RAILROAD GAZETTE

FRIDAY, MAY 25, 1877.

Contributions.

Signal Equipment of the Pennsylvania Railroad—Centennial System of Tracks.

BY R. H. SOULE.

All the great international expositions have demanded special passenger transportation facilities; and in the case of the Centennial at Philadelphia, the burden of the provision of such facilities fell heavily on the Pennsylvania Railroad Company. The officers of that company, appreciating the fact that the bulk of travel, other than local, would necessarily be over their lines, or at all events tributary to those parts of their lines in and about Philadelphia, determined upon the elaboration of a system of track connections and terminal facilities which could not fail to be adequate to the emergency.

The location of the new passenger station at West Philadelphia made it advisable that the *passenger* tracks should be on the southern side of the yard. Therefore, to make east and west connection between these main-line passenger tracks and the Centennial circle, involved the use of at least two crossings over all the tracks in the yard. Existing cross-over switches at Hestonville, and its propinquity to the Centennial circle, determined the location at that point of the crossing for Centennial trains from or to the main line. On the other hand, as trains from Philadelphia for New York diverged from the main line at Thirty-sixth street, it was evidently best also to make use of that crossing for trains between Philadelphia and the Centennial, they making a second divergence after the crossing frogs were cleared.

At Mantua the Centennial tracks from Philadelphia and New York converged, and a junction and crossing were established at that point.

Thus it is seen what considerations induced the location of the tracks as they are, and led to the establishment of the very important crossings and junctions mentioned. By reference to the plan others will be observed within its scope. Enumerating all, from west to east, we should have:

1. Hestonville, junction, crossing and single track.
2. Belmont Tower, junction and crossing.
3. Mantua Tower, junction, crossing and single track.

V. THIRTY-THIRD STREET SWITCH HOUSE.

Passenger trains inbound to West Phila. station.
" " " " Phila. City or south.
" engines " " Middle track.
" trains from {W. Phila. station, / Phila.city, or s'th} to {West, N. Y., or "Cen." / Centennial.}
" " "

VI. BRIDGE STREET SWITCH HOUSE.

Passenger trains from W. Phila. station, west, N. Y., or "Cen."
" " " " " to South.
" " " Phila. city or south " Centennial.
" " " Centennial " Phila. city or south.
" " " the south " W. Phila.
" engines " W. Phila. station " round house.
" " " round house " W. Phila. station.

(The Bridge street switches are at the point where the upper and lower yards attain a common level; there being a difference of perhaps 25 feet between the floor level of the new passenger station and the grade of the tunnel tracks. Consequently a large amount of shifting, for making up and storing passenger trains was done over these switches.)

VII. TUNNEL SWITCH HOUSE.

Passenger trains from south to W. Phila. or "Cen."
" " " W. Phila. or "Cen." to south.
Freight " " south to W. Phila.
" " " W. Phila. to south.

VIII. DEPOT TOWER.

All inbound and outbound trains passed this point, and every variety of shifting operations was conducted at and about it.

The officials of the Pennsylvania Railroad, foreseeing this great diversity in the classes of trains to be handled, and real-

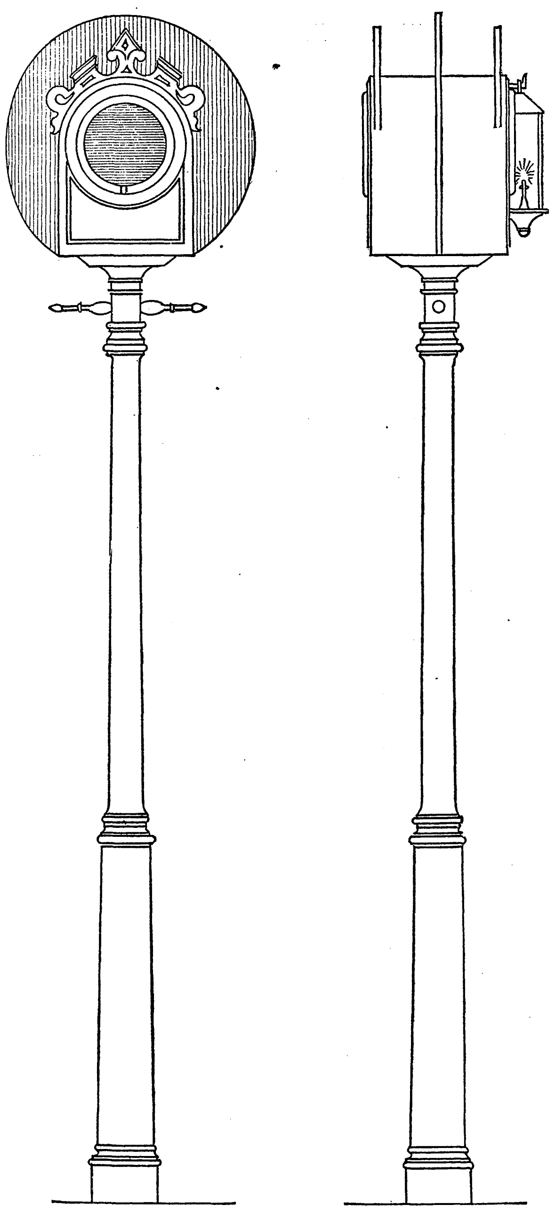

Fig. 1

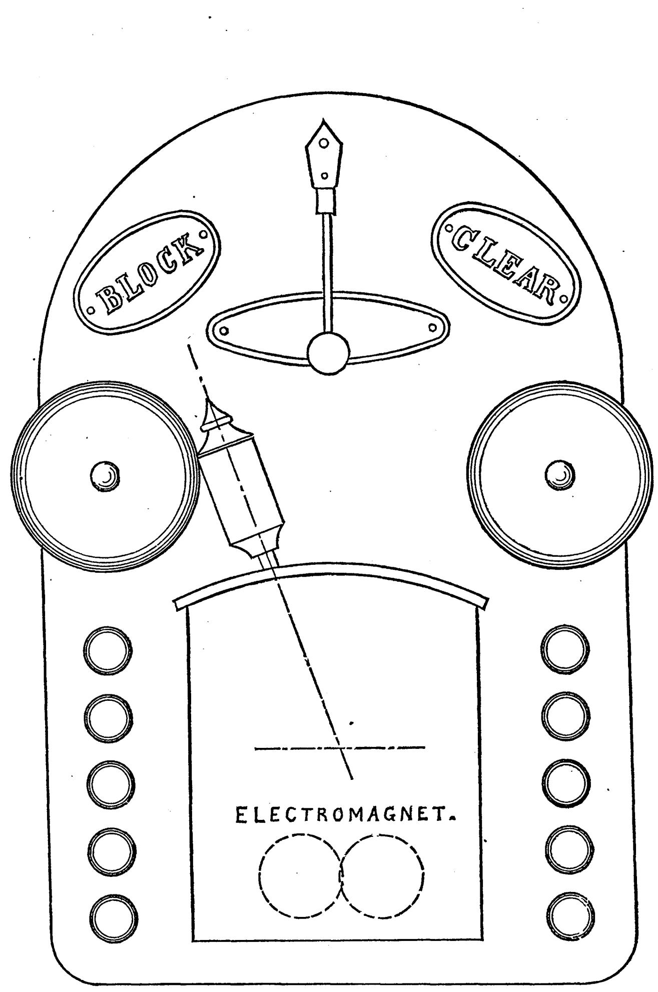

Fig. 2

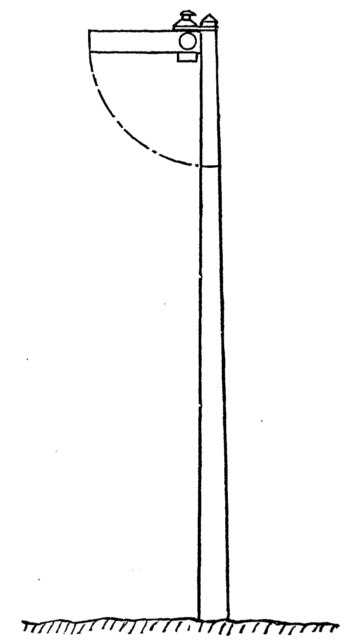

Fig. 3

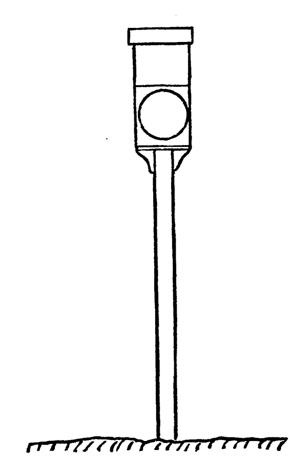

Fig. 4

The passenger terminus at West Philadelphia had long been pronounced insufficient for the accommodation of even ordinary travel; and the new scheme was therefore made to comprehend the erection of a large permanent passenger station at that point (West Philadelphia), an ample station at the Centennial Grounds (two miles further west) and the establishment of track connections for the use of passenger trains exclusively.

Referring to the accompanying plan (the large folded plate) there will be observed, at the points opposite the "Thirty-sixth street switch tower" and "Hestonville Station," two tracks shown in dotted lines. Under the old system these were main tracks for both passenger and freight trains as far east as Spring Garden street. Under the new arrangement these tracks are for the exclusive use of freight traffic, while the passenger trains are run on the tracks shown in heavy black lines. The present junction of these passenger and freight tracks is at Merion station, five miles out.

The Centennial Grounds were very conveniently located with reference to the Pennsylvania Railroad main line, the principal entrance to them being about 1,400 ft. distant from it, and an open tract intervening. This ample expanse of ground, available for whatever system of connections should be determined upon, at once suggested the circular arrangement of tracks, and the advantages of such an arrangement were so many and obvious that it was at once adopted. Arriving trains, whether from the east or west, entered the circle so as to traverse it in the same direction. So with departing trains, which were switched off at the circle at different points, according to their destinations.

4. Thirty-sixth street, junctions and crossings.
5. Thirty-third street, crossing.
6. Bridge street switch-house, junction and single track.
7. Tunnel switch-house, junction, crossing and single track.

To give a clear idea of the variety of classes of trains passing these different points, the following table is presented. The classification is complete for each locality in turn:

I. HESTONVILLE.

Pessenger trains from west to Philadelphia.
" " " " " Centennial.
" " " Philadelphia to west.
" " " Centennial to west.
Freight " " west to Philadelphia.
" " " Philadelphia to west.

II. BELMONT TOWER.

Arriving trains from east to track "A."
" " " " " " "B."
" " " " " " "C."
" " " west " " "A."
" " " " " " "B."
" " " " " " "C."
Empty " " sidings " " "A."
" " " " " " "B."
" " " " " " "C."
" " " " " east.
Departing " " Centennial " "

III. MANTUA TOWER.

Passenger trains from New York Div. to Centennial.
" " " Phila. and south " "
" " " Centennial " New York Div.
" " " " " Phila. and South.
Freight " " New York Div.
" " to " " "

IV. THIRTY-SIXTH STREET TOWER.

Passenger trains from Phila. and south to the west.
" " " " " " " New York Div.
" " " " " " " Centennial.
" " " the west " Phila. and South.
" " " New York Div. " " " "
" " " Centennial " " " "
Freight " " Phila. and south " the west.
" " " the west " Phila. and south.

izing that the number of such trains would exceed all precedent, readily determined the following points:

First—That the whole system of passenger rail approaches to the Centennial Grounds (within the limits of the accompanying map), and the control of trains thereon, should be given to one person, whose jurisdiction and responsibility in these respects should not extend beyond those limits.

Second—That for the protection and safety of the traveling public the trains should be run upon the "absolute block" principle.

Third.—That the more important of the junctions and crossings, within the limits of this jurisdiction, should be equipped with interlocking apparatus for the proper working of switches and signals.

Conformably with the first of these conclusions, Mr. Charles E. Pugh, General Agent of the company at West Philadelphia, was assigned the management of the system, and under his direction all the signal and switch equipment was designed and established. Mr. Pugh's assistant, Mr. W. J. Latta, acted as engineer for the electrical part of the work.

The train runner's office was located at the Centennial station, and it was the headquarters from which emanated all orders relative to the dispatching of trains, or their movements when under way. All the signal towers were in direct telegraphic communication with it, and all switch-houses, either directly or through the medium of the nearest adjacent tower.

The fact that a large portion of this track system would be but temporary made this an excellent opportunity for the trial of different kinds of signal and interlocking apparatus, without committal, on the part of the railroad officials, in favor of either one. The systems which had attracted the most attention were three in number:

I. The Rousseau system of electric signals and indicators.

II. The Toucey-Buchanan manual interlocking apparatus for switch and signal levers.

III. The Burr pneumatic interlocking apparatus, for operating switches and signals by compressed air.

The Rousseau system, in its completeness, is intended to be automatic—that is, signals are blocked and cleared by the action of the train itself, through the means of circuit-closers (placed under the rail), wherein an electrical contact is effected by the depression of the rail as the load passes over.

It was decided not to use the automatic attachment, and the circuits were closed at the will of the operator in the adjacent tower, by means of the ordinary button.

The Rousseau signal consists of a circular flannel target, about 15 inches in diameter, which revolves on a vertical axis, in one direction only, ninety degrees at a time. When this target stands in a plane at right angles to the track it is said to be at "block." When it stands in a plane parallel to the tracks it is said to be at "clear." Just below the target, the vertical spindle carries four arms, the outer ends of which in turn engage a stop-catch, which limits the motion at one time to ninety degrees. This catch is withdrawn by an electro-magnet directly below it, the armature having a vertical motion. It must be distinctly understood that the rotatory movement of the target is not accomplished by electric force. The function of the electric current is merely to withdraw the stop-catch. The rotation of the target is caused by a weight suspended within the signal post, and so connected (by a cord and small bevel gears) to the vertical spindle of the target as to tend to revolve it, always in one direction.

The arrangement of the circuits is thus: A battery wire is led direct to the electro-magnet of the signal. After leaving the coil it branches; the two branch wires then connect with spring circuit-closers on the vertical spindle of the revolving signal, the connection being made complete for each wire in turn, according to the position of the signal banner. The two wires are led back to the signal station, and each connected with a button circuit-closer, the two having a ground wire in common. These buttons are marked "block" and "clear," or else colored red and white. It is evident that by punching them alternately the signal may be made to revolve by quadrants consecutively.

To work an indicator (fig. 2) automatically from the signal, a fourth and fifth wire are required between signal and tower, where the indicator is placed. A short battery wire is led to the electro-magnet of the indicator, and after passing through the coil is thrown, automatically by the motion of the indicator hammer, into alternate connection with the wires already spoken of as fourth and fifth. At the signal, these same wires are in turn thrown into connection with a common ground wire. The signal and indicator both being at "block," say, the circuit would be complete over one of these wires, except at the signal itself, where an open circuit-closer interrupts its continuity. If, however, the signal be turned to "clear," the circuit over the one indicator wire is completed, and the hammer records the movement of the signal by itself jumping to the 'clear" side, and striking the gong there placed, thus effecting both audible add visible indications. The connection from the battery is now over the other indicator wire, which in turn has a break at the signal, only to be closed by a further revolution of the target.

The general appearance of the Rousseau signal, as mounted on its post complete, is as shown in fig. 1. The indicator is represented in fig. 2. The use of this instrument is not limited to its relation to the signal as an indicator or repeater of its movements, but it is available for other purposes. In the general signal system here described, it was in many cases worked independently, to notify an operator of the approach of a train toward his station.

The second of the systems which had come to the notice of the railroad officials, viz., the Toucey-Buchanan manual interlocking system, was already in operation at Spuyten Duyvel junction and the Fifty-second street crossing of the Hudson River Railroad. Its construction and working were copiously explained and illustrated in the *Railroad Gazette* of Oct. 16, 1875 (page 424). Hestonville crossing, Thirty-sixth street junction, and the entrance to the Centennial Circle at Belmont were decided upon as the points to be equipped with these interlocking levers. The signals used in connection with these interlocking levers were of the semaphore type, and of a general elevation similar to that given in fig. 3.

The third of the systems above alluded to, viz.: the Burr pneumatic interlocking apparatus, was of very recent origin and conception, and when presented to Mr. Pugh for consideration, was in an extremely crude state. The determination to give it a trial was therefore based solely on the possibilities of the development of the system. As first put in place it was a failure; but after some of the parts were re-designed it was established in good working order, and was in service from July to the close of the Centennial Exhibition. The mechanism of the system will be alluded to in detail later.

As the patentees of the system had not presented any particular form of signal, but had only made provision for giving it a vertical motion of twenty-four inches, whatever its type might be, a modification of the Pennsylvania Railroad standard block signal box was made use of, and the general appearance of the modified signal was as in fig. 4.

The junction and crossing at Mantua were selected as the best point for the trial of this pneumatic apparatus.

On the general plan are located and mapped all the signals of the various systems. They are denoted by solid black square dots, with arrows adjoining. The direction in which the arrow points is the same with the direction of motion of trains governed by the signal to which the arrow is adjacent. For convenience of reference the signals are numbered consecutively from east to west. The Roman letter which is suffixed to the number in every case refers to the form of the signal, "E" meaning "electric" (as in fig. 1), "S" meaning "semaphore" (as in fig. 3) and "B" meaning "box" (fig. 4).

A complete index of these signals is subjoined. An explicit statement of the functions of each will enable the reader better to comprehend the relations which maintain between them. This is given on the plate with the plan.

At Thirty-sixth street, Mantua, and Belmont tower, where the interlocking systems were used, certain switches were in the combinations, being operated, locked and unlocked by the operator in the tower through the medium of the usual lever and rod connections.

The switches so operated are marked on the plan as follows:

At Thirty-sixth street	D, E, F, G.
" Mantua Tower	H, I, J, K.
" Belmont Tower	L, M, N, O, P, Q.

All other switches were worked by switchmen, by means of the ground-lever or harp-stand arrangements. As will be seen further on, these switchmen were in most cases in some sort of telegraphic communication with an adjacent tower or office, from which they received instructions.

The Rousseau indicators were an important element in the general equipment, and their locations and connections are worthy of special tabulation. It has already been stated that they were not in every case worked automatically by a signal, as a repeater of its movements, but in many instances independently, as will be seen by the table headed "Enumeration of Rousseau Indicators," printed on the plan.

(TO BE CONTINUED.)

ANNUAL REPORTS.

Pittsburgh, Fort Wayne & Chicago.

This company owns a line from Pittsburgh to Chicago, 468.39 miles, and it leases the New Castle & Beaver Valley road, from Homewood, Pa., to New Castle, 14.9 miles, and the Lawrence road, from Lawrence Junction, Pa., to Youngstown, O., 22.04 miles; the earnings of these lines are not included. Its track is used by the trains of the Cleveland & Pittsburgh road from Pittsburgh to Rochester, 26 miles. The whole property is leased to and worked by the Pennsylvania Company. The following is from the report for the year ending Dec. 31, 1876, presented by President G. W. Cass at the annual meeting last week:

The earnings of the road for the year were:

	1876.	1875.	Inc. or Dec.	P. c.
Freight	$5,266,172 18	$5,430,510 69	Dec.. $164,338 51	3.0
Passengers	2,215,135 88	2,024,438 29	Inc.. 190,697 59	9.4
Express	149,301 00	290,151 00	Dec.. 42,373 53	14.6
Mails	98,477 47			
Rents	100,365 45	118,564 30	Inc.. 6,198 08	5.2
Miscellaneous	24,396 93			
Total	$7,853,848 91	$7,863,664 28	Dec.. $9,815 37	0.1
Expenses	4,787,161 37	4,602,091 66	Inc.. 185,069 71	4.0
Net earnings	$3,066,687 54	$3,261,572 62	Dec.. $194,885 08	6.0
Gross earn. per mile	16,767 75	16,789 00	Dec.. 21 25	0.1
Net earn. per mile	6,547 29	6,963 00	Dec.. 415 71	6.0
Per cent. of exps.	60.95	58.52	Inc.. 2.43	4.2

This shows a better result than was expected from the long duration of the war between the trunk lines. The increase of expenses is due to the greater volume of traffic carried at unremunerative rates.

The report says: "During the year there was expended for repairs, renewals and replacements $1,882,537.94. This is less by $48,906.22 than was expended the previous year for like purposes. The amount reported by the lessee as expended for improvements and additions, which, according to article XVI. of the lease, is to be represented by an issue of guaranteed special stock, was $400,472.01. This is $166,523.75 more than was expended last year for like purposes, the increase being in steel rails and passenger equipment required for the Centennial travel. The items as given above have not been approved in form or for the objects stated by your board of directors; but the expenditures claimed to have been made under article XVI. of the lease by the lessee up to Dec. 31 last have been thoroughly examined and approved to the extent found correct, as stated hereafter."

The net result to the lessee is stated as follows:

Net earnings		$3,066,687 54
Profits of New Castle & Beaver Valley road		51,410 81
" " Lawrence road		17,845 55
Total		$3,135,943 90
Amount paid Cleveland & Pittsburgh of joint earnings	$201,989 05	
Tax on capital stock	16,321 42	
		218,310 47
Net balance		$2,917,633 43
Fixed charges by terms of lease		2,796,882 50
Profit to lessee		$120,750 93

The report says: "This amount is inclusive of $104,100 paid to the company's sinking fund. From July 1, 1869, to Dec. 31, 1875, a period of 6½ years, the profits of the lessee in operating your railway have exceeded $6,000,000, and the incidental advantages growing out of the lease have continued to increase the business and revenues of the road and of the lessee to an extent that cannot be stated in figures. A full settlement has been made of all expenditures claimed to have been made by the lessee under the provisions of article XV. of the lease, up to Dec. 31, 1876, and the objects and amounts for which such expenditures were made will be found attached to this report. The aggregate amount thus expended since July 1, 1869, is $5,504,327.27, or about $725,000 a year. The amount of guaranteed special stock issued to the lessee on account of this expenditure is $5,073,000, leaving yet to issue in full payment $431,327.27. The lessee has made, with exact punctuality, all the payments during the year which were required by the terms of the lease. * * * *

"The whole amount of bonds purchased for and now in the sinking fund is: First-mortgage bonds, $835,500; second, $915,000; total, $1,750,500. To this add cash on hand, $212,189.01; total of sinking fund, Dec. 31, 1876, $1,962,689.01. The high price at which these bonds are now held makes their purchase slow and difficult, and, what is still more objectionable, is that a large percentage of the sinking fund is absorbed in the payment of a premium on the bonds, instead of being applied on the principal. It is suggested to the bondholders that the question of a modification of the provision of the mortgage on this point is worthy of consideration.

"The annual report of the Consulting Engineer on the material condition of your road and property is also appended. Excepting certain of the original station-houses, all of the property is in good condition, and no false economy has been adopted by the lessee to obtain or retain money by allowing the property to deteriorate for want of repairs.

"Slow progress has been made during the year in adjusting the claims against the company. The swage-block case has recently been decided in the Supreme Court of the United States against the company. If a re-hearing cannot be had, judgment will be taken, and provision must very soon be made to pay it. The payment of this judgment and other payments made during the year will reduce the assets on hand at the date of the last report to about $250,000 at their cash value. All the claims except that of Sayles, assignee of the Tanner brake patent, can be settled for not over $50,000. No reasonable conjecture can be formed as to the result of the suit for the use of the Tanner brake.

"The account of the Treasurer, showing the receipts and disbursements of the fund for maintaining the organization of the company, as also his general account of receipts and disbursements for the year, are submitted herewith. As stated in the last annual report, $973,000 of guaranteed special stock were issued to the lessee after the close of that fiscal year (1875); the whole amount of the share capital issued to the close of the year 1876 is $24,787,285.71 ($52,920 per mile owned)."

Indianapolis, Cincinnati & Lafayette.

This company owns a line from Lafayette, Ind., southeast through Indianapolis to Cincinnati, 179 miles, with a branch from Greensburg, Ind., south 5½ miles to some large stone quarries, making 184½ miles in all. The road from Cincinnati to the Indiana line, 20½ miles, is owned by the Cincinnati & Indiana Company, all of whose stock, however, is held by this company. The road is now in the hands of Mr. M. E. Ingalls as Receiver, and his last report covers five months from his appointment as Receiver, Aug. 1 to Dec. 31, 1876, with supplementary statements including the entire year.

The liabilities of the company were as follows at the time of the Receiver's appointment:

Common stock	$5,587,150 00
Preferred stock	1,419,300 00
Cincinnati & Indiana stock outstanding	18,000 00
Total stock ($38,073 per mile)	$7,024,450 00
Bonded debt ($48,739) per mile)	8,992,300 00
Pay-rolls, bills payable and loans	716,782 21
Unpaid coupons and interest on same	582,894 54
Total ($93,856 per mile)	$17,316,426 75

The company has a very heavy capital account, the interest charge on the bonded debt alone being nearly $3,500 per mile. It was once before in the hands of a receiver, but was reorganized without foreclosure, the bondholders funding their coupons.

The earnings for the five months of the receivership were:

Gross earnings ($3,309 per mile)	$610,526 01
Expenses (50 36 per cent.)	307,490 60
Net earnings ($1,642 per mile)	$303,035 41

The train mileage for the five months was:

	Passenger.	Freight.	Total.
Train mileage	204,946	194,000	398,946
Receipts per train mile	$1 36	$1 65	......
Receipt per passenger or ton mile	2.60 cts.	1.65 cts.	......

The statement of earnings for the year ending Dec. 31 is as follows:

	1876.	1875.	Inc. or Dec.	P.c.
Passengers	$542,897 73	$639,668 74	Dec. $96,771 01	15.1
Freight	796,346 46	923,657 20	Dec. 127,310 74	13.8
Express and mails	69,852 08	75,874 53	Dec. 6,022 45	7.9
Rents and miscellaneous	52,162 65	52,947 78	Dec. 785 13	1 5
Total	$1,461,258 92	$1,692,148 25	Dec. $230,889 33	13.6
Expenses	761,247 85	1,036,228 03	Dec. 274,980 18	26 5
Net earnings	$700,011 07	$655,920 22	Inc. $44,090 85	6.7
Gross earn. pr mile	7,920 10	9,453 34	Dec. 1,533 24	16.2
Net " "	3,794 10	3,664 36	Inc. 129 74	3.5
Per ct. of expenses.	52.10	61.24	Dec. 9.14	14.9

The falling off in receipts came partly from the general depression of business, partly from short crops along the line, but chiefly from the extremely low rates on through business which diverted both freight and passenger traffic to other lines, besides diminishing the earnings on what was left. The Receiver was left in many instances the alternative of losing business altogether or of carrying at a loss, and has taken only such through freight as could be hauled in cars which would otherwise have gone empty.

The expenses were reduced by strict economy: 11½ miles of track were renewed with steel, one mile with iron, 29,324 new ties were laid and 10 miles of road ballasted.

Since the Receiver's appointment he has paid off the back pay-rolls (four months), and paid current interest on $1,996,000 Cincinnati & Indiana bonds and the $1,600,000 Indianapolis, Cincinnati & Lafayette bonds of 1858. The holders of $1,000,000 Cincinnati & Indiana bonds due Jan. 1, 1877, have agreed to extend them 15 years. He recommends that he be authorized to pay interest on $423,000 equipment bonds and also some $90,000 coupons on the bonds of 1867, which became due in 1874 and 1875, but were not collected when other bondholders were paid. After this amount is settled, he believes the coupons on the bonds of 1867 can be paid as they mature.

The Cincinnati & Martinsville road having been reorganized, business over it has been resumed, and it is a valuable feeder.

Cleveland, Tuscarawas Valley & Wheeling.

This road extends from Lake Erie at Black River, O., south by east to Uhrichsville on the Pittsburgh, Cincinnati & St Louis, 101.14 miles. At the close of the last fiscal year, Dec. 31, 1876, the capital account was:

Stock ($10,441 per mile)		$1,055,950
First mortgage bonds	$2,180,000	
Second-mortgage bonds	988,921	
Total bonds ($31,332 per mile)		3,168,921
Total ($41,773 per mile)		$4,224,871

The stockholders have authorized an increase of the stock to $3,000,000 and the execution of a consolidated mortgage for $2,000,000 to replace the present second mortgage. These additions to capital are for the purpose of building the proposed extension from Uhrichsville to Wheeling, about 40 miles.

The road was formerly the Lake Shore & Tuscarawas Valley, and was sold under foreclosure in 1874 and the present company organized, taking possession of the property Feb. 1, 1875.

The earnings for the year were:

	1876.	1875.	Inc. or Dec.	P. c.
Freight	$318,858 35	$329,475 30	Dec.. 10,616 95	3.2
Passengers	77,643 43	78,110 11	Dec.. 466 68	0 6
Express, mail, etc	7,716 24	7,175 77	Inc.. 540 47	7.5
Total	$404,218 02	$414,761 18	Dec. $10,543 16	2.5
Expenses	277,968 44	219,841 07	Inc.. 58,127 37	26.4
Net earnings	$126,249 58	$194,920 11	Dec. $68,670 53	35.2
Gross earn. per mile	3,996 62	4,101 00	Dec.. 104 38	2.5
Net " "	1,248 26	1,927 00	Dec.. 678 74	35.2
Per cent. of expenses	68.77	53.00	Inc.. 15.77	29.7

The net results of the working under the present company from Feb. 1, 1875, to Dec. 31, 1876, were:

Net earnings		$321,169 69
Interest on bonds	$294,705 90	
Interest, exchange, etc	24,122 79	
		318,828 69
Surplus		$2,341 00

The road is chiefly a coal road and has suffered from the depression in the iron and coal interests of the country which it

RAILROAD GAZETTE

FRIDAY, JUNE 1, 1877.

Contributions.

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BY R. H. SOULE.

[Continued from page 230.]

Of the thirty-four indicators enumerated, it will be noted that twenty-two worked on the automatic plan, as repeaters of the movements of adjacent signals, while twelve were worked independently by the operators, with ordinary button circuit-closers.

The latter arrangement may be adopted from either of three reasons: First, because the electric circuits may in some cases be thereby simplified and shortened; second, because there are emergencies in which it is desirable to work an indicator without operating the signal to which it would otherwise presumptively be connected; and third, because the indicator is sometimes used merely as a notification that a block is occupied.

A third principal feature in the general equipment was the bell wires, and the arbitrary code of signals between operators and switchmen through their means. The bell wires were established from two principal reasons: First, to afford electric communication where the use of the Morse telegraph was impracticable; second, to provide a means of reporting trains independent of the main wires, where contention for circuit would have caused provoking delays. (Inasmuch as the blocks are very short between Hestonville and the city, the utmost promptness is requisite in making such reports). The bell wires were as follows:

TABLE OF BELL WIRES.

1. Between tunnel switch house and Bridge street switch house, 2 gongs.
2. Between depot tower and Bridge street switch house, 2 gongs.
3. Between depot tower and Thirty-sixth street tower, *via* Thirty-third street switch house, 3 gongs.
4. Between "3" office (New York Division) and Thirty-sixth street tower, 2 gongs.
5. Between "3" office (New York Division) and Mantua tower, 2 gongs.
6. Between Train Master's office and Centennial switch house, 2 gongs.

Wire No. 1 enables the switchmen to come to mutual understandings as to the passage of trains over the single track between their posts, a code of bell-tap questions and answers having been established for that purpose. By referring back to the table of signals, it will be noticed that 1 E and 7 E are cleared, each from the place where the other is located, so that there must be co-operation between both switchmen to allow of the passage of any train whatever.

Wire No. 2 puts the Bridge street switchman in communication with the operator at depot tower, from which place he must obtain permission to pass any train or engine on to the main out-bound track.

Wire No. 3 is for the benefit of switchmen at depot tower, Thirty-third street and Thirty-sixth street. It is operated on only from its terminal points, but the gong at Thirty-third street switch house enables the operator at that place to know what trains are coming in either direction. When a train is about to pass out from West Philadelphia it is very important that the operator at Thirty-sixth street should know it in ample time to get his crossing clear of freights, and set his switches conformably with the destination of the train in question, as three different routes may be taken from that point. On the other hand, it is equally important that the depot switchmen and yard crews should know when a train is about to arrive, and where from, as the latter fact decides on what track it shall unload its passengers. Again, as many inbound trains did not come into the West Philadelphia depot at all, but passed on to Market street, or to some southern destination, the provision of a gong at Thirty-third street gave the switchman at that point sufficiently early notification to enable him to cross the train out on to the track marked "Market street trains" or "southern trains." Hence the establishment between these signal stations of a code of bell-tap signals which gives information as to the whither and the whence of all trains passing in either direction. Whenever a train is about to arrive at the West Philadelphia depot, the operator at depot tower, on the receipt of his bell-tap signal from Thirty-sixth street, repeats it on a mammoth gong outside the tower, thus giving all hands a timely notification of the fact.

Wire No. 4 was worked between "3" office and Thirty-sixth street to notify operators of the approach of trains from one tower towards the other.

Wire No. 5 furnished the same facilities of bell-tap communication between "3" office and Mantua tower.

Wire No. 6 was solely for the purpose of instructing the switchman at the Centennial switch house as to the destination of departing trains, so that switches might be set accordingly.

Among some of the Rousseau signals, electrical "interlocking" was performed. The object arrived at, in each case, was to effect such an arrangement of the circuits that it should not be possible for the two signals to show "clear" at the same time. This was the only limitation, as it was frequently necessary either that both should stand at "block" or one at "block" and the other at "clear." The following are some of the cases of this electrical interlocking:

Signals 1 E and 7 E were interlocked, because they each gave admission to the piece of single track between them.

Signals 3 E and 4 E were interlocked to preclude the possibility of collision between inbound trains and trains or engines backing out of inbound side of depot.

Signals 5 E and 6 E were interlocked because they governed trains on two adjacent tracks which converged into one at the Bridge street switches.

At Thirty-sixth street, Mantua and Belmont towers, which were equipped with apparatus for moving both the switches and signals adjacent, interlocking of the manipulating levers was accomplished by mechanical devices, and carried out to the fullest possible degree of its development. This mutual interlocking of the operating levers, when properly designed and adjusted, guarantees the following important desiderata:

1st. The impossibility of giving to any train a signal to advance, until the route implied by that signal has been perfected by setting the switches conformably with it.

2d. The impossibility of altering the setting of any of these switches over which the approaching train has to pass, after and while the safety signal has been given.

3d. The impossibility of preparing routes and giving safety signals simultaneously to trains which would conflict with one another if allowed to advance at the same time.

By the use of interlocking apparatus which fulfills these requirements, practically infallible mechanism is made to do the work of fallible human judgment; while, moreover, the concentration of the apparatus (which is essential to the accomplishment of the interlocking) enables one person to assume the formerly distinct and diverse duties of switchman, signalman and telegraph operator.

Perhaps the best way to obtain an idea of the consecutive regulations of the signals, etc., which have been enumerated and described, would be to take the case of a single train, traversing nearly the whole extent of the system, and record the duties of each signalman or switchman as the train progresses.

Let us suppose a train about to leave the Centennial for Baltimore *via* the tunnel under Market street. Suppose it to be standing on track C in front of the station.

The Train-Master, when ready to dispatch the train, clears the signal 36 E. (The normal condition of signals 34 E, 35 E and 36 E is at "block.") This signal having an indicator (No. 34) in the adjacent switch house, the switchman is therefore at

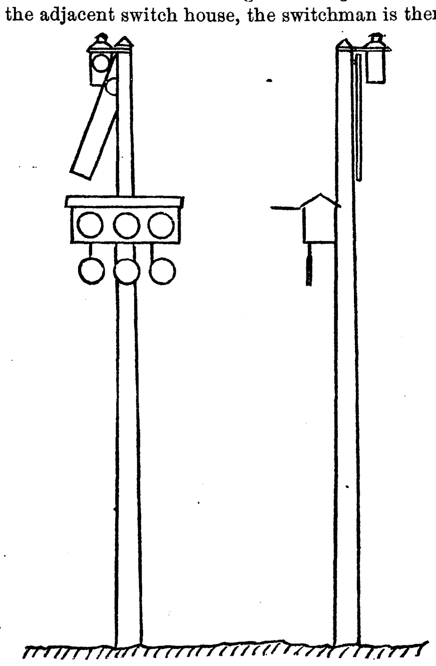


Fig. 5

the same time notified of the fact that a train is about to start out from track C, and he awaits instructions from the Train-Master as to its destination. These instructions the Train-Master gives, immediately after having cleared the signal, through bell wire No. 6, and the switchman has ample time to set his switches accordingly.

The Train-Master then, by telegraph, calls up all the operators along the path of the train, viz., Belmont tower, Mantua tower, Thirty-sixth street tower, Thirty-third street switch house, and depot tower, and notifies them of the departure of a train for Baltimore.

In this notification, the answer to the telegraphic call was not waited for, but the message was proceeded with as soon as all the offices had been enumerated in the call. This arrangement obviated delay and kept the operators on the alert.

Belmont tower, in preparation for the train, lowers his semaphore signal 29 S; the interlocking mechanism requiring, however, that signals 30 S and 31 S should first be at "block." For this train no switches would have to be operated. When the last car of the train has fairly passed the tower, the operator blocks indicators 26 and 22, the one being in his own tower, the other at Mantua tower, and both being marked "Belmont E bound." He thus at once provides himself with a visible reminder of the fact of the block being occupied, and also warns Mantua tower of the approach of a train.

Mantua tower, before he can give the requisite safety signal at 26 B and 27 B (home and distance signals), must block off all trains at 21 B, 22 B and 23 B, and set switches I and H for the crossing, all this being demanded by the arrangement of the interlocking cams. When the train has passed his tower he clears the two indicators 26 and 22 which Belmont tower had previously blocked, and notifies Thirty-sixth street (by Morse instrument) of the approach of the train. He is then at liberty to reset his switches and signals to their normal positions.

Thirty-sixth street tower has had two notifications of the approach of this train, and is probably in readiness for it. Having cleared the crossing of freights (which are numerous in this vicinity), he has moved switches D, E and G from their normal positions to complete the path of this train, and then lowered the semaphore signal 16 S to indicate "all right." The interlocking mechanism in this case demands that 13 S, 14 S, 15 S, 17 S, 18 S and 20 S should first be at "block," before the switches can be set for this train.

As the train approaches the tower, the operator signals to Thirty-third street and depot tower, by bell wire No. 3, the approach of a train from the Centennial bound south through the tunnel. As the train passes the tower Thirty-sixth street blocks indicators No. 20. "E. bound Thirty-third street," and No. 14 "E. bound Thirty-sixth street;" the first in his own tower as a reminder that the block is occupied, and the second at Thirty-third street as a notification that the train has actually entered the block and is approaching that station.

At Thirty-third street, the switchman and operator having been notified accordingly by bell tap, the train finds the switches set for crossing out on to the track marked "For Southern Trains." The signals 9 E. and 10 E. are in this case left standing at red and green, as they apply only to trains going directly in to the West Philadelphia passenger station. When the train has passed, Thirty-third street clears indicators 20 and 14 previously blocked by Thirty-sixth street.

The Bridge street switchman receives his instructions from depot tower by bell wire No. 2, immediately after the train passes Thirty-sixth street, it being remembered that both Thirty-third street and depot tower were notified at that time by bell wire No. 3. The Bridge street man, in turn, after receiving and answering his instructions from depot tower, communicates with the tunnel switchman by bell wire No. 1, and asks him to clear his signal (7 E). If no train is about to enter the single track from the opposite direction, the tunnel switchman clears 7 E. as requested, and the train may proceed by the Bridge street block. The Bridge street switchman, as soon as the train has passed him, blocks signal 7 E. behind it. Indicator No. 3 (marked "Bridge street,") at the tunnel switch house, being worked automatically by signal 7 E, notifies the occupant of the switch house that his train is near at hand, and he sets his switches conformably.

After passing him the train goes through the tunnel on to the Junction Railroad.

Although the junctions and crossings were so very near to one another, yet the entire signal system was so fully elaborated, and such ample notification always given of the approach of trains, that stoppages never occurred from causes other than legitimate ones.

Safety to passengers being of paramount importance, all the signals were worked on the absolute block principle, and therefore some detention necessarily and properly occurred at the junctions of converging lines, in the case of the nearly simultaneous arrival of two trains.

There are certain points in the equipment which have not yet been touched upon, and some of these will best be shown by supposing the case of a train moving in the opposite direction from that already considered. Let us then briefly outline the course of a train coming from some point south of Philadelphia to the Centennial. The tunnel switchman knows of its approach when it is yet half a mile off, and immediately corresponds with the Bridge street switchman, who, if everything is reported right, clears signal 1 E. Now it will be noted that indicator No. 10 (in depot tower) is worked automatically from this signal 1 E, and the attention of the operator at that point is therefore attracted to the fact that a train is approaching from the south. If the movement of this train will not conflict with those of any others he may be intending to dispatch, he clears signal 6 E (which, it will be remembered, can be cleared only when 5 E stands at "block"), and the train may pass that point unchecked.

As it passes him, the depot tower operator notifies Thirty-third street and Thirty-sixth street (by bell wire No. 3) of its approach and its destination.

Before proceeding further, a point should be noted in regard to switch Z at Bridge street. This switch is on the main out-bound track, and it was deemed necessary that the depot tower operator should know when it was misplaced, and have an audible reminder of the fact. An electric bell of small size was therefore placed in the tower and the circuits so established that this bell would ring continuously when the switch Z was thrown so as to break the main outbound track.

This precaution was adopted from the fear that the Bridge street switchman might carelessly allow some shifting or other engine to come on the main track without first asking (as the rules prescribe) permission from headquarters. In which case, if at night, the depot tower operator, were it not for his switch bell, would have no knowledge of the fact, and might very probably allow some train or engine to proceed out from the depot and cause collision.

Resuming the matter of the progress of the train towards the Centennial, the next point worthy of notice is the signal 12 S, which, as seen from the approaching train, appears as in fig. 5. This is a combined block and route signal, and informs the engineer of a train not only whether he may proceed, but also what route has been prepared for him.

As the junction at Thirty-sixth street is a triple one, it was feared that the operator at that point might, through some mistake of his own, or of the operator at depot tower, send a train up the wrong line. The route signal was therefore devised, and its *modus operandi* is as follows:

A box is attached to the signal post twenty feet from the ground, and provided with three circular openings or bull's-eyes, each about fifteen inches in diameter, and facing the approaching train. At night three white lights are placed in this box, one at each bull's-eye. Two of these bull's-eyes have each a pair of light sheet-iron doors (on the inside of the box), swung on vertical axes. The third and left hand bull's-eye is not provided with them. Rod connections are made from switches D and F in such a manner that these bull's-eye doors shall be closed when the switches are in their normal position, and open when changed from that position. (Switch D normally stands set for main line West; switch F for New York Division.)

Across the whole front of the box and on the *outside*, is a sheet-iron door or "flap" hung on a horizontal axis just above the bull's-eyes. When down, this flap completely obscures all the bull's-eye openings, and it is so connected with the semaphore blade as to be up when that is down, and *vice versa*. Hence at night, if a "block" signal is given at the head of the pole, the lights of the route signal below are not to be seen. But when the semaphore is lowered, and the white light shown at the mast-head, the outside flap of the route signal is raised, and the bull's-eyes uncovered. According to the setting of the switches, either one, two, or three white lights show themselves below. The arrangement is such that one white light denotes "Main Line," two "New York Division," and three "Centennial."

As a *day* route-signal, three white discs bordered with black, are made use of. These depend from the box, directly under the bull's eyes. The left-hand one is permanently attached to the under side of the box, and always faces approaching trains full front. The other two are carried each on a hinge-rod of the bull's-eye door directly above, and are so set as to stand edgewise toward approaching trains when switches D and F are in their normal positions, and to present full face when the switches are thrown into their altered positions. One, two, or three white discs, seen by day, have then the same meaning, as regards route, as one, two, or three white lights when seen by night.

The train proceeding westward, and passing Mantua tower, approaches signal 28 S, to which the engineer looks for permission to enter the circle. Although the train may be passed in on either of three tracks, yet it was not deemed necessary to establish a route signal in combination with 28 S, as in most cases the engineers did not know on which line they were to enter.

After passing signal 28 S, it was impossible for a train to leave the track by reason of a misplaced switch, as beyond that point all facing-point switches were of the "stub" variety, while all trailing points were Lorenz's.

It has already been stated that the Rousseau system is susceptible of entirely automatic operation, but full confidence in its safe working under such conditions not having been established in the minds of the railroad officials, it was not so operated. To give the apparatus a trial, however, two "track instruments" (circuit-closers) were located at the points marked 37 and 38 on the plan (between Belmont tower and Hestonville) and connected with indicator No. 28 in Belmont tower, so as to "block" it when a train passed over 38, and "clear" it when it reached 37. From the time these circuit-closers were located and connected, they never failed to work regularly and promptly, and thenceforward the operator at Hestonville tower was relieved from the duty of reporting to Belmont tower east-bound Centennial trains passing his station.

(TO BE CONTINUED.)

Effect on Track of Inside and Outside Connected Engines.

To the Editor of the Railroad Gazette:

Referring to article in your issue of April 27 in regard to damage to track by "Mogul engine," will some of the readers of the *Gazette* inform us how it is with the use of outside and of inside connected engines? Are not the former harder on the track and do they not "knock" it more out of line than the latter?

H. C. S.

Richards' Train Reflector.

Most people have at times felt that to "have eyes in the back of one's head" would often be a great advantage. Perhaps no class of people, however, have so often occasion to feel this need as locomotive enginemen. The device represented by our engraving is intended to serve the purpose which a duplication of the organs of vision would effect. It consists, as indicated by the engraving, of a mirror attached to the side of a locomotive cab in such a position that the back end of the train is reflected so that the locomotive runner can see its position without turning around, as he must do under ordinary circumstances in order to see "what is going on" behind him. It is claimed that this simple contrivance, will to a great extent prevent rear collisions caused by trains breaking in two; that it will enable the runner to see when a train is approaching from the rear, when and what brakemen apply the brakes when the signal is given for them, what signals are given from any part of the train or ground contiguous, hot boxes or burning cars, or when cars are off the track, when passengers, baggage, mails or express packages are all on or off the train, and the condition of switches when the train has passed or left them. These reflectors are said to be especially advantageous in switching engines.

Mr. Edward S. Richards, No. 158 Franklin street, Chicago, is the patentee and manufacturer.

ANNUAL REPORTS.

Terre Haute & Indianapolis.

This company owns a line from Indianapolis westward to the Illinois line near Terre Haute, 79.70 miles, with 34 miles of coal branches and laterals, and 36.22 miles of sidings. It is equipped with 40 engines; 22 passenger and 13 baggage and express cars; 193 box, 96 stock, 8 lime, 509 coal flat, 119 coal dump, 68 platform and 15 caboose cars; 1 directors,' 1 wreck, 1 crane and 35 platform work cars. The report is for the year ending Nov. 30, 1876.

The company also works under lease the St. Louis, Vandalia & Terre Haute road, from the Illinois line to East St. Louis, 158.3 miles; the annual report of this company we have heretofore given.

The liabilities of the Terre Haute & Indianapolis Company as stated in the general account were, at the close of the year:

Stock ($17,486 per mile)	$1,988,150 00
Bonds ($14,072 per mile)	1,600,000 00
Bills and accounts payable	407,089 87
Coupons and dividends unclaimed	13,805 00
December dividend	99,407 50
Surplus	1,207,583 04
Total ($46,755 per mile)	$5,316,035 41

The company owns $522,900 of its own stock; $476,700 stock and $202,800 bonds of the St. Louis, Vandalia & Terre Haute; $201,270 stocks and bonds of other companies, and has due from the St. Louis, Vandalia & Terre Haute, on account of construction, etc., $110,352.25, and from the joint guarantors of the lease, $144,886.42.

The work done for the year was as follows:

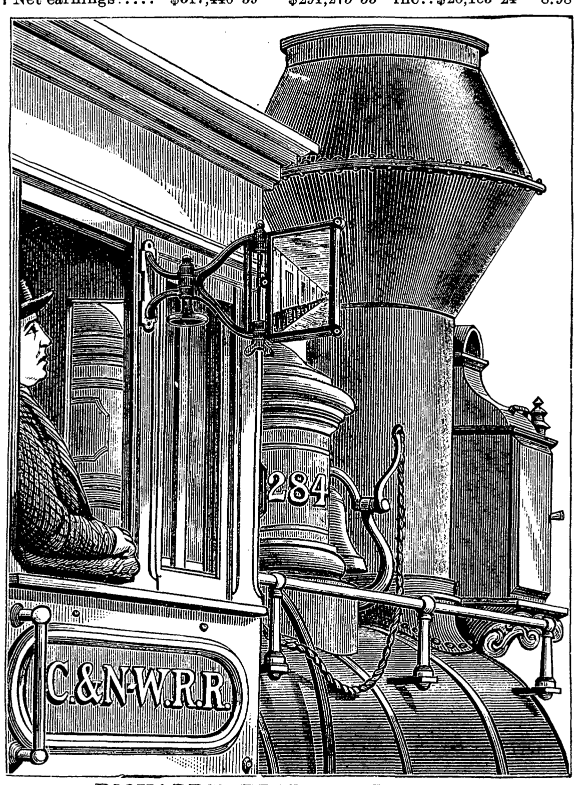
	1875–76.	1874–75.	Inc. or Dec.	P. c.
Passenger train mileage	231,238	211,809	Inc.. 19,429	9.17
Freight " "	649,706	595,624	Inc.. 54,082	9.08
Other " "	18,801	21,706	Dec.. 2,905	13.34
Total	899,745	829,139	Inc.. 70,614	8.52
Passengers carried	244,179	256,675	Dec.. 12,496	4.87
Passenger mileage	10,444,302	10,587,351	Dec.. 143,049	1.36
Tons freight carried	951,213	897,499	Inc.. 53,714	5.98
Tonnage mileage	47,408,031	43,017,606	Inc.. 4,390,425	10.21
Av'ge pass. train load, No.	45.17	49.99	Dec.. 4.82	9.64
Av'ge freig't tr'n load, tons	72.97	72.05	Inc.. 0.92	1.28
Earnings per train mile	$1.18	$1.25	Dec.. $0 07	5.68
Net earn. per train mile	0 36	0 36	....	....
Average receipt per passenger per mile	3.009 cts.	2.019 cts.	Inc.. 0.190 ct.	6.74
Average cost per passenger per mile	1.970 "	1.980 "	Dec.. 0.010 "	0.50
Average receipt per ton per mile, local	3.147 "	2.840 "	Inc.. 0.307 "	10.81
Average receipt per ton per mile, through	0.601 "	0.754 "	Dec.. 0.153 "	20.29
Average receipt per ton per mile, all	1.445 "	1.584 "	Dec.. 0.139 "	8.14
Av'ge cost per ton per mile	1.087 "	1.190 "	Dec.. 0.103 "	8.66

Of the passenger mileage 76.5 per cent. and of the tonnage mileage 66.5 per cent. was of through business. A considerable addition to passenger business was from Centennial travel.

The cost of engine service was $21.99 per 100 miles, a decrease of 6.4 per cent. It is believed that further economy could be secured by improving the Terre Haute shops and by the purchase of three heavy passenger, four freight and two switching engines, and by condemning several of the old light engines.

The earnings for the year were:

	1875–76.	1874–75.	Inc. or Dec.	P. c.
Passengers	$314,325 74	$298,515 89	Inc.. $15,809 85	5.25
Freight	689,858 32	681,487 87	Inc.. 8,370 45	1.23
Express	12,223 03	14,193 79	Dec.. 1,970 76	13.88
Mails	22,043 28	17,372 53	Inc.. 4,670 75	26.88
Total	$1,038,450 37	$1,011,570 08	Inc.. $26,880 29	2.65
Expenses	721,009 78	720,294 73	Inc.. 715 05	0.10
Net earnings	$317,440 59	$291,275 35	Inc.. $26,165 24	8.98
Gross earn'gs per mile	9,133 25	8,896 83	Inc.. 236 42	2.65
Net earnings per mile	2,791 56	2,561 79	Inc.. 229 77	8.98
Per cent. of exps.	69.43	71.21	Dec.. 1.78	2.50



RICHARDS' TRAIN REFLECTOR.

Rates were lower than ever before, in consequence of the contest between the trunk lines. The pooling arrangement on St. Louis business was maintained nearly till the end of the year, but was of little benefit, as rates had to be reduced to meet those from Chicago.

During the year 11.54 miles of steel rails were laid, making 50.18 miles of steel now in use; 35,473 new ties were used. A good deal of work was done on bridges and trestles, and more is needed this year, on account of freshets. The sidings were increased by 9,360 feet, 12,009 feet having been laid and 2,649 feet taken up.

The income account is as follows:

Net earnings		$317,440 59
Pooled earnings received from other roads		3,653 85
Dividends on company's stock		34,860 00
Total		$355,955 44
Interest on bonds, less interest received	$90,405 00	
Dividends (10 per cent.)	188,815 00	
New locomotive	8,280 40	
Real estate and right of way	2,800 00	
Worthless accounts charged off	1,335 71	
Paid Indianapolis & St. Louis Co., on account of pooled earnings	41,844 63	
		343,480 74
Balance		$12,474 70

The net result of the Vandalia lease was as follows:

Gross earnings, Vandalia road		$1,084,125 85
Expenses (76.14 per cent.)		825,435 54
Net earnings		$258,690 31
Pooled earnings received from other roads		19,256 56
Total		$277,946 87
Rent of road	$317,986 00	
Paid Indianapolis & St. Louis on account of pooled earnings	43,429 07	
		361,415 07
Loss on operating road		$83,468 20

The report says: "One-fifth of this loss is borne by your company. If you deduct the amount expended in constructing permanent improvements, and charged to maintenance of way —$38,381.59—it would make the loss $45,086.61.

"It is a pleasure to be able to congratulate you upon the fact that your road has shown itself capable of enduring the worst that disastrous times and ruinously low rates could inflict, and, through them all, of earning and paying 10 per cent. upon its capital, of bettering its condition and adding to its value, without encroaching upon its reserve fund. These results demonstrate that it can safely be relied upon, even under the worst of circumstances, as at least a *ten* per cent. property; and in the face of them we feel sanguine that a maintenance of fair rates through the present year—which we have reason to hope for—will enable us to submit results in every way gratifying, and we hope to be able to present them in the substantial form of increased dividends."

Morris & Essex.

This company owns a main line from Hoboken, N. J., to Phillipsburg, 84 miles, and the Boonton Branch, a loop line from Bergen Junction to Denville, 34 miles; it leases the Newark & Bloomfield road from Roseville to Montclair, 6 miles, and the Chester Railroad, from Dover to Chester, 13 miles, making 137 miles in all, of which 118 miles are owned and 19 leased. The whole property is leased to and worked by the Delaware, Lackawanna & Western Company.

The report to the Comptroller of New Jersey for the year 1876 gives the following statements, comparisons being made with the similar statements for 1875. The capital account was as follows:

Stock ($127,119 per mile)		$15,000,000 00
Funded debt ($162,661 per mile)		19,194,000 00
Total ($289,780 per mile)		$34,194,000 00
Less amount expended on Bergen Tunnel and new lines not yet available	$2,545,210 92	
Less sundry assets	855,871 12	
		3,401,082 04
Balance ($260,957 per mile)		$30,792,917 96

Cost of railroad is given at $18,656,011.64; equipments, etc., $12,136,906.32. During the year the bonded debt increased by $1,082,000; amount expended on Bergen Tunnel, etc., by $1,231,260.93, and the sundry assets were decreased by $464,604.48. Cost of road and equipment was increased by $315,353.55.

The earnings for the year were:

	1876.	1875.	Inc. or Dec.	P.c.
Passengers	$848,703 00	$857,192 55	Dec. $8,489 55	1.0
Freight	772,844 34 }	3,289,762 04	Dec. 886,256 62	26.9
Coal	1,630,661 08 }			
Other sources	200,110 95	193,396 22	Inc. 6,714 73	3.5
Total	$3,452,319 37	$4,340,350 81	Dec. $888,031 44	20.5
Expenses	2,267,595 81	2,967,456 74	Dec. 699,860 93	23 6
Net earnings	$1,184,723 56	$1,372,894 07	Dec. $188,170 51	13.7
Gross earn. pr mile	25,199 41	31,681 39	Dec. 6,481 98	20.5
Net " "	8,647 62	10,021 12	Dec. 1,373 50	13.7
Per ct. of expenses	65.68	68.37	Dec. 2 69	3.9

The rental paid by the lessee is the interest on the bonds and 7 per cent. on the stock. The amount paid is not given, but allowing that the increase of bonded debt ($1,082,000) drew interest for only half the year, the rental was $2,355,710, which would leave a deficit of $1,170,986.44 to be paid by the lessee. The amount of taxes paid in 1876 is not stated; in 1875 it was $102,819.82.

Allegheny Valley.

This company owns and works the following lines:

	Miles.
River Division, Pittsburgh, Pa., to Oil City	132
Plum Creek Branch	7
Low Grade Division, Redbank to Driftwood	110
Sligo Branch, Junction to Sligo	10
Total	259

There are 64.98 miles of company sidings and 13.35 miles of private sidings. The company also owns the Buffalo, Corry & Pittsburgh road, from Corry, Pa., to Brocton, N. Y., 43 miles, which was purchased several years ago at foreclosure sale. The latest report is for the year ending Dec. 31, 1876.

The equipment consists of 17 passenger, 45 freight and 12 shifting engines; 18 first and 13 second class passenger, 5 baggage and 5 baggage and mail cars; 299 box, 1 stock, 133 tub-tank, 296 boiler-tank, 1,134 gondola, 39 coke-rack, 15 bark-rack, 56 stone-flat and 33 caboose cars; 1 officers', 1 pay, 3 tool and 35 dump cars.

The capital account liabilities are as follows:

Stock ($8,365 per mile)		$2,166,500 00
River Division first-mortgage bonds	$1,000	
" " second-mortgage bonds	4,000,000	
Low Grade Div. first-mortgage bonds	10,000,000	
" " " second-mortgage bonds	3 300,000	
Income bonds	5,841,800	
Total funded debt ($89,357 per mile)		23,142,800 00
Bonds and mortgages on real estate	$136,443 97	
Suspended debt, payable in income bonds	453,159 01	
Bills payable, Buf., Corry & Pittsburgh purchases	111,895 22	
Current bills, balances and accounts payable	255,843 53	
Guaranteed coupons, paid and held by Penn. R. R. Co	1,377,145 00	
January and April coupons	410,266 28	
Floating debt ($10,598 per mile		2,744,753 01
Total ($108,317 per mile)		$28,054,053 01

The income bonds are issued to creditors under the composition in bankruptcy made in 1874, and the interest thereon is partly met by a contribution made by the Pennsylvania, the Philadelphia & Erie and the Northern Central companies from their earnings on business coming over this road. The company has $988,028 64 invested in the Pittsburgh, Titusville & Buffalo road, $30,000 in the Brady's Bend Bridge and $496,606.09 in the Buffalo, Corry & Pittsburgh road. The amount of debt less all assets other than road or equipment is $23,341,125.70, or $90,120 per mile. The capital account is very large; the greater part of the liabilities were incurred in the construction of the Low Grade Division and other unprofitable works during a period of extravagant management prior to 1873.

The work done for the year was as follows:

	1876.	1875.	Inc. or Dec.	P.c.
Train mileage, pass	432,361	466,344	Dec.. 33,983	7.3
" " , freight	1,058,182	1,006,755	Inc.. 51,427	5.1
" " , service	114,147	136,122	Dec.. 21,975	16.1
Total	1,604,690	1,609,221	Dec.. 4,531	0.3
Mileage of pass. train cars	1,722,147	1,562,380	Inc.. 159,767	10.2
Mileage of freight cars	17,917,382	16,356,509	Inc.. 1,560,873	9.5
Passengers carried	812,437	698,767	Inc.. 113,670	16.3
Passenger mileage	16,785,768	13,536,643	Inc.. 3,249,125	24.0
Tons freight carried	2,287,274	2,119,219	Inc.. 168,055	7.9
Tonnage mileage	102,551,536	97,042,724	Inc.. 5,508,812	5.8
Av. pass train load, No.	38.82	29.03	Inc.. 9.79	33.8
Av. freight train load, tons	96.91	96.29	Inc.. 0.62	0.6
Earnings per train mile	$1.73	$1.63	Inc.. $0.10	6.1
Net " " "	0.87	0.67	Inc.. 0.20	29.9
Rec't per pass. per mile	3.02 cts.	3.12 cts.	Dec.. 0.10 ct.	3.2
Net " " " "	1.39 "	0.75 "	Inc.. 0.54 "	72.0
Rec't per ton per mile	1.96 "	1.95 "	Inc.. 0.01 "	0.5
Net " " " "	0.99 "	0.82 "	Inc.. 0.17 "	20.7

Of the freight car mileage 44.4 per cent. was of empty cars. The freight carried included 5,437,983 barrels crude oil, 1,032,-

RAILROAD GAZETTE

FRIDAY, JUNE 8, 1877.

Contributions.

Signal Equipment of the Pennsylvania Railroad—Centennial System of Tracks.

BY R. H. SOULE.

(*Concluded from page* 242.)

It remains to speak more in detail of the apparatus in use at Belmont tower. The pneumatic system, as then established, embodied the use of apparatus for effecting the quick movement of switches and signals, by the expansive force of compressed air, and for *repeating* those movements (by indicators) at the point where the system was operated and controlled. The system comprised special apparatus as follows:

I. Apparatus for compressing and storing air.

II. Apparatus for controlling the distribution of the air, for exhibiting certain indication its work has been done; and for *interlocking* the operating levers or handles.

III. Apparatus for effecting (at the will of the operator) the unlocking movement, and locking again, of switch-rails, and for allowing a *return current* which should move the indicator.

IV. Apparatus for moving signals promptly, and allowing a return current, as before.

V. Connections.

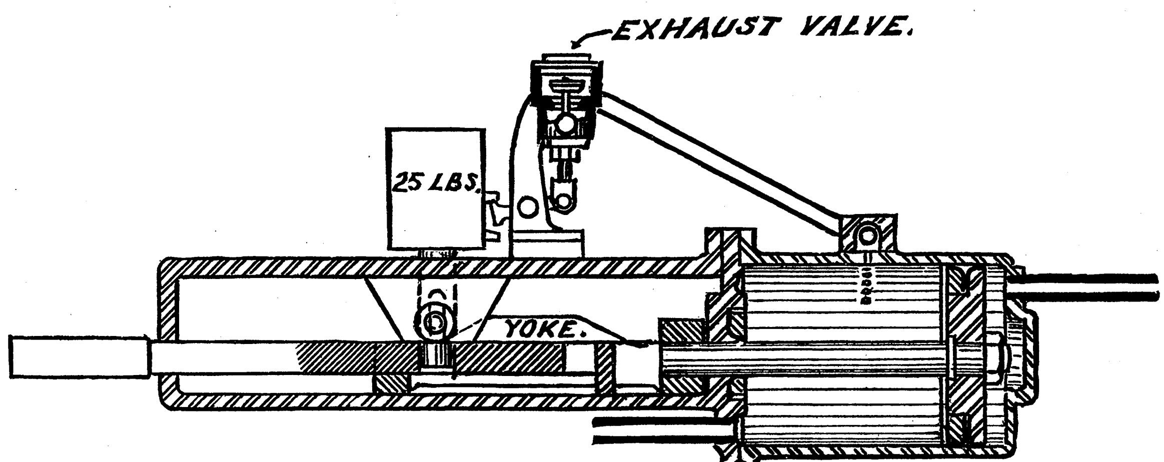


Fig. 6

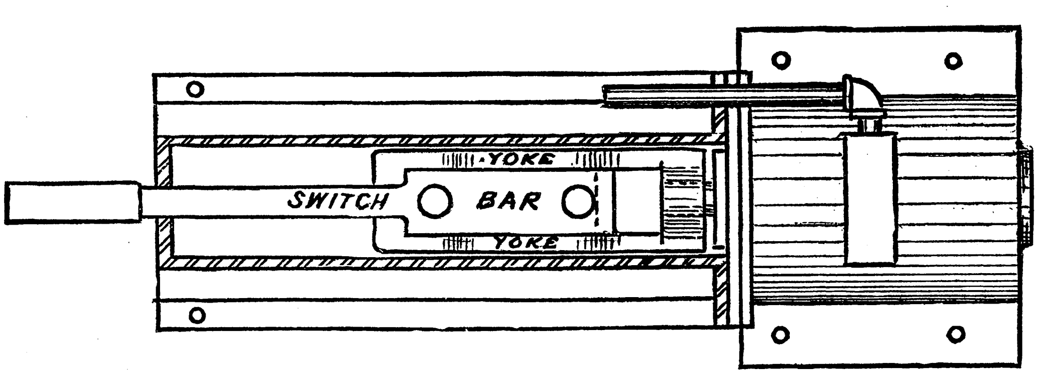


Fig. 7

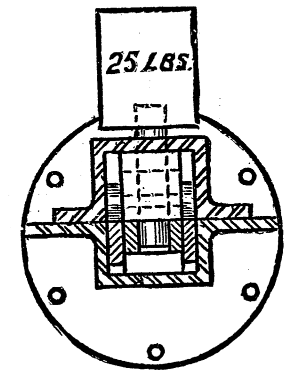


Fig. 8

The apparatus will be briefly described under the above heads.

Apparatus for Compressing and Storing Air.—At Mantua crossing use was made of a Westinghouse air-pump, which took steam from a small vertical tubular boiler. By this pump air was forced into a cylindrical reservoir (30 in. diameter by 20 ft. long), and there stored at as high pressure as could be attained. With the boiler and pump used at Mantua, 60 pounds air pressure in the first storage reservoir was found to be an average maximum.

A second reservoir (24 in. diameter by 12 ft. long) was provided, and received its air supply from reservoir No. 1, by a proper pipe connection. In this connecting-pipe was placed a reducing valve, which acted *automatically*, cutting off the supply of air from No. 2 reservoir when 20 pounds pressure had been attained in it, and instantly feeding in air when the pressure fell below that point again.

It was from this second reservoir, containing air at 20 pounds, that the switch and signal cylinders received their supply as controlled by the operator in the tower.

II. *Apparatus for Distributing, Interlocking, etc.*—The distribution of the air was controlled entirely by the operator in the signal tower. The operating cocks were all in the same horizontal plane, their stems projecting forward through the front of the case which enclosed this portion of the apparatus, and terminating in short lever handles. The pressure main from No. 2 reservoir was led horizontally under the operating case, and from it extended short branch pipes communicating dir ctly with the several air cocks, the further progress of the air being then determined by the position of the ports in the plugs.

Directly above each cock handle was its appropriate indicator. These indicators were colored slides attached to the piston rods of small indicating cylinders, and working close to the face of the case, their changes of position and color being visible through openings, which were made round for signals and square for switches.

The signal indicators changed color from red to white, or green to white, to correspond to the signal which they represented, and the switch indicators from blue to black, when the switches were moved from their nominal to their altered positions.

The interlocking devices were very simple. Each cock stem was provided with a small cam which worked between two fingers depending from a horizontal bar directly above, and the horizontal bar therefore had a longitudinal motion whenever the position of the cock plug was altered. A proper disposition of hooked fingers on these traveling bars, and notched cams on the various cock stems, provided such mutual interlocking action as was essential to the situation.

III. *Apparatus for Unlocking, Moving, and Locking Switches, etc.*—Figs. 6, 7 and 8 are sectional views of the switch cylinder and its appendages. This cylinder is spiked firmly to the ties opposite the head of the switch rails, between which and the "switch bar" (so marked in Figs. 6 and 7) a suitable jointed connection is introduced. This "switch bar" is widened out at the end nearest the cylinder (Fig. 7) and provided with two circular holes, into one or the other of which, at the termination of the stroke, the vertical lock-bolt drops, it being surmounted by a heavy weight (25 lbs., Figs. 6 and 8).

To effect a raising of the lock, preparatory to a movement of the rails, a special device is made use of. A rectangular "yoke" (Fig. 7) is attached to the piston rod, and embraces the widened end of the "switch bar," allowing about $2\frac{1}{2}$ in. lost motion between the two. The *sides* of this yoke are raised, and terminate either way in inclined planes, which, when the piston and yoke move, have the effect of *lifting* the lock, through the medium of the transverse pin and rollers which are attached to it (Figs. 6 and 8).

When the lock is entirely disengaged from the switch bar the yoke has traveled through all its lost motion, and the switch bar and rails begin to move. When fairly over in their new position, the lock drops into the other hole, and the rails are secure.

To rightly understand the course of the air currents during one complete cycle of movements would necessitate reference to diagrams which want of space precludes us from inserting. We will, however, briefly outline the progress of the current from the time the operator turns on the supply. The air rushes through the line of piping to the switch and forces the piston (Fig. 6) towards the lock, and thereby *closes* the exhaust valve; then forces the switch rails over; whereupon, if everything is right, the lock drops into the hole and *opens* the exhaust valve. The supply of air has not yet been cut off, and the current returns, through a second line of pipe (which is lead off from the exhaust valve below the valve seat), to the tower. Here it accumulates pressure behind the piston of a small indicating cylinder (already alluded to) and forces it over, thereby moving the attached indicator slide, and, by means of a cock worked from the piston rod, automatically cutting off the supply of air which has been continuously feeding in from the pressure main. Exhaust vents are, by the same action, opened, and the air confined in pipes and cylinders is allowed to escape. The hand cock, worked by the operator, is six-way and three-ported, while the indicator-cock is six-way and two-ported.

The whole arrangement of cocks and pipes is a very pretty mechanical conception, and possesses the merit of being compact and readily accessible.

To review the action of the air pressure, it will be observed that from the simple turning of a cock handle, the following results ensue:

The switch is unlocked, moved, and locked again; the indicator in the tower has been moved (provided the switch movement and locking were perfect); the air supply has been cut off; the confined air allowed to exhaust; and the whole system of ports, pipes, and passages left in readiness for effecting the reverse motion, at the will of the operator.

Thus it is to be seen that the operations are for the most part automatic.

IV. *Apparatus for Moving Signals, etc.*—a line of piping is led from the hand cock (three-way) in the tower to the cylinder directly under the signals. A second line returns from near the top of the cylinder to the indicator cylinder in the tower. Both cylinders stand vertically, and both signal and indicator banners are loaded so as to drop down to red when relieved from air pressure below. When the operator admits air to the signal cylinder, the piston and signal are raised. Near the end of its up stroke, the piston rod automatically opens a three-way cock so that the air is admitted to the return pipe; and immediately the indicator changes to correspond to the signal.

By reversing the hand cock, the air is exhausted from the signal cylinder, and the signal falls to red. Near the bottom of its stroke, the piston rod automatically reverses the three-way cock, allowing the air, which was confined in the indicator pipe, to exhaust at the signal post, whereupon the indicator itself immediately falls to red.

V. *Connections.*—With the exception of the piping in the engine house, and the air main to the tower, the connections were all $\frac{1}{2}$ in. gas-pipes. There must be two lines of pipes to each switch, and to each signal having an indicator.

Some of the advantages in the use of the pneumatic system are:

First. Economy of space occupied by the apparatus (relatively to any of the manual systems).

Second. Economy of cost of putting in the apparatus.

Third. Economy of time of operation of switches and signals.

Fourth. Concentration of moving parts.

The Thirty-sixth street tower may be taken for illustrating the first point. This tower was made 14 ft. 10 in. × 18 ft. 9 in. to take the apparatus of 16 levers (manual system) which governs the junction at that point. The floor space in the second story is very largely monopolized by the levers, while the room below is divided and cluttered up by the connections which depend from above. A pneumatic apparatus of the same number of levers (16) could have been readily contained in an ordinary standard telegraph tower (12 × 12 ft. octagonal), with nearly as much floor space remaining available in the second story as there now is at Thirty-sixth street, while the lower story would have been wholly free from any encroachment by the apparatus. The relative cost of the two towers is approximately 2 to 1.

The space occupied by the air-compressing apparatus is not here taken into account, it being assumed that it is separately provided for; one set of compressors being adequate to the supply of several adjacent towers.

As to *economy in cost of putting in the apparatus*, it is quite certain that the two lines of piping to each switch and signal, in the pneumatic system, are less costly, when laid ready for service, than the single line in the manual system.

In the latter case it is incumbent to excavate a continuous and carefully-aligned trench of an average cross-section of 200 sq. in.; to make, lay in place, level and align boxing of 55 in. timber section; to provide, place and fasten down shieve-stands every 7 or 8 feet; to provide and sink *oak foundations* every 500 ft. or thereabouts for equalizers, and at every angle for bell cranks; to lay the piping and space the joints so as to clear the shieve-stands.

To reach the same signal or switch by the pneumatic connections, our trench would be about 50 sq. in. section; our boxing about 16 sq. in. timber section, while neither would have to be carefully aligned. The piping could be jointed in full lengths, no cutting being necessary.

There is also economy in placing that portion of the apparatus which is within the tower. The lever frame in the manual system has to be erected complete in the shop where it is built, marked, taken apart and re-erected in place. The pneumatic frame is erected, tested and shipped complete to destination.

The *economy in time of operation* can best be shown by tabulation. The figures below have been obtained by direct observation and experiment.

In comparing the speed of action for the different systems, it should be observed that the figures here given for the manual system (as exemplified at Thirty-sixth street) cannot be improved on; while the speed of action for the pneumatic system is entirely dependent on the air pressure used in working the apparatus: the higher the pressure the quicker the movements. The Mantua system was worked on 20 lbs. pressure.

In determining the best working pressure to be used, a compromise had to be made between economy in time of operation and economy in amount of air pumped and drawn off. At Mantua, 20 lbs. air pressure accomplished a working which was sufficiently prompt for ordinary business. The operator could, however, at his discretion, use any pressure up to about 60 lbs., the limit imposed by the capacity of boiler and pump used at that place.

TABLE OF SWITCH AND SIGNAL MOVEMENTS.

NOTE.—The intervals are all given in seconds, reckoning from turning cock-handle in pneumatic apparatus or depressing treadle in manual apparatus.

SWITCHES.

Pneumatic System (20 lbs. pressure).				Manual System.			
Switch.	Distance from tower along connections.	Rails moved and locked.	Indication complete.	Switch.	Distance from tower along connections.	Rails moved.	Rails moved and locked.
No. 1 (stub)........	90 ft.	1½	3	No. 11 (Lorenz)	215 ft.	....	8
No. 2 "	405 "	3½	7	No. 13 "	200 "	4	....
No. 3 "	445 "	4	8	No. 7 "	340 "	....	8
No. 4 (Lorenz)......	630 "	7	14	No. 6 "	325 "	4	....
All four in quick succession... ...	......	7	14	All four in quick succession.	......	....	18

SIGNALS.

Pneumatic System (20 lbs. pressure).					Manual System.		
Signal.	Dist'nce along connections.	Direction of motion.	Signal moved in.	Indicator moved in.	Signal.	Dist'nce along connections.	Moved either way.
N. Y. Home ..	282 ft.	Up	3	5	No. 1 (Home)	100 ft.	2½
		Down	5	10			
N. Y. Distant.	600 "	Up	5	....	No. 2 (Dist.)	2,000 "	4
		Down	10	....			
"Cen." Home	600 "	Up	6	15	No. 3 (Dist.)	1,050 "	4
		Down	30	40			
"Cen." Dist..	1,135 "	Up	9	45	No. 4 (Home)	593 "	3
		Down	42	60			
"Phil." Home	35 "	Up	¾	1½	No. 5 "	514 "	2½
		Down	2	4			
Frt. Home. ..	66 "	Up	1¾	3½	No. 9 "	280 "	2½
		Down	2	4			
Frt. Home....	356 "	Up	2½	5	No. 14 "	275 "	2½
		Down	6	12			
					No. 15 "	540 "	2½
					No. 16 (Dist.)	2,100 "	4

NOTE.—The New York distant signal (pneumatic system) has no return or indicator pipe.

In observing the figures of *switch movements* (in the preceding tabulation) irrespective of their indications, it will be noticed that the pneumatic system is quicker for all but one switch, and that in two cases out of four the switch is moved, locked and indication complete in the same or less time than when moved and locked *without any indication* by the manual system.

But the most marked difference of time consumed is in the case of combinations involving the movement of *all four switches*. Here 14 seconds suffices, in one system, for the movement, locking and indication of four sets of rails, against 18 seconds, in the other system, for the movement of the same number of switches, two of them only being locked and indication received from none.

In the figures for *signal movements* the pneumatic system seems to suffer. But the home signals all move reasonably quick, two of them sooner than by the levers, one in the same time, one in one second later, while the fifth ("Cen." Home) is tardy in its action from very good reasons. That home signal and its corresponding distant signal receive their air supply from the same pipe; whence the fact that the home signal does not move until nearly the whole length of piping to the distant signal (1,135 feet) has been charged with air at the requisite pressure.

The tardiness of the downward movement of the signals is due to the fact that it does not begin until the pressure in the pipes has fallen off from full boiler pressure to the pressure due to the weight of the piston signal and attached counterpoise; while, again, the indication is retarded in the same manner, until the pressure under the indicator piston is reduced to a similar extent.

An improved arrangement is suggested, whereby the *distant-signals*, when such are used, should be of the Rousseau electric pattern, and be worked by a circuit-closer attached to and operated by the home signal. An electric indicator being placed in the tower, and connected with the distant signal, its striking would be conclusive proof that both home and distant signals had done their work, comformably to the intention of the operator, and the indication would be practically instantaneous.

The *concentration of moving parts*, previously alluded to, is a manifest advantage. In the manual systems the moving parts are principally in the form of connections, ramifying in all directions from the tower, mostly underground, and are liable to serious derangement from various causes. Moreover, these connections are the most vital part of the machine, inasmuch as the relations of movement between the levers and the switches or signals are entirely dependent on their good and perfect condition.

In the pneumatic system the moving parts are concentrated at the terminal points of the connections, where they can be readily reached, oiled and kept in order.

The applicability of the pneumatic system to the movement of *switches* and *semaphore signals* gives it a decided advantage over any electric system which can ever be offered, and its characteristic feature of return indications places it in advance of all manual systems, in that one particular at least.

The effect of extreme cold weather on the air in the pipes can only be conjectured, as the apparatus at Mantua was in operation only during the season of Centennial traffic. Engineers and practical men, who inspected the Mantua apparatus, gave conflicting predictions on this question; and nothing short of a practical test in winter weather will answer it conclusively.

Provided it stands the cold weather test, the pneumatic system promises to be preferable to others for terminal points, yards, etc., where it would be objectionable to erect large buildings for housing levers, and unsightly and inconvenient to clutter the ground with boxing, etc., where concentration of parts would be a desideratum and compressing apparatus could be readily maintained.

At isolated junctions, where but a small number of levers would be needed, and at places remote from populous centres, the manual system will probably be found preferable.

The Translations of Weyrauch.

NEW HAVEN, Conn., May 30, 1877.

TO THE EDITOR OF THE RAILROAD GAZETTE:

I hear from various sources, and in fact it is openly stated in the last number of the *Journal* of the American Society of Civil Engineers, that I am the translator of one of the editions of Weyrauch's "Strength and Determination of Dimensions of Iron and Steel Structures," a review of which you gave in your issue of May 4. As a matter of self-defense I wish to say, through your columns, that I have not translated that work or in any way aided its publication.

Your reviewer mentioned, indeed, both translations, but he omitted to state—and this, I think, is of some importance to readers—that one edition is authorized by the author, while the other is published against his expressed wish. Prof. Weyrauch has produced a book containing clear and concise statements of the general results of experiments on the strength of materials. To examine the original records of experimenters in Germany, England, Sweden and America, to divest them of tedious technical details and place the essence in a compact form, so that the engineering student may in a few hours learn what years of experience and experiment have taught regarding the properties of iron and steel, was not an easy task, but required long and patient labor, which readers—and certainly purchasers—of his book ought to respect. The octavo edition translated by Prof. DuBois was published at his desire, has enjoyed the benefit of his revision, and he receives some pecuniary compensation for every copy sold. The duodecimo edition, with which my name has been connected, is published not only without his consent, but against his wish. It is an axiom that every workman has *some* property right in the product of his labor, yet most American publishers claim that foreign authors have no rights!

But this is not the only difference between the two editions. The translation by Prof. DuBois (xi.+ 210 octavo pages) contains excellent tables for the reduction of metric to English measures besides many reductions in the text, has a lengthy appendix by Prof. Thurston, and preserves carefully Weyrauch's numerous foot-notes containing references to original literature. That of the unknown translator (112 duodecimo pages) has neither reductions nor reduction tables, the references to literature have been entirely disconnected from the text—by which they lose one-half their value—and it contains numerous errors of translation and of printing.

These points, it seems to me, ought to be known.

MANSFIELD MERRIMAN.

MASTER MECHANICS' ASSOCIATION.

Report on Feed-water and Incrustation.

To the American Railway Master Mechanics' Association:

GENTLEMEN: Your committee appointed to report on the "Best Point in the Boiler to introduce Feed-water, and the Cause and Prevention of Incrustation in Boilers," submit the following:

We think the best point in the boiler to introduce feed-water is the usual one on nearly all American locomotives—a point near front flue-sheet, at central line on side of boiler. The injection of feed-water near highly heated plates is undoubtedly injurious to them and liable to cause their rupture, because the surface near which the feed-water enters the boiler loses its heat more rapidly than do the surrounding parts; hence there is an inequality of temperature and consequent unequal strains. At the point of injection designated as the proper one there are no highly heated surfaces for the feed-water to have immediate contact with. Impurities held in solution in water are precipitated by heat, and if feed-water is injected as far as possible from the furnace, it is fair to assume that it will precipitate some of its solid matter before reaching the highly heated plates of the furnace. In recommending that the point of injection be as described, we of course assume that in all cases the lowest water-level is above the central line of boiler. We do not think the feed-water should be injected into the steam-space under any circumstances.

Your committee have not had analysis made of different kinds of water to determine the component parts of the impurities held in solution. This branch of the subject has been fully treated by many able chemists and writers. The practical part is all your committee feel in the least degree able to discuss, and therefore they will confine themselves to the three following branches of the subject of boiler incrustations:

1st. Effect of incrustations on the consumption of fuel.

2d. The effect on life of furnace sheets and outside shells and flues.

3d. Remedies and their cost.

The increase in the consumption of fuel on account of incrustations on the heating surface of boilers varies with the thickness and density of the deposit. When porous, the water will penetrate it, but when hard and compact it presents a complete barrier to the contact of the water with the heating surfaces. As incrustations are poor conductors of heat, an increased consumption of fuel is inevitable when they exist. To determine the percentage of increase in the practical operation of locomotives, your committee present the following table, showing the average miles run to one ton of coal by engines for three months prior to and for three months after the removal of incrustations from the boilers. Your attention is called to the fact that 120 cases are given of engines on the Illinois Central Railroad during the last three years. In many cases the same engine is given two or three times, because during the period stated it was necessary to clean the boilers that often. The general average of the 120 cases cited show an increase of 11 per cent. in the consumption of coal for the three months prior to the boilers being cleaned, as compared with the three months immediately succeeding:

No. of engine.	Date when cleaned.	Average miles run per ton of coal before cleaning.	Average miles run per ton of coal after cleaning.	No. of Engine.	Date when cleaned.	Average miles run per ton of coal before cleaning.	Average miles run per ton of coal after cleaning.
8	Aug., 1875.	41.48	49.74	105	June, 1874.	23.66	28.07
21	Jan., 1876.	27.29	36.82	105	Dec., 1875.	25.23	28.70
23	Oct., 1874.	40.51	37.25	109	July, "	25.21	34.14
23	Aug., 1876.	36.58	33.67	110	May, 1874.	27.79	29 37
26	Jan., 1874.	37.35	33.76	110	Oct., 1875.	26.13	28.39
26	Oct., 1875.	40.02	39.21	128	June, "	35.24	41.34
26	Sept. 1876.	40.10	39.24	132	Oct., "	32.01	35.00
28	April, "	45.80	41.12	135	March, "	30.95	33.89
34	Jan., "	42.26	46.83	137	Jan., "	39.45	42.17
35	July, 1875.	36.42	40.45	138	Sept., 1876.	47.79	45.31
35	" 1876.	37.56	37.59	139	June, 1875.	26.38	29.62
36	Aug., 1874.	42.38	37.36	140	Nov., "	28.69	28.20
37	Jan., 1875.	32.24	39.98	140	Aug., 1876.	34.30	27.26
43	April, "	40.88	49.08	141	Jan., 1875.	29.11	36.62
44	Jan., 1875.	36.87	42.57	142	" "	25.78	31.77
46	Oct., 1874	34.52	40.46	143	March, 1875.	27.67	35.75
47	Feb., 1876.	25.30	51.51	144	" 1874.	27.91	34.09
48	Oct., 1875.	33.88	36.10	146	Jan., "	26.74	34.89
52	July, 1874.	37.85	36.38	147	Aug., "	25.72	30.26
52	Jan., 1876.	43.35	43.35	148	" 1876.	29.21	34.68
57	March, 1874.	39.37	41.35	149	March, 1874.	22.41	31.90
57	June, 1876.	44.77	47 34	152	Dec., 1875.	25.68	34.51
65	Jan., 1875.	35.47	50.55	155	Jan., 1876.	31.33	38.24
69	Nov., 1874.	37.00	38.13	159	Dec, 1874.	29.16	32.36
76	March, 1875.	30.08	38.81	161	June, 1875.	37.06	47.26
76	" 1876.	27.04	23.19	162	Jan., "	37.84	49.31
77	Jan., 1874.	20 33	24.15	165	" 1876.	41.18	46.08
78	Oct., "	35.54	34.82	166	July, "	34.75	40.54
78	July, 1875.	29.82	32.29	167	March, 1875.	33.56	43.10
79	March, 1874.	28.87	27.69	168	" "	28.54	34.25
80	April, 1876.	25.35	44.09	169	Jan., 1874.	22.87	39.62
81	Jan., 1874.	22.88	22.26	169	Nov., 1875.	35.57	28.80
81	" 1875.	27.10	27.97	170	" 1874.	25.97	32.27
82	May, "	29.16	34.78	171	April, 1876.	30.04	35.86
83	Jan., "	23.14	35.74	172	March, 1874.	27.34	29.16
83	June, 1876.	29.81	33.99	172	Aug., 1875.	28 06	26.47
84	" 1874.	24.20	31.44	172	Oct., 1876.	31.96	25.58
84	Feb., 1875.	30.73	45.68	173	Aug., 1875.	31.84	32.83
85	Sept., 1874.	24.71	29.06	174	July, "	31.58	36.41
86	Aug., "	29.43	34.73	174	Feb., 1876.	30.12	29.08
88	May, 1875.	21.42	32.20	174	Nov., "	27.48	22.72
90	" "	33.57	40.62	177	Feb., 1874.	21.98	24.38
91	July, 1874.	22.18	26.72	177	" "	23.60	28.86
91	Dec., 1875.	24.96	25.53	178	" "	29.49	28.78
92	April, 1874.	24.79	29.69	179	March, "	28.20	38.18
92	" 1875.	28.72	26.42	180	July, "	30.26	24.11
92	July, 1876.	30.51	23.79	181	June, 1875.	33.83	36.46
94	June, 1874.	30.06	36.31	183	July, "	33.10	33.93
94	July, 1876.	33.84	29.09	184	March, "	28.15	31.65
97	April, 1875.	25.56	37.47	185	Aug., "	35.78	31.51
97	May, 1876.	36.93	38.87	186	" "	34.90	31.05
98	April, 1874.	24.42	32.81	187	July, 1875.	34.95	35.07
98	Nov., 1875.	30.32	33.03	188	Nov., "	32.68	29.90
99	Sept., 1874.	38.49	38.42	189	Sept., "	34.90	32.07
99	Nov., 1875.	37.86	34.73	191	Aug., 1876.	28.42	28.75
99	June, 1876.	37.29	31.73	193	Sept, 1875.	30.18	29.38
100	May, 1875.	26.30	32.56	194	Aug., "	26.50	29.43
102	Feb., 1874.	20.53	31.45	195	May, "	25.72	30.01
102	March, 1876.	21.05	32 00	196	March, 1876.	24.84	33.98
103	Aug., 1875.	25.67	32.31	197	July, 1875.	26.07	28.90

General average before cleaning, 30.04; after, 34.49 miles.

By examining the table in detail, it will be seen that in some cases engines ran less miles per ton of coal with clean boilers, but in nearly every instance it is due to the difference in the weather. For instance, an engine running during August, September and October with an incrusted boiler, and during December, January and February with a clean one, would give the result stated, because the first three months were warm and the last three cold winter months. We do not wish to deal with individual cases, however, in this branch of the subject, but with the general result obtained from a large number of engines. We feel justified in saying that the average of 120 cases, under all circumstances of weather, etc., may be taken as an index of the practical effect of incrustations on the consumption of fuel.

Mr. Reuben Wells, Master Mechanic of the Jeffersonville, Madison & Indianapolis Railroad, in an interesting letter to your committee, gives the result of his investigations on the effect of incrustations on consumption of fuel. The cases cited are of two passenger and two freight engines on the main line of road. He says:

"The two passenger engines were of the same size and pattern, having cylinders 16×22 in. and drivers 5¼ feet diameter, and were run with the same trains on alternate days. The coal was weighed as put on the tenders, and the engines were run and fired without any reference to a test or trial, and without the men knowing that trials were being made. The results given are from the ordinary, every-day working of the engines, subject to the usual delays, inclement weather, etc., occurring in conducting the business throughout the year. Passenger engines Nos. 10 and 11, referred to, were run during the same time and on the same trains. From the time the boilers were new until the tubes were removed and boilers thoroughly cleaned they had made an average of 100,779 miles each. They then commenced running again comparatively clean, and made an average of 34,047 miles; then in the six succeeding months November to April, inclusive, a further mileage of 20,048 miles, making a total of 54,095 miles since the boilers were cleaned,