thus eliminating the need for double crossarms.

A General Electric Type-T.C. line transformer rated at 750 v.a. is mounted on the crossarm at each switch location to reduce the voltage to 110 volts. Pellet-type G.E. arresters are used for the protection of these transformers. Union rectifiers are used to charge the storage batteries. The color-light signals are normally lighted from the a-c. supply, with the storage battery stand-by controlled through power-off relays.

As the field units of the code system are in series on the line, inductive types of arresters cannot be used. Therefore, the Western Electric block type, with a minimum of 10 mills clearance are used. The arresters for the remaining line control circuits are Railroad Supply Company No. 5. All ground rods are Copperweld ½ in. by 8 ft.

The underground wiring is in parkway cable; most of it is Okonite with two wraps of steel type, but no lead covering, while some Rome trenchlay with no metallic covering was installed for test purposes. For rail connections, single conductor No. 9 solid cable runs from the relay and instrument houses to Union pedestal-type rail outlets from which a stranded connection, Copperweld Type-14B12, extends to a plug in the rail. From the house to each switch machine, there are two cables, one containing two No. 6 conductors and the other containing 12 No. 12 conductors. The cable to the leaving signal includes 12 conductors No. 9 wires and the one to the entering signal 12 conductors No. 12 wires.

The control machine in the dispatcher's office at Peru is located on the third floor of an office building in the business section of town about ¼ mile from the railroad. The three-code control wires are, therefore, run in a No. 8 lead-covered cable placed in a Western Union underground duct system leading from the railroad to the office.

As this building is of modern construction with concrete floors and as no vertical chases had been provided, this new cable was run up through the elevator shaft to the attic and down through a conduit to the control machine in the top story, thus eliminating any damage to the concrete floors.

A set of 110 cells of 20-a.h. Exide battery Type B1-5 is used for the code control circuit and 12 cells of 168-a.h. Exide battery Type EMG07 for coding energy and reserve for indication lights, located in the basement of the building, are charged by Union rectifiers RP43 and RP41, respectively. When the field installation is extended approximately five cells will be added to the code battery for each field station. The battery racks are designed to permit expansion.

Installed by Railroad Forces

The rearrangement of the automatic signaling and the installation of the centralized traffic control system was handled by the signal department forces of the Wabash. Detail wiring diagrams were prepared and the concrete houses were wired complete with all apparatus in place at the signal shop in Decatur, Ill., thus securing uniformly standard construction. This method was also much faster, as the work would otherwise have been done in the field during the winter season, thus losing considerable time.

The construction program was so arranged that a carload of four of these concrete houses could be forwarded at one time. If a wrecking crane and crew had been called out to handle these houses in the field, the cost would have been excessive in proportion. A method was, therefore, devised of unloading the houses on skids. The houses were loaded four on a flat car, as shipped from the factory. This car was then hauled over the territory in the local freight train. Having lined up with the dispatcher for a period of at least 30 min. for occupancy of the main line, the car was then spotted at a location. Two ties were placed under a house and two pieces of 90-lb. rail 24 ft. long were then pushed under the house to be unloaded, leaving about 18 ft. sticking out toward the field. These rails were greased and a set of block and tackle was used to pull the house off the car and another set was used in the opposite direction to hold it from going down too fast. A pair of track jacks and several ties were used to block up the house so as to give it an even bearing on the rails and to start it down the skids. With this arrangement, a house could be unloaded successfully in about 20 to 30 min.

Special Highway Crossing Circuits Permit Switching Movements

By A. C. McMahan
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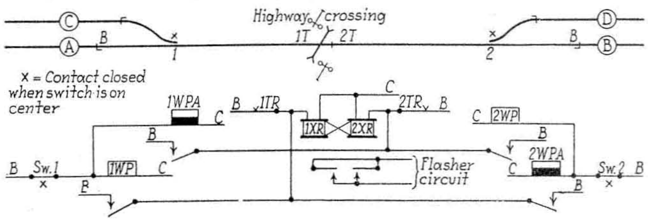
THE control circuit shown in the sketch below was developed for a special application in which it was necessary to provide for highway crossing protection when a switching movement is being made at a siding switch. Referring to the track layout shown in the sketch: Ordinarily, if a train were to pass from *B* or *D* to *C* and then return over the crossing without having cleared the fouling at *C*, the crossing signal would not operate while the train was approaching the crossing on the return trip. This fault may be overcome by employing the control circuit shown, the operation of which is as follows:

A train moving from *B* to *C* enters track section *2T* and drops relays *2TR* and *2XR*, thereby putting the crossing signal in operation. The train proceeds across the highway to track section *1T* and drops relay *1TR*. This causes the armature of relay *1XR* to drop on to the interlocking pawl, and, after the train clears track section *2TR*, the crossing signals cease to operate. Switch *1* is now reversed to permit pushing cars into the siding. Because the train is occupying track section *1T* and holding the armature of relay *1XR* against the pawl of the interlocking relay, the highway crossing signal ordinarily could not again start flashing when the train returns across the highway. But, the function of relays *1WP* and *1WPA* is to overcome this operating defect. It will be seen that these relays are energized through a switch-circuit-controller contact which is closed when the switch is on center. Therefore, when the switch is opened, these two relays are energized momentarily, picking relays *1XR* and *2XR*, and when the switch is placed in the full reverse position, their circuits are broken and their armatures are released, but relay *1WP* drops away faster than relay *1WPA* (a slow-release relay), and, for this reason, interlocking relay *1XR* is dropped before interlocking relay *2XR* is dropped. Therefore, the system is set up for the operation of the flashing lights while the train is working at switch *1* and until it has returned across the highway.



Highway crossing circuit provides for backup switching movements

Relays *2WP* and *2WPA* provide similar operation for a train proceeding from *A* or *C* to *D* and returning. In all other respects, this circuit provides normal operation.