Automatic block signal at leaving end of E. B. siding, L. R.

Train Operation by Signal Indication on the Erie

The Use of Power-Operated Train Order Signals Has Eliminated Some Forms of Train Orders

By Henry M. Sperry

THE 999 MILES of main line of the Erie from New York to Chicago is completely equipped with automatic block signals, with the exception of 184 miles. Progress in the installation of automatic block signals on the Erie did not make much headway until 1910, when they were put in use on the Susquehanna division. In 1906 only 6.8 miles were reported in service and in 1909, 124.8 miles; but by 1916 the total was increased to 1,018.1 miles of road. The improved results in train operation under automatic block on the Susquehanna division account in part for the progress made since 1909.

Prior to 1910 the Susquehanna division, which is a heavy traffic division, was operated under manual block and telegraph train dispatching. The following is a brief summary of the disadvantages experienced under the manual block and the improvement in train operation under the automatic block:

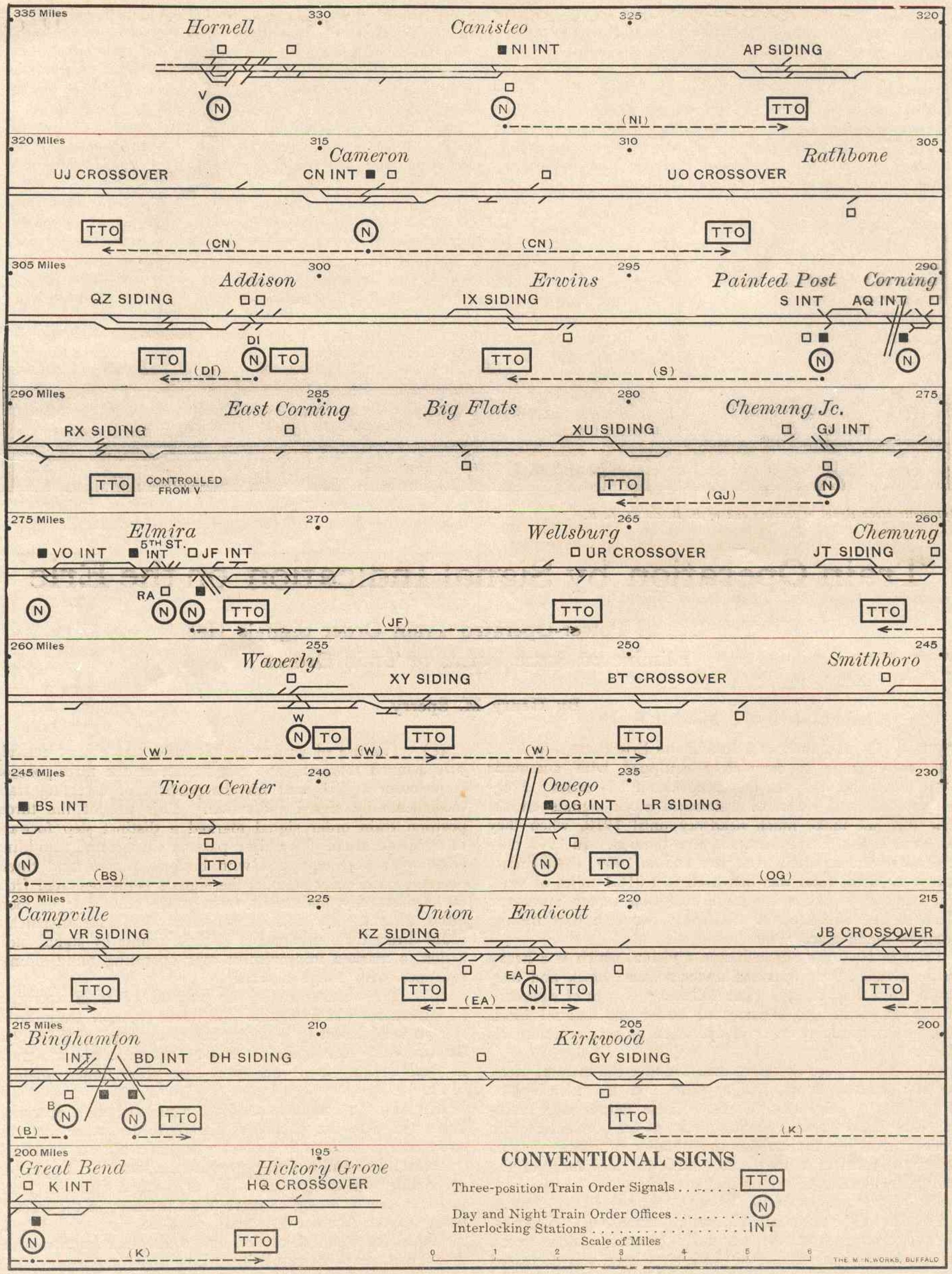
(a) There were excessive delays under the manual block due to a common fault of this system, i. e., irregular lengths of and excessively long blocks. These delays were eliminated by the automatic block signals, as the automatic block made it possible to increase the number of block sections and make them of a length to permit the movement of the maximum number of trains without delays.

(b) The number of blocks was changed from 90 manual blocks to 296 automatic blocks, an increase of 206 blocks. By the change from the manually-operated system to an automatic one, the number of block signalmen was decreased from 136 required under the manual block to 58 under the automatic, with a corresponding decrease in wage expense.

(c) The use of written train orders was almost entirely discontinued following the installation of the three-position train order signal used for the purpose of directing train movements by signal indication. This use of the three-position train order signal marked a distinct step forward in train operation. The blind passing sidings and also blind cross-overs were equipped with both telephones and three-position train order signals, the signals being operated from the nearest day and night train order office one or more miles distant. By this arrangement the train dispatcher could direct train movements at these points by signal indication, a marked improvement over operating blind sidings equipped with telephones only.

(d) The results under this method of train operation by automatic block signals and three-position train order signals were shown by a saving in train operation of $87,969 for the first year operated under automatic block signals in comparison with the previous year under manual block.

In making a comparison of the results of train operation under two different systems of signals to determine the relative value of each, it is necessary to select a road where the track facilities and motive power are the same for the periods covered by the comparison. If, as is often the case, track facilities are increased or there is an increase in the tractive power of the locomotives, credit must be given not only to the improved signal facilities, but to all other improvements that might affect the result in making any comparison. The Susquehanna division of the Erie was selected because the improved results were due entirely to the improvement in



Passing Sidings and Train-Order Signals; Susquehanna Division, Erie Railroad

the signal facilities, there being no change whatever in track facilities or motive power.

This division runs almost due west from Susquehanna, Pa., to Hornell, N. Y., 139.7 miles. The entire distance is double tracked. The alinement is 70 per cent tangent, with a curvature for the balance of 32 deg. per mile. This division is 31 per cent level, and the ruling grade is but 0.3 per cent. Passing sidings are all long enough for 85 car trains. The total number is 31, of which 16 are used for eastbound and 15 for westbound trains. The important junction points are six in number—Binghamton, Owego,

Automatic Block and Train Order Signal at Passing Siding L R

Waverly, Elmira, Corning and Addison. The freight traffic for 1917, measured in tons carried one mile per mile of road, averaged 14,373,017.

Handicaps of the Manual Block

Prior to the installation of automatic block signals the Susquehanna division was operated under manual block signals with a total of 46 block signal stations, 18 of which were block stations only and 28 both block and interlocking stations. The average length of blocks was 3.07 miles, but there was a wide difference in their length. The shortest block was 0.30 mile in length, and 30 blocks ranged from 0.39 to 4 miles; eight blocks from 4 to 5 miles; six blocks from 5 to 6 miles; one block 6.89 miles, and the longest block 7.27 miles in length. This variation in block lengths is characteristic of the manual block, as block stations are usually placed at passenger stations, passing sidings, junctions, etc., with the result that it is often impossible to avoid delays to trains moving under close headway. It is also the usual practice to close a number of the block stations at night.

This often results in making a number of the block sections excessively long, and thus creates an added source of delay. The operation of 46 stations required a force of 136 signalmen at a total cost of $94,752 a year for wages on a basis of the eight-hour day.

Under the manual block the train dispatching was by written train orders sent by telegraph. The division was divided into two dispatchers' districts with two men for each district, or four men for the division for each of the three eight-hour tricks, or 12 men for the 24 hours, in addition to two chief train dispatchers.

The block signals did not "supersede the superiority of trains." Trains were required to have train orders to pass or run ahead of other trains and extra trains required running orders.

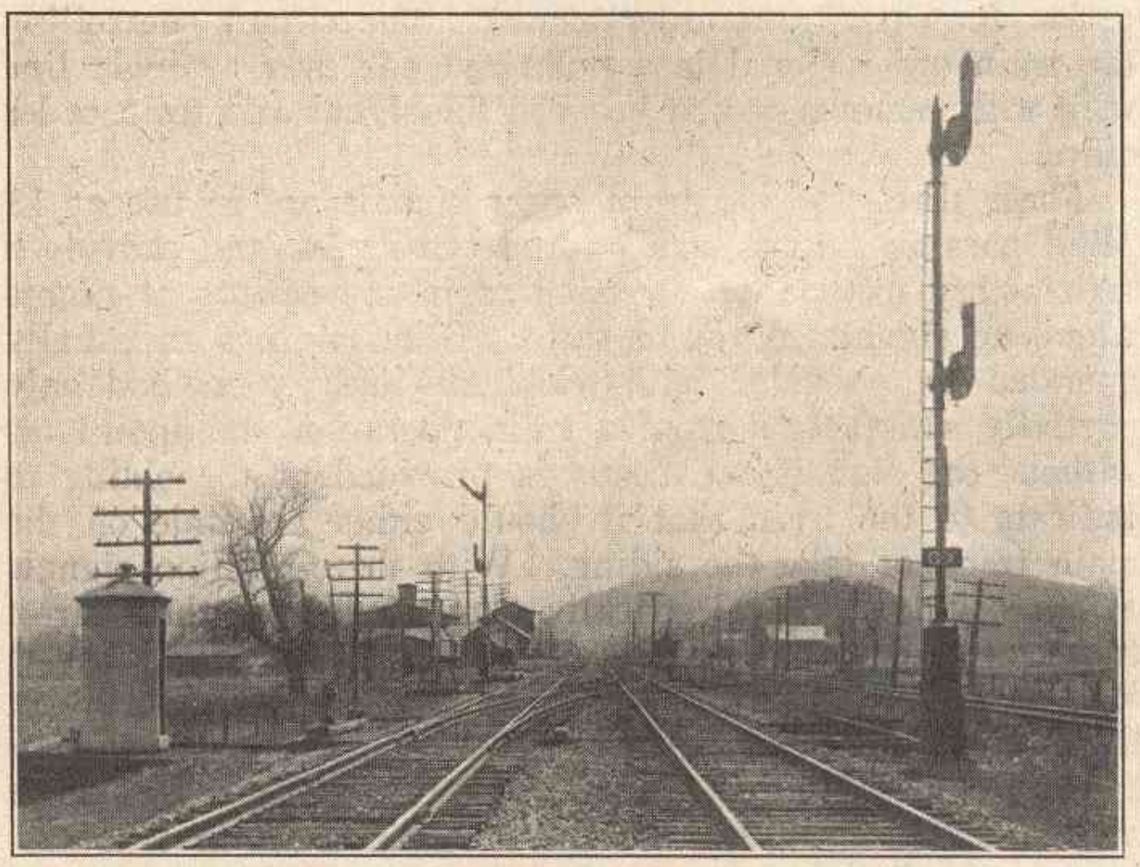
Delays under the manual block were due to—

(a) Long block sections. Trains could not follow each other under close headway, thus causing serious delays; i. e., a freight train waiting on a passing siding could not follow a passenger train until the passenger train had cleared the block three or more miles in length. And again these blocks often included a station stop for the local passenger train.

(b) Blocks of irregular length were another source of delay. A point often overlooked is that the longest block section *in time* determines the headway between trains for the entire division.

(c) Time lost by trains operating under *written* train orders, the trains being required to either slow down or stop to receive them; i. e., an extra train running ahead of a regular train could not continue on the main track on the time of the regular train without a written train order, although the regular train might be an hour or more late. The delivery of the train order required the extra to slow down to receive it. This illustrates one of the weak points of the written train order, as in the foregoing case the moving train is brought almost to a stop for the sole purpose of receiving instructions permitting it to keep in motion.

Automatic block signals were put in service on the Susquehanna division on December 17, 1910. Up to the date of this installation progress in equipping the Erie with automatic block signals had not been rapid as only 124.8 miles of road were signalled. The marked increase from 124.8 miles on January 1, 1910, to 1,018.1 miles on January 1, 1917, can be accounted for by the improvement in train



Automatic Block and Train Order Signals at Tioga Center

operation on the Susquehanna division for which full credit was given the automatic block signals.

The several divisions were equipped with 298 automatic signals, controlling 296 blocks of an average length of 4,959 ft. The signals are of the one-arm, three-position upper quadrant type, electrically operated by storage batteries. The signals are controlled by polarized track circuits.

Power-Operated Train Order Signals

The old style train order signals were replaced with three-position signals electrically operated, and as these signals marked a departure in the use of train order signals a full description will be of interest. The three-position train order signal is an electric motor signal on the mast with the automatic block signal; the number now in use is 42 (1918), all located at passing sidings or crossovers, indicated on the diagram by the letters TTO. The control of these signals is from the nearest day and night train order office, thus

making it possible for the train dispatcher to direct the operation of these signals by telephone instructions to the offices controlling them. For example, the train order office at Waverly (W) controls three signals, the train order signal at JT siding 5½ miles west and the train order signals at XY siding two miles east and at BT crossover 5½ miles east.

Another drawing illustrates a typical passing siding, showing the automatic block signals, telephone train order signals and telephones. The telephone train order signals are the lower arms of the automatic signals 280-1 and 280-2. Signal 280-1 upper arm, which is the block signal, indicates "Proceed," and the lower arm, the train order signal, indicates "Proceed regardless of following superior train until otherwise ordered." Signal 280-2 upper arm (the block signal) indicates "Stop," and the lower arm (train order signal) indicates "Take Siding."

Circuits for Train Order Signals

The circuits controlling the train order signal require the block signal (upper arm) to be in the "Stop" position whenever the train order signal is moved to either the 45-deg. or the "Stop" position. The block signal in the "Stop" position sets the first block signal 281-2 in the rear to the caution position. This arrangement of the circuits insures the display of the caution block signal approaching the train order signal, whenever the train order signal is either at the 45-deg. or "Stop" position. This is in accordance with the best practice, as it provides a distant or approach indication for each train order signal. The circuit controlling the train order signal is a polarized one over a single line wire with common return between the signal and train order office.

These three-position train order signals are in use at 13 blind passing sidings and 7 blind crossovers, and provide a satisfactory method of directing train movements at points where no signalmen are on duty. Blind sidings as usually operated are provided with telephones only, a method only partially satisfactory from a train operation standpoint, as without the signals no means is provided at the siding to indicate to the train that it should either continue on the main track or take the siding. With three-position signals at the blind siding, electrically controlled from the nearest train order office, which may be one or more miles away, it is a simple matter for the train dispatcher to display at the blind siding the required signal indication for directing the train movement to be made at the siding. Trains at the blind siding either continue on main track or take siding, as required by the signal indication of the train order signal. If they enter the siding they report by telephone to the office from which the train order signal is controlled.

The installation of the automatic block signals was completed in a little over twelve months' time from the date that the work was authorized by the railroad company. A train dispatcher's circuit with telephones in all train order offices was installed, also local circuits from each train order office to the adjacent blind passing sidings and blind crossovers.

Changes in Train Operation

Train dispatching methods were changed following the installation of automatic block and three-position train order signals in order to secure the full advantages of train operation made possible under the improved signal system. With the installation of the telephone train dispatcher's circuit the use of the telegraph train dispatcher's circuit was abandoned. With the three-position train order signals, signal indications for directing train movements largely replaced the directing of train movements by written train orders. With the automatic block, safety and facility in operation were both increased.

The Susquehanna division is divided into two train dispatchers' districts—Susquehanna to Elmira (81.2 miles) and Elmira to Hornell (58.5 miles). There is one dispatcher for each district, requiring two men for each eight-hour trick, or six men in all, for the 24 hours, with two chief train dispatchers, one on day and one on night duty. The train dispatcher's office is at Hornell.

The train dispatcher's telephone circuit provides telephones at all train order offices. In addition, local telephone circuits are provided between the telephone train order signals at blind passing sidings and blind crossovers and the train order offices from which these signals are controlled. There is a total of 133 telephones on the main and local circuits. The telephones at the train order signals are housed in concrete booths.

For emergency use in communicating with trains that may be stopped at points distant from a fixed telephone every train is provided with a portable telephone set with fish pole attachment for cutting in on the telephone circuit. The telephone wires are easily identified by a white square painted on the crossover arms under the two telephone wires on every fifth pole.

There are 17 train order offices open day and night. At 11 interlocking towers, the interlocking signals are used as train order signals; at 20 blind passing sidings and blind crossovers telephone train order signals are located, controlled from the nearest day and night train order office; at three stations two-position train order signals are operated. This makes a total of 34 locations at which train order signals are operated.

Rules for the movement of trains by signal indications given by the train order signals are few and simple.

"Telephone train order signal rules:

"(A) Arm horizontal. Red light at night. Indication: Stop on main track and consult dispatcher on telephone.

"(B) Arm inclined 45-deg. above horizontal. Yellow light at night. Indication: Take siding and consult dispatcher on telephone when clear of main track. Passenger trains will report before pulling in siding.

"(C) Arm inclined 90 deg. above horizontal. Green light at night. Indication: Proceed regardless of following preferred trains until otherwise directed by dispatcher.

"It is forbidden for trains to accept the proceed indication, Paragraph 'C,' if there is any known cause that will prevent them from making their usual running time. In such an event they will consult immediately with the dispatcher. When a train accepts the proceed indication, paragraph 'C,' and for any cause is unable to make its usual running time, it must protect itself against the following preferred train according to Rule 99, operating department.

"It is forbidden to use a crossover at any point where a telephone train order signal is located without permission from the dispatcher.

"(D) When trains approach interlocking points with insufficient time to clear the schedule of a superior train at the next passing point, the whistle must be sounded for the siding, and if proceed signals are displayed, trains will proceed in accordance with Paragraph 'C'."

The three indications of the train order signal—"Proceed on main track," "Take siding" and "Stop for instructions"—are unmistakable. The issue of written train orders is the exception. Under the method of operating by the signal indications of the train order signal there is no need for the use of the following Standard Code train order forms:

Form B—"Directing a train to pass or run ahead of another train." This information is given entirely by the train order signal directing the train to "proceed on main track" or "take siding" as required.

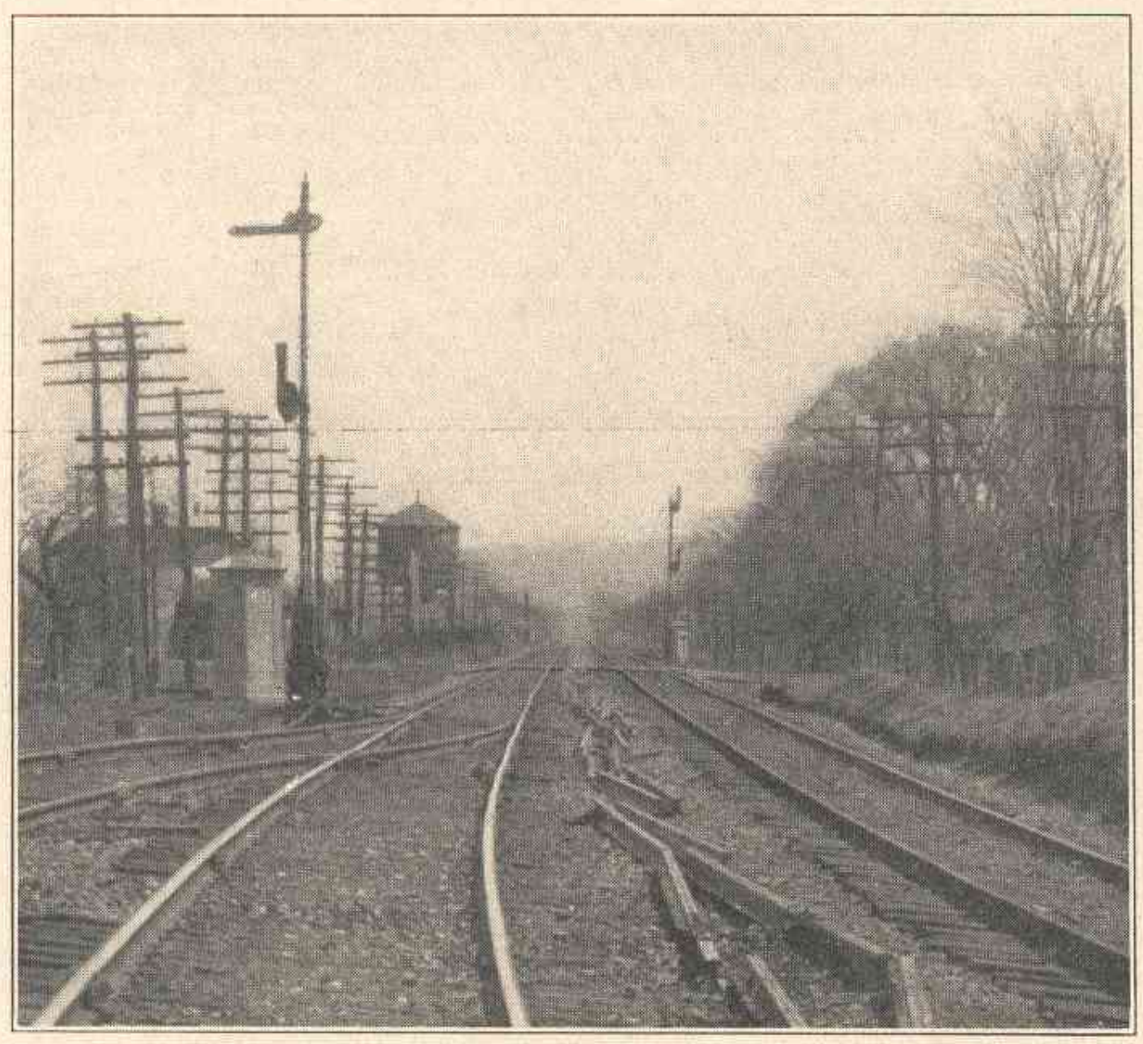
Form D-E—"Time Orders." Under the method of operating trains by signal indication the issue of time orders is not necessary.

Form G—"Extra Trains." Train orders are not required, as under time table rule B "extra trains will start from their initial point and proceed on double track without running orders."

Form J—"Holding Order." Not used, as train order signal in stop position takes its place.

The following train order forms of the Standard Code are still in use, as the information covered by them cannot be given by signal indication:

Form F—"For Sections."
Form D-H—"Work Extra."
Form K—"Annulling a Schedule or a Section."
Form L—"Annulling an Order."
Form D-M—"Annulling Part of an Order."
Form D-P—"Superseding an Order or Part of an Order."



Signal 235-1 at W. B. Passing Siding L R

For movements against the current of traffic or for the use of a section of a double track as single track Forms D-R and D-S are used.

Train Movements

The extensive use of the telephone makes it possible for the dispatcher to keep a close supervision over the movement of every train. There are four methods of reporting trains:

(a) By telephone train reports (OS) from the 17 day and night train order offices. The distance between these offices averages 8.7 miles.

(b) By telephone reports from trains taking siding or, if a passenger train, about to take siding.

(c) By telephone reports from trains stopped in answer to train order signals in "Stop" position.

(d) By telephone reports from trains using emergency telephone outfits at other than fixed telephone locations.

The dispatcher directs train movements of extra trains or schedule trains running late by sending telephone instructions to the signalmen at the 17 train order offices. These instructions direct the signalmen to place the train order signal either in a 90-deg., 45-deg. or "Stop" position. If the signal is at an interlocking tower, the signalman places the interlocking signal used as a train order signal in the position directed. If the signal is at a blind passing siding or blind crossover, the signalman at the train order office places the signal in the position directed by operating the three-position switch controlling the signal.

The dispatcher makes no written record of the train movement authorized by him until after the train has acted upon the instructions of the train order signal. For example, if the dispatcher instructs a train order office by telephone to set "train order signal at 45 deg." at a blind siding for an extra train to "take siding," the entry is made on the train sheet after the extra takes the siding and the conductor has reported over the telephone that the movement has been made as directed.

There is a marked difference in the simplicity of this method of directing a train movement by signal indication as compared to the written train order method. Under the written train order method the dispatcher would have issued a Form B order, the signalman would have been required to deliver the order to the train, the train would have had to slow down to receive it and finally after the train had made the movement, as required, the conductor would have had to telephone the completion of the movement. Under the method of train orders by signal indication, the dispatcher, with a few words over the telephone, would direct the train order office to display the required train order signal and the signal would be displayed *at the point where the train is required to act upon it.* The train would not be required to slow down simply to receive instructions, as the instructions are conveyed to the train by the unmistakable indication of the train order signal. And, further, these instructions are given to the train at the point where the train is required to act upon them and not at some distant point, as is so often the case under the written train order system.

As a further example of the two methods, take the case of an extra train to be run ahead of a scheduled train running late. Under the written method a "19" order would be issued and the train would be required to slow down to receive the instructions directing it to continue on main track, the slowing down of the train defeating in a measure the very purpose for which the instructions are issued. Under the signal indication method the train order signal in the 90-deg. position will instruct the train to continue on

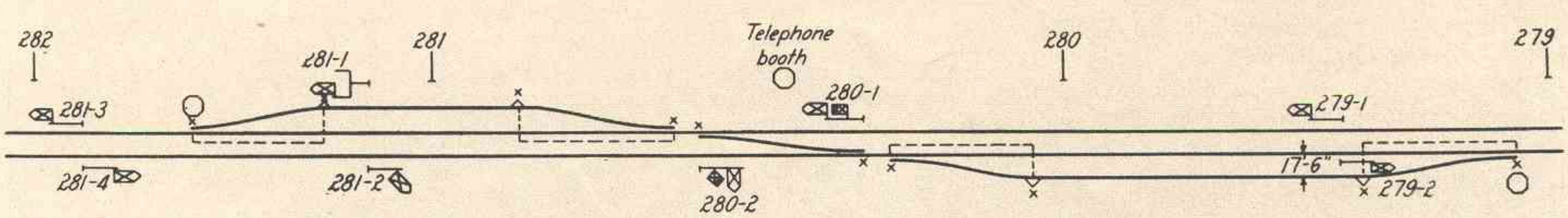


Diagram Showing Blind Siding and Typical Arrangement of Signals

the main track and the train will not be required to lose any time by slowing down to receive these instructions.

The installation of automatic block signals on the Susquehanna division, together with the three-position train order signal and telephone train dispatching, resulted in the maximum protection for train movements by the automatic

block signals, and the three-position train order signal with the telephone train dispatching system furnish the train dispatcher with an efficient means for directing train movements by signal indication.

Results

The improved results in train operation under automatic block signals were as follows:

Delays to freight trains due to the manual block were practically eliminated. The train load was increased and, although the speed was slower than formerly, less time was consumed in passing over the division. The average time for freight trains to cover the division—139.7 miles—was:

Under manual block.....10 hours 29 minutes
Under automatic block..... 8 hours 49 minutes
Difference ..... 1 hour 40 minutes

Or a saving in time of 15 per cent.

The total saving in train operation is shown in Table I, compiled from data furnished by the railroad company through the superintendent's office of the Susquehanna division. This estimated saving of $87,969 is equal to the interest on an investment of $1,759,380.

The improved results in train operation more than justified the installation of this system of automatic block and train order signals. The success of the system was due to the fact that it provided an effective method of operating trains by signal indication.

Erie Railroad
Susquehanna division

	Manual block	Automatic block
Block stations, number of		
Block (only)	18	None
Interlocking and block	28	None
Total	46	None
Interlocking stations (only)	None	11
Block sections, number of		
Day and night	90	296
Block section lengths		
Minimum miles	.39	...
Maximum miles	7.27	...
Average	3.07	0.94
Block signalmen		
All telegraph operators	136	...
Telephone and telegraph operators	...	58
Wages per year	*$94,752	$55,176
Average per man	696.70	919.60
Train order offices		
At block stations	18	None
At interlocking stations	28	11
At passenger stations	4	6
Total	50	17
Train order signals		
At block stations	36	None
At interlocking stations		
Interlocking signals used also as train order signals	56	22
At passenger stations	2	6
At blind sidings and crossovers	None	†40
Total	94	68
Train dispatcher's force		
Dispatchers	12	6
Chief dispatchers	2	2
Total	14	8

*Total is computed on basis of eight hours per day for comparison with total under automatic block.
†Ten put in service in 1918.

Table 1—Results of Freight Train Operation on the Susquehanna Division—Erie Railroad

For Months of December, 1909, to November, 1910, Under Manual Block
Compared with Months of December, 1910, to November, 1911, Under Automatic Block

	Ton miles		Ton miles per train			Reductions a/c temperature			Freight trains				
Months (a)	1909-10 Manual block (b)	1910-11 Automatic block (c)	1909-10 Manual block (d)	1909-10 Manual block (Corrected) (See Note a) (e)	1910-11 Automatic block (f)	1909-10 (See Note b) (g)	1910-11 (See Note b) (h)	(i)	1909-10 (k)	1909-10 Manual block (Corrected) (See Note c) (l)	1910-11 Automatic block (m)	Saving in freight trains (n)	Saving in train operation (o)
December	173,387,082	177,605,807	227,542	217,757	228,285	8.5	12.8	+4.3	762	811	778	33	$4,511
January	162,944,115	194,134,250	224,750	232,392	251,795	12.4	9.0	—3.4	725	835	771	64	7,401
February	154,443,876	180,987,865	225,136	231,215	252,072	12.0	9.3	—2.7	686	782	718	64	7,629
March	199,235,797	178,197,673	247,497	239,577	244,106	6.0	9.2	+3.2	805	744	730	14	4,284
April	131,246,585	168,295,833	245,320	241,640	256,548	2.2	3.7	+1.5	535	696.5	656	40.5	6,512
May	170,527,993	189,061,368	268,548	268,348	276,002	0.0	0.0	0.0	635	704	685	19	4,931
June	160,521,776	202,898,946	250,815	250,815	293,206	0.0	0.0	0.0	640	809	692	117	11,944
July	189,088,090	207,184,154	271,289	271,289	298,106	0.0	0.0	0.0	697	764	695	69	8,242
August	195,734,433	203,503,501	297,921	297,921	302,832	0.0	0.0	0.0	657	683	672	11	3,834
September	195,588,923	189,772,505	273,550	273,550	296,057	0.0	0.0	0.0	715	694	641	53	7,041
October	210,030,355	221,607,785	260,583	260,583	308,216	0.0	0.0	0.0	806	850	719	131	12,765
November	195,119,249	208,820,764	267,653	263,370	293,700	3.7	5.3	+1.6	729	792.9	711	81.9	8,875
	2,137,868,274	2,322,070,451	254,751 (Average)	254,054 (Average)	274,217 (Average)	44.8	49.3	+4.5	8,392	9,165.4	8,468	697.4	$87,969

Note.—(a) The "Ton miles per train" under manual block (corrected Col. e.) are the totals for 1909-10 corrected by the difference in temperature of the winter months of the two years in order to place the totals for the two years on an equal basis in respect to weather conditions.

(b) The "Reduction on account of temperature" (Cols. g and h) are the percentages by which the monthly ton mile totals were reduced on account of low temperatures. These percentages were used to arrive at the totals under manual block (corrected).

(c) The "Freight trains" manual block (corrected Col. 1) were computed by dividing the "Ton miles per train" manual block (corrected Col. e) into the ton miles per month moved under the automatic block (Col. c). The results (Col. 1) show the number of trains that would have been required to move the traffic that was moved under automatic block if the trains had been operated on the manual block basis.

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Loading Shells on a Light Railway Train