requirement that each insulator have a mark indicating the year of manufacture. He said that such information was of no value and would delay shipments as the manufacture would not stock up on insulators. The committee agreed to consider the elimination of this requirement and the specification as revised was accepted for presentation at the annual meeting.

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Report of Committee I—Economics of Signaling

COMMITTEE PERSONNEL

J. E. Saunders (D. L. & W.), chairman
B. J. Schwendt (N. Y. C.), vice-chairman

J. J. Brinkworth (N. Y. C.)	G. A. Rodger (Wab.)
E. B. DeMeritt (C. of G.)	L. R. Stahl (L. & N.)
W. F. Follett (N. Y. N. H. & H.)	R. A. Sheets (C. & N. W.)
J. S. Gensheimer (Penna.)	W. S. Storms (Erie)
E. Hanson (A. T. & S. F.)	C. A. Taylor (C. & O.)
R. B. Jones (C. P.)	O. R. Teague (S. A. L.)
C. A. Mitchell (N. Y. N. H. & H.)	L. C. Walters (Sou.)
F. W. Pfleging (U. P.)	L. S. Werthmuller (M. P.)

B. J. SCHWENDT, assistant signal engineer of the New York Central, as vice-chairman, presented the report of the Committee on Economics of Railway Signaling, which included data on four installations where train movements are directed by signal indication, and three papers on interlocking economics, as well as one paper comparing operating results before and after improvements were made in signaling facilities.

Train Operation by Signal Indication on N. Y. C.

The New York Central, on July 25, 1927, placed a centralized traffic control system for train operation by signal indication in service on a 40-mile section of track between Berwick, Ohio, and Stanley. The installation covers 37 miles of single track and 3 miles of double track, all tracks being signaled in both directions, making the equivalent of 43 miles of single-track signaling. The daily traffic in this territory consists principally of the movement of coal northward and of empties southward, in addition to 10 to 12 high-speed passenger trains and 2 local passenger trains. The movement totals about 18 to 20 freight and 12 to 14 passenger trains per day. Of the 20 freight trains, approximately 15 are loads northbound and 5 are empties southbound. This section of road is used for northbound trains of different divisions owing to its 0.2 per cent descending grade, and empties are returned by other routes.

The centralized traffic control system permitted the elimination of a large number of train stops, which contributes to the reduction in running time and the ability to establish or change meeting points quickly, thereby reducing delays. As the grade is practically 0.2 per cent against southbound trains over the entire district, the elimination of stops on the grade made it possible to increase the tonnage of these trains, although there has been no change in the class of power. The economic statement concerning this installation, which was included in the report, explained that there had been a 26 per cent decrease in the freight train hours per trip, a 36 per cent increase in freight train speed, and a 39 per cent increase in the gross tons per train hour. The net annual saving is $128,518 which is equivalent to 24 per cent on the investment, over and above interest charges. When consideration is given to the deferred investment for second track the saving is increased to 65 per cent.

A Recent Study on the P. M.

The centralized traffic control system on the Pere Marquette between Mt. Morris, Mich., and Bridgeport was installed to provide additional capacity on a 20-mile section of single track between two sections of double track, and on which there are three intermediate passing sidings. The double-track junctions and ends of sidings are controlled by the system, switches as well as signals being operated by means of a control machine at McGrew yard. This system was placed in service on June 30, 1928. A full description of the installation and characteristics of traffic appeared in *Railway Signaling* for October, 1928.

Recently a study was made to determine: (1) What the actual time savings in operation have been with the various densities of traffic; and the total time savings for the year. (2) How closely these results could have been predicted from an analysis of train records, and by graphic re-dispatching for periods before the installation. (3) The financial savings of the centralized traffic control system. (4) Financial comparison with other methods of operation. A brief outline of the methods used, the results obtained, and the conclusion drawn from the study is given below.

The six Bender children had several new songs for luncheon entertainment and Paul Gault presented them with a 105-lb. Arkansas watermelon to carry back to Jersey

FIRST—ACTUAL TIME SAVED IN OPERATION

In determining the actual time saved for the year and with the various densities of traffic, a study was made of 61 days in each of the two years preceding the installation and in the year following the installation. In order to secure days with light and heavy traffic, as well as an equal number of days in the same season of each year, every sixth day in each of the three years was chosen. Two years preceding the installation were used to determine the relation that existed between them and to test the accuracy of the method.

As meets, which are the cause of most avoidable delays, are approximately proportional to the square of the total number of trains, it was necessary to calculate the train time consumed between Mt. Morris and Bridgeport at the various densities of traffic (trains per day) and apply this time consumed to the number of days for the year on which each

density of traffic occurred. The results were as follows:

	Train hours	Minutes per train	Miles per hour
1926-1927	5,957	59.87	.....
1927-1928	5,840	58.69	.....
Weighted average for above	5,853	58.82	20.22
1928-1929	4,635	46.58	25.53
Saving	1,218	12.24	5.31
Per cent increase or decrease	21% dec.	21% dec.	26% inc.

Data for the years 1926-1928 were reduced to a density of traffic equivalent to 1928-1929, *i.e.*, to the time that would have been required in 1928-1929 if there had been no installation.

SECOND—ACCURACY OF PREDICTING TIME SAVED

In making the comparison between the predicted time saved and the actual time saved, 30 days were chosen at random in the year previous to the installation and the trains were graphically redispatched to secure the anticipated performance under the proposed operation. The time consumed per day and per train, for each number of trains per day, and the total time consumed for the year, were then calculated as in the previous case. Results of this procedure for 30 days were as follows:

Train hours per year—Original operation	5,680
Train hours per year—Predicted operation	4,937
Train hours per year—Predicted saving	743
Minutes per train —Original operation	57.08
Minutes per train —Predicted operation	49.62
Minutes per train —Predicted saving	7.46
Miles per hour —Original operation	20.83
Miles per hour —Predicted operation	23.97
Miles per hour —Predicted saving	3.14

The number of actual train hours saved was 1,263 per year and the number of minutes saved was 12.70 per train; the predicted time saved, to compare with this, was 743 train hours per year and 7.46 min. per train, or 61 per cent of the actual time saved. It is not contended that 61 per cent would obtain in all studies, as the personal element in the redispatching as well as the inadequacy of delay reports, etc., will cause variation. However, it is believed that the predicted savings, where care is used in the redispatching would generally be less than the actual savings. It is hoped that further studies will be made to more accurately determine the range of this factor.

FINANCIAL COMPARISON WITH TRAIN ORDER SYSTEM AND WITH OTHER METHODS OF OPERATION (BASIS $15 PER TRAIN HOUR)

	Per year
1. Train operation by signal indication—centralized traffic control system as installed between Mt. Morris, Mich., and Bridgeport (single track)	$19,035 Profit
FINANCIAL COMPARISON WITH TRAIN ORDER AND OTHER SYSTEMS	
Double Track	
2. Train order system	$41,750 Deficit
Single Track	
3. Train order system with switch tenders at each passing track switch	12,440 Deficit
4. Train order system with automatic block signals and switch tenders at each passing track switch	17,940 Deficit
5. Train order system with automatic block signals	3,800 Deficit
6. Train operation by signal indication with operator control of switches and signals	1,600 Profit
PROFIT AND RETURNS ON THE INVESTMENT ABOVE INTEREST AND MAINTENANCE CENTRALIZED TRAFFIC CONTROL SYSTEM	
At $15.00 per train hour	$19,035 or 18 per cent
At $18.00 per train hour	$22,893 or 22 per cent
At $25.00 per train hour	$31,895 or 30 per cent

Note: In items 1 and 6 a profit is shown as the savings per year exceed the annual expenses, including interest. In items 2, 3, 4 and 5 a deficit is shown as the annual expenses and interest exceed the savings per year.

Train Operation by Signal Indication on the B. & O.

Members of the committee inspected an installation of color-position-light signals and remote control swiches between Grafton, W. Va., and Parkersburg, a distance of 102 miles, of which 89 miles is single track and 13 miles double track, and upon which train operation is governed by signal indication. This subdivision traverses a mountainous section with numerous curves, grades and tunnels. The ruling grades vary from 0.96 to 1.47 per cent, and the tunnels, of which there are 23, are from 300 ft. to 2,710 ft. in length. The sub-division is a part of the Philadelphia-Cincinnati main line, with a traffic of 18 high-class passenger and 22 freight trains each day. The time scheduled over the sub-division for a passenger train is 3 hr. 7 min., and for a freight train is 5 hr. (20.4 m.p.h.).

Previous to the installation of this system, the first section of which was placed in service on December 1, 1928, and the last on May 28, 1929, trains were operated by train orders and time-tables under Standard Code rules. Now trains of every class are normally moved by signal indications without train orders and with a marked increase in operating efficiency. The division officers and employees are enthusiastic regarding the additional flexibility of operation effected by the signals. The train orders issued have been decreased approximately 1,000 per month. (For a detailed description of this installation see *Railway Signaling* for September, 1929.)

Semi-Automatic Block Signals and Remotely-Controlled Switches on the C. & O.

In December, 1928, the Chesapeake & Ohio placed in service, on a five-mile section of single track between Brighton, Ohio, and Cheviot, an automatic block system with semi-automatic signals and remotely-controlled switch-operating mechanisms for the operation of the switches at the ends of the siding at Brighton. The switches and the signals at both ends of this siding, also the first eastbound and last westbound signal at Cheviot, were placed under the control of the operator at Brighton, thus giving him full control of train movements.

Because of a 1.91 per cent grade, pusher engines are used on all westbound freight trains from Cincinnati to Cheviot, the engines returning light to Cincinnati. Before the new system was placed in service, manual block signals were in use. On account of the heavy down grade and restricted view of the engineman, all eastbound trains, including the light pusher engines from Cheviot to Brighton, were operated under absolute block and, as this spaced trains about 4.5 miles apart, delays were unavoidable. Under the new system, with three blocks, a large part of this delay was eliminated by permitting eastbound trains to follow under close headway under the indications of the signals. A study of train operation for one month before and one month after the installation shows that the improvement in operation resulted in an annual saving of $26,209, or a return on the investment of 101 per cent.

TABLE SHOWING SAVINGS ON C. & O. INSTALLATION

Average number of trains per day:		
March 1928 (before the installation)		57
May 1929 (after the installation)		47
Cost of installation		$26,000
Net saving per year		$26,209
Annual return on investment over and above interest charges		101%
Net Saving Per Year in Detail (Basis $6.52 per freight train hour)	Hours	Amount
Savings per day:		
By eliminating stops entering and leaving siding at Brighton through use of remotely-controlled switch operating mechanisms, average of 4 trains at 15 min. each	1.00	$6.52
By eliminating "block" cards at Cheviot and Brighton, average of 20 trains at 5 min. each	1.67	10.88
By permitting eastbound trains from Cheviot to follow under closer headway and under signal protection, average of 3.17 trains at 20 min. each	1.05	6.85
By eliminating delay to pusher engines (Mallet)	9.00	58.68
Total gross saving per day	12.72	$82.93
Total gross saving per year, $82.93 × 365 days		$30,269.00
Annual expenses:		
Maintenance and operation	$2,500.00	
Interest charges at 6%	1,560.00	
Total annual expenses		4,060.00
Net saving per year		$26,209.00

Automatic Block System Replacing Manual Block on M. P.

An automatic block system with color-light signals was installed to replace manual block signals on the Arkansas division of the Missouri Pacific on 326 miles of main road comprising two freight districts, between Poplar Bluff, Mo., and Texarkana, Ark., including 216 miles of single track and 110 miles of double track. Either-direction operation has been provided for on the double-track sections from Bald Knob to Little Rock, 57.5 miles; Little Rock to Benton, 23 miles; and Clear Lake Junction to Texarkana, 9.9 miles. No permissive signals were installed for "against-traffic" moves, but an absolute signal is provided for such moves, at each station, in addition to the usual block signals for the "with-traffic" direction. In order to cross over for an against-traffic movement, a clockwork time release located in the telephone booth at the cross-over switch, is operated by the telegraph operator at open offices or by trainmen at blind sidings. When the release is operated to make an against-traffic movement into a clear block, all opposing signals in the block in advance assume the stop position, and a clear indication is given to the train desiring to make the move. After this train has crossed over, entered the block, and is moving against-traffic, it automatically clears ahead of itself, the against-traffic absolute signal leaving each station, provided the train continues to move against traffic into another block and provided, of course, the block is not occupied. Center siding locations were selected as reversal-of-traffic points and a train moving against traffic in one block and returning to the with-traffic track at the end of that block will do so at the near switch end and, therefore, will not set up the signal for an against-traffic movement in the next block. (Description of other signaling and interlocking facilities on these divisions as given in the remainder of this report was also included in an article in the Railway Age for January 26, 1929.)

A comparative study of the through freight-train movements from the train sheets before and after the signal installation shows that a saving of 24.4 min. southbound and 63.7 min. northbound has been effected for the average through freight-train movement between Little Rock and Texarkana. This time saving represents the delays that have been eliminated by the signals, the remotely-controlled switch-operating mechanism installations, the interlocking plants, and by facilitating the train movements with the against-traffic running on double track.

Before the signal installation, the average train load from Little Rock to Texarkana was approximately 1,840 tons. Without any increase in power, this train load has now been brought up to approximately 2,000 tons, an increase of about 160 tons or 8.7 per cent for the average through freight train. This means that the cost of running one train out of 12 has been saved.

The average engine mileage previous to the signal installation was 130 miles per day, whereas it is now 162 miles per day, or an increase of 24.6 per cent. Owing to the installation of remotely-controlled switch-operating mechanisms, 32 operator positions have been abolished on the territory, Poplar Bluff to Texarkana. As the average time of the trip before the installation ran into overtime, the wage saving can be figured at the overtime rate. Recently three cases of broken rails were detected by signals. In one of these, near Russell, Ark., a fast passenger train was stopped by a signal at the entrance to a section of track with three feet of rail out, which probably prevented a serious accident.

Consolidation of Interlockings on N. C. & St. L.

Prior to 1928, two all-electric interlockings were located at Howell, Ga., tower No. 2 being about 1,400 ft. from tower No. 3. These two towers served four roads, the Louisville & Nashville; the Nashville, Chattanooga & St. Louis; the Seaboard Air Line; and the Southern. Six operators were employed, three at each tower.

At a site about halfway between the two towers a third story was added to an existing building, at a cost of $2,489, and machines in towers No. 2 and 3 were moved to this new location. The consolidated plant consists of 107 levers with 95 functions and 12 spare spaces, operating 31 switches. The switches are at an average distance of 1,000 ft. from the tower, with a maximum of 1,600 ft. and a minimum of 400 ft. Train movements average 480 every 24 hr., with a lever movement every 18 sec. The cost of the consolidation was $10,057.

Table Showing Saving on N. C. & St. L.

1.	Saving in labor:	
	(a) Man-hours per year	8,760
	(b) Man-hour rates, average	$0.6425
	(c) Labor, 1a × 1b	$ 5,628
2.	Cost of installation (Consolidation of the two machines)	$10,057
3.	Annual expenses and charges (Includes only the expenses due to the consolidation):	
	(a) Maintenance expense	$ 503
	(b) Interest charges at 5 per cent	502
	(c) Total annual expenses and charges	$ 1,005
4.	Gross saving per year:	
	(a) Labor, 1c	$ 5,628
	(b) Other saving, tower expense	372
	(c) Total gross saving	$ 6,000
	(d) Deduct annual expenses and charges, 3c	1,005
5.	Net saving per year: 4c—4d	$ 4,995
6.	Annual return on investment over and above interest charges 5 ÷ 2	49.6%

Consolidation of Interlockings on the Pennsylvania

Prior to the consolidation, two mechanical interlockings with tower signals were located at Aynes, Ind., and Kouts, about four miles apart. At the Kouts interlocking two main tracks cross the Erie and two sidings extend to Aynes, where they connect with the two main tracks. Six operators were employed, three at each tower. The two towers were combined and electric switch-operating mechanisms installed at Aynes and controlled from Kouts.

Table Showing Saving of Pennsylvania

1.	Saving in labor:	
	(a) Man-hours per year	8,760
	(b) Man-hour rates, average	$0.6975
	(c) Labor, 1a × 1b	$ 6,110
2.	Cost of installation	$24,802
3.	Annual expenses and charges:	
	(a) Maintenance expense	$ 460
	(b) Operation expense	220
	(c) Interest charges at 5 per cent	1,240
	(d) Total annual expenses and charges	$ 1,920
4.	Gross saving per year:	
	(a) Labor, 1c	$ 6,110
	(b) Other saving, tower expense	1,700
	(c) Total gross saving	$ 7,810
	(d) Deduct annual expenses and charges, 3d	1,920
5.	Net saving per year: 4c—4d	$ 5,890
6.	Annual return on investment over and above interest charges: 5 ÷ 2	23.7%

Discussion

In presenting the report concerning the centralized traffic control on the New York Central, Vice-Chairman Schwendt explained that the amount of savings accomplished may be more or less than shown in the report, depending upon the volume of traffic handled during other months of a year. Mr. Schwendt also explained that the $15 value for the train hour saved was a conservative figure based on several tangible items, such as coal, water, etc., and wages of train and engine

crews drawing an average as to whether on overtime or not.

E. C. Poole, of the Union Switch & Signal Company, gave a detailed explanation of methods used in securing the data included in the report on the Pere Marquette installation of centralized traffic control and stated that as a general rule an installation of centralized control on a busy single-track line would save 60 per cent of the delay time caused by meets and train interference. The annual cost of the centralized control installation will amount to approximately one-fifth to one-tenth of the charges for interest and maintenance on a proposed second track. On this basis four-fifths of the investment for second track would result in eliminating only the remaining 40 per cent of the train delay time.

In discussing the reports concerning the consolidation of interlockings, T. S. Stevens (A. T. & S. F.) said that the charges to operation due to the retirement of the old plants was not taken into consideration in the economic statements shown and that although the savings might show decided economies on charges to capital account, nevertheless the changes to operation must also be considered.

C. A. Taylor (C. &O.), in answer to a query from a member, explained that the savings shown in the report on the Chesapeake & Ohio installations were based on an actual check of train movements. In numerous cases the use of a pusher engine and crew was saved for a full eight-hour period.

Following the presentation of the report concerning the signaling on the Missouri Pacific, W. E. Lamb, superintendent of the Arkansas division of the Missouri Pacific, gave an illustrated lecture, explaining how installation of signal facilities had facilitated train movements at numerous points on the Arkansas division, where congestion of train movements had previously caused serious delays, and had likewise deferred expenditures for additional tracks. Comparing operation for August, 1928, with August, 1929, he explained that the cost per thousand gross ton miles had been reduced from 25.6 to 19.5 cents, the tons per train had been increased from 2,058 to 2,404, the gross ton miles per train hour was increased from 2,696 to 3,747. Mr. Lamb stated that the installation of the signal facilities was the largest single factor contributing to these improvements in train operation. He estimated that the savings accomplished 15 per cent on the investment, and explained that although the savings in fuel and wages were large, nevertheless the improved safety to train operation was more important.

J. Davis, superintendent of the Missouri Pacific with headquarters at Falls City, Neb., then explained the operation of trains on the line between Kansas City, Kan., and Atchison, where centralized traffic control was placed in service in January, 1930. In addition to the information contained in an article published in *Railway Signaling* for March, page 93, Mr. Davis stated that 50 per cent of the meets were now being made without either train stopping, which was especially beneficent in extremely cold weather. Based on records of train operation for August, 1929, compared with that for August, 1930, the average speed of freight trains has been increased 6.5 m.p.h. and 59 min. running time is saved on freight trains on the 42-mile territory. The average train load has been increased 217 tons. The issuance of from 130 to 150 train orders and 35 caution cards has been eliminated daily. The savings are equivalent to 22.8 per cent on the investment and in addition the safety of train operation has been improved.

R. A. Sheets (C. & N. W.) discussed the installation of centralized control on the Chicago & North Western between Green Bay, Wis., and Duck Creek, as explained in *Railway Signaling* for September, 1929. He stated that a recent study revealed that the savings were equivalent to 115 per cent on the investment, based on the savings in operation, wages and the elimination of train stops, figuring the cost of stopping a freight train of 50 cars at $2, and a passenger train at 25 cents. When discussing an installation betwen Chadron, Neb., and Dakota Jct., Mr. Sheets stated that the annual saving in overtime was $18,225, and that the total net saving was $14,465 annually, which is equivalent to 39 per cent on the investment.

C. R. Hodgdon (C. P.) discussed an installation of centralized traffic control on the Canadian Pacific between Medicine Hat, Alta., and Dunmore, as explained in *Railway Signaling* for January, 1930, page 20, and stated that the saving was 47 per cent on the investment. He also explained that the installation of automatic block signals on 125 miles on a single track in British Columbia had permitted the elimination of one pusher engine on each of three long grades.

H. G. Morgan (I. C.) explained the installation of two short sections of centralized control on the Illinois Central, one of which eliminated the three operators, and the second, six operators, the savings being 30 per cent on the investment.

W. F. Zane (C. B. & Q.) explained several centralized control installations on the Burlington, referring particularly to that described in *Railway Signaling* for August, 1930. He was emphatic in his statement that the control machine should include indications to show the location of each train all the time, and the position of each signal and switch, also that the indications should be controlled from conditions in the field, not by mechanical connections to levers or other parts of the machine.

G. H. Dryden (B. & O.) discussed certain installations on the Baltimore & Ohio and stated that the most important point for consideration is that the passing tracks must be in the proper locations to secure maximum benefit from centralized traffic control installations.

While at Hot Springs, George Thomas received this cartoon from his boy, it being the son's idea of what happens at a convention