Separate Goods Yards.

The general adoption of separate goods yards, away from the main line, and communicating only with it at the ends, is likely to do a great deal in the direction of taking goods traffic out of the way of the passenger traffic. A good example of this improvement, as carried out at Lincoln by the Great Northern Railway Company, is shown in Fig. 146. The lines marked "old main line" were, until June, 1873, the main lines for all traffic. On each side of the main lines were sidings for making up goods trains, with the usual cross-over and through roads, and of course there was a great deal of shunting going on on the main lines. In the early part of the year 1873, new roads were made for the main line outside of the goods sidings, and with a wide space of ground between the sidings and the main line, which will probably be ample for their extension for some time to come. The traffic from the north arrives at A. Passenger trains go along the new lines to the Lincoln station. Goods trains go into the old lines (small dotted) and are there disposed of by the shunting staff: goods trains ready to go south or north are let out by the signalmen, with due reference to the block system of working. Wherever this improvement of confining the goods traffic to a site on one side of the line only is carried out, the main lines are relieved of a great deal of the cross shunting, now a principal source of delay and danger.

Fig. 147 shows a similar arrangement for the accommodation of coal traffic on the Great Eastern railway at Temple Mills near Stratford. Many similar alterations have recently been carried out by the principal railway companies.

Conclusion.

The advantages of the block and interlocking system scarcely require further proof, than the mention, that the chief railways in England have already adopted it on the busiest parts of their lines, from experience of its necessity.

It secures not only a controlled interval of space, but when distant signals sufficiently far off are used, it secures virtually two intervals of controlled space; and in many cases, even if a driver fails to observe one signal, observance of the next would still preserve him from accident.

As points of detail, attention should be directed to:—

Identity of type of signal for trains on their journey.

Identity of type of signal for shunting purposes in station yards.

Identity of meaning of signals, viz., "stop" and "go on."

Identity of arrangement of adjacent signals, the high speed or main line to be the highest signal.

As a rule signals should be placed to "safety" (if the line is clear) before an expected train comes in sight. The practice of keeping signals at "danger" until they are "whistled off" by the drivers is apt to lead drivers to be too venturesome, in running up to signals without sufficiently reducing the speed of their trains.

The protection of all switches, whether facing or trailing, by interlocking apparatus of few parts and simple construction.

The protection of all facing switches by locking bars.

The use of detector bolts to ascertain that the switches are fully set as intended.

Distant signals sufficiently in advance of the point of danger, and, where necessary, furnished with repeaters.

Separate distant signal arms for each home signal.

The use of "stop" and "advance" signals for the relief of station yards, by enabling trains to stand outside the station under protection of signals.

Free use of loop lines to enable fast and slow traffic to clear each other.

Wherever possible, separate goods yards for shunting purposes should be provided.

At remote stations the use of the fixed signals is sometimes omitted altogether; and then when required they are apt to be unobserved.

Also the taking out of locks from the interlocking apparatus at such times as races and fairs should be not only prohibited but prevented.

At places of light work the hours of signalmen should be sufficiently long to make a day's work.

At places of constant work the hours of signalmen should be varied according to the time of day or night, and according to the severity of the traffic.

The usual wages of signalmen vary from 18*s*. to 28*s*. per week, a rate of pay which cannot be said to be out of proportion to the not very highly skilled class of labour required. Any attempt to give an exceptionally high rate of pay to signalmen would be apt to lead to an artificial class forcing their way into the service to its certain disadvantage.

Many of the railway companies give a gratuity every six months to signalmen who have acquitted themselves without fault. This plan seems a good one, as it effectively passes in review the conduct of all from time to time, and so leads to a painstaking service, quite as much for the sake of the credit attaching to success, as for the sake of the pecuniary reward.

On most lines of railway, a book is kept in each signal box, in which is recorded the actual time of passing of each train, with its number and destination, and any remarks which circumstances may require.

Each signal box ought to be visited by an inspector every day, to see that the men and the machinery are in proper order, and it is a good plan for him to record the time of his visit in the train book.

That all intended movements of bodies in such rapid motion as railway trains should be clearly signalled well in advance is now universally allowed. The means of effecting this signalling are now complete, and the checks against accidental mistakes are such as to reduce the effects of error, whether on the part of the person signalling, or on the part of the person signalled to, to a minimum.

Selection of Signalmen.

All men are not constituted by nature for signalmen; consequently much care is requisite in their selection and training. The Metropolitan railway may be taken as an instance, and perhaps as an example. If an applicant is accepted as a candidate, he has first to undergo a drill of two hours per day for three months. After that he has to go on permanent, but not responsible, duty under supervision until he has performed the duty for fourteen clear days without once requiring the assistance of the responsible signalman. He is then appointed to some intermediate signal box, and his wages are raised from the previous rate of 18*s.* per week as a porter, to 22*s.* as a signalman, with a bonus for good conduct equal to 2*s.* per week more. Every signalman is required to know the working of the signal box on each side of him in addition to his own.

Promotion takes place from intermediate or inferior to more important stations, with a constant advance of pay up to 30*s.* per week. It frequently happens, however, that even very good signalmen decline promotion to the highest places where the traffic is incessant, and requires strong nerves and clear heads.

The bonus is paid quarterly in sums of 25*s.* each, conditionally

TABLE 148.—ESTIMATED FIRST COST OF INTERLOCKING AND BLOCK SYSTEM OVER AND ABOVE COST OF SIGNALS.

1. Company.	2. Miles.	3. *Actual Number of Connections in Passenger Lines.	4. Probable total Signal and Point Levers required.	5. Cost per Lever, including Gear and Telegraph.	6. Total Cost of Interlocking and Block.	7. Whole Cost of Railway.	8. Percentage Column 6 of Column 7.	9. Company.
				£.	£.	£.		
L. N. W. Ry. .	1,539	3,132	15,660	25	391,500	71,604,143	·55	L. N. W. Ry.
Per Mile . .		2·04	10·2		255	46,526		*Per Mile.*
G. W. Ry. . .	1,402	2,460	12,300	25	307,500	51,339,713		G. W. Ry.
Per Mile . .		1·75	8·75		219	36,620	·6	*Per Mile.*
N. E. Ry. . .	1,337	2,399	11,995	25	299,875	44,875,111	·66	N. E. Ry.
Per Mile . .		1·8	9·0		225	33,564		*Per Mile.*
Midland Ry. .	1,024	2,099	10,495	25	262,375	45,791,413	·59	Midland Ry.
Per Mile . .		2·05	10·25		256	44,718		*Per Mile.*
G. E. Ry. . .	833	1,587	7,935	25	198,375	32,495,478	·61	G. E. Ry.
Per Mile . .		1·9	9·5		238	39,000		*Per Mile.*
N. B. Ry. . .	831	1,444	7,220	25	180,500	24,164,417	·79	N. B. Ry.
Per Mile . .		1·74	8·7		217	29,080		*Per Mile.*
Caledonian Ry.	797	1,328	6,640	25	166,000	23,195,669	·71	Caledonian Ry.
Per Mile . .		1·6	8·0		200	29,090		*Per Mile.*
G. N. Ry. . .	578	1,166	5,830	25	145,750	21,122,044	·69	G. N. Ry.
Per Mile . .		2·03	10·15		254	36,540		*Per Mile.*
L. and Y. Ry. .	446	1,478	7,390	25	184,750	24,253,849	·76	L. & Y. Ry.
Per Mile . .		3·31	16·55		413	54,380		*Per Mile.*
L. B. & S. C. Ry.	345	593	2,965	25	74,125	20,537,675	·36	L. B. & S. C. Ry.
Per Mile . .		1·43	7·15		179	59,530		*Per Mile.*
M. S. & L. Ry. .	258	758	3,790	25	94,750	18,117,249	·41	M. S. & L. Ry.
Per Mile . .		2·94	14·70		367	70,200		*Per Mile.*
S. E. Ry. . .	327	669	3,345	25	83,625	19,706,107	·43	S. E. Ry.
Per Mile . .		2·05	10·25		256	60,260		*Per Mile.*
Highland Ry. .	335	241	1,205	25	30,125	3,522,060	·85	Highland Ry.
Per Mile . .		·72	3·60		90	10,510		*Per Mile.*
Metropol. Ry. .	7½	40	400	50	20,000	8,359,655	·23	Metropol. Ry.
Per Mile . .		5·3	53·00		2,666	1,114,620		*Per Mile.*
Totals . . .	10,160	19,394	96,970	..	2,439,250	409,084,577	·6	Totals.
Averages per Mile . .	..	1·92	9·6	..	240	40,264	..	*Averages per Mile.*

* The numbers given in Column 3 are the numbers returned by the Companies to the Board of Trade in 1872-73. All other particulars are taken for the same period.

upon no mistake having been made during the quarter. So carefully selected and trained, and so well conducted are the signalmen as a rule, that on the Metropolitan railway, there have not been in ten years more than three instances of failure to obtain the bonus, notwithstanding the strictness of the quarterly investigation.

About one-third of the signalmen on the Metropolitan railway have been sailors. It is found that sailors make excellent signalmen, but soldiers do not.

Cost of the Interlocking and Block System.

It is almost impossible to ascertain what has been the total cost of the interlocking and block system on any given railway, because the work has been done sometimes on revenue account and sometimes on capital account, and is always more or less mixed up with other work.

A fair estimate, however, may be made as follows:—

Cost per Signal Station.

15 levers @ £8	£120
15 sets connections @ £7	105
Signal house	60
Block telegraph instruments and wires	60
	15) 345
Per lever	£23

The cost of complete interlocking apparatus, exclusive of the signals themselves, which would be used in any case, but inclusive of the necessary signal house, and of the block telegraph apparatus, does not exceed £20 per lever on an average, and £25 per lever may be taken as an outside estimate.

The number of levers required is approximately as follows:—

For a level crossing, where one railway crosses another, 8 levers.

For an ordinary junction of double lines 10 levers are required.

For a small station, 10 or 12 levers.

For a medium station, two frames, each with 20 levers.

For an important station and junction combined, perhaps three or four frames, of 20 to 70 levers each, averaging perhaps 40 in each frame.

Some idea of the gross cost of interlocking, as compared with the whole cost of a railway, may be derived from table 148.

Fourteen railways, having a gross mileage of 10,160 miles, have, by the Board of Trade returns (for the year 1873), 19,394 points of

communication with the metals of the passenger lines, either by level crossing or by switches. Now, allowing 3 signals as an average to every such set of switches, there would be a total of 19,394 switch levers, and 58,182 signal levers, together 77,576 levers; and, allowing also an equal number of switches not communicating directly with the main line, but which would have to be connected to the apparatus, the gross total would be 96,970 levers; and this number, divided by 10,160 miles, gives an average of 9·6, or nearly 10 levers per mile. Now 10 levers multiplied by £25 each gives £250 per mile as the cost of interlocking and block telegraph apparatus, equal to about ½ per cent. on the total cost of the railways.

The cost of signal work is generally very much greater per mile on the railways of higher cost, or of larger traffic, such as the Metropolitan or the Charing Cross; but it is a lower proportion of the whole cost of the railway.

Cost of Maintenance and Attendance.

If the average number of levers in each signal-box be taken as 15, and three men be allowed to each box, including inspectors and extra men, this would make one man to every 5 levers. Now 10 levers are, in the last calculation, the complement of a mile of railway; so two signalmen to every mile of railway would be required.

The number of signal stations and the number of men required by this calculation agree almost exactly with the actual facts, as follows:—

On the Great Northern railway from London to Askern there are 109 block-signal stations in 162 miles; and at the rate of three men per station, this would require three hundred and twenty-seven men for 162 miles = 2 men per mile.

On the London and North-Western railway from London to Stafford, 132 miles, there are 88 block-signal stations; and at the rate of three men per station the total number would be two hundred and sixty-four for 132 miles, or exactly two men per mile.

On the one hand some persons argue that the gathering together of switch and signal levers, enables one signalman on the new system to do the duty of several pointsmen on the old. On the other hand some persons are of opinion that all the signalmen are really additional men. A view somewhere between these two is most probably the correct one The following calculation is based on the supposition that half of the whole number of men required would be additional men; that is to say, one additional man per mile of railway.

TABLE 149.—TABLE SHOWING PROBABLE ANNUAL COST OF ADDITIONAL ATTENDANCE AND MAINTENANCE OF INTERLOCKING AND BLOCK SYSTEM.

1. Name of Company.	2. Miles of Line.	3. Levers taken from Table 148.	4. No. of Signal Stations.	5. Men per Signal Station.	6. Total Men.	7. Total Additional Men.	8. Wages, Interest and Maintenance per Man per Annum.	9. Total Additional Cost per Annum.	10. Total Traffic per Annum.	11. Per Cent. Column 9 of Col. 10.	12. Annual Increase of Traffic Receipts.	13. Total Ordinary Capital.	14. Per Cent. Column 9. of Col. 13.	15. Total Capital.	16. Per Cent. Column 9 of Col. 15.	17. Name of Company.
							£.	£.			£.	£.		£.		
L. N. W. Ry.	1,539	15,660	1,044	3	3,132	1,566	100	156,600	8,119,832	1·9	541,177	36,882,269	·42	71,604,143	·22	L. N. W. Ry.
Per Mile						1·02		102	5,276							*Per Mile.*
G. W. Ry.	1,402	12,300	820	3	2,460	1,230	100	123,000	4,984,052	2·5	330,000	13,761,514	·89	51,339,713	·24	G. W. Ry.
Per Mile						0·88		88	3,555							*Per Mile.*
N. E. Ry.	1,337	11,995	800	3	2,400	1,200	100	120,000	5,434,968	2·2	401,337	17,229,933	·72	44,875,111	27	N. E. Ry.
Per Mile						0·9		90	4,065							*Per Mile.*
Midland Ry.	1,024	10,495	700	3	2,100	1,050	100	105,000	5,134,213	2·4	567,162	17,094,307	·61	45,791,413	·23	Midland Ry.
Per Mile						1·02		102	5,014							*Per Mile.*
G. E. Ry.	833	7,935	529	2	1,058	529	100	52,900	2,462,764	2·1	123,577	12,428,926	·42	32,495,478	·16	G. E. Ry.
Per Mile						0·63		95	2,957							*Per Mile.*
N. B. Ry.	831	7,220	481	2·5	1,203	602	100	60,200	1,825,908	3·3	133,341	5,096,430	1 20	24,164,417	·25	N. B. Ry.
Per Mile						0·72		87	2,200							*Per Mile.*
Caledonian Ry.	797	6,640	443	2·5	1,106	553	100	55,300	2,539,405	2·2	216,384	7,976,002	69	23,195,669	·24	Caledonian Ry.
Per Mile						0·7		80	3,187							*Per Mile.*
G. N. Ry.	598	5,830	389	3	1,167	584	100	58,400	2,557,314	2·3	140,937	11,864,537	49	21,122,044	·28	. . Ry.
Per Mile						0·98		101	4,277							*Per Mile.*
L. and Y. Ry.	446	7,390	493	3	1,479	740	100	74,000	3,212,002	2·3	265,788	13,334,594	·55	24,253,849	·30	L. and Y. Ry.
Per Mile						1·7		166	7,202							*Per Mile.*
L. B. & S. C. Ry.	345	2,965	198	2·5	495	248	100	24,800	1,514,195	1·6	112,743	8,191,709	30	20,537,675	·12	L. B. & S. C. Ry.
Per Mile						0·72		71	4,400							*Per Mile.*
M. S. & L. Ry.	258	3,790	253	3	759	380	100	38,000	1,483,824	2·6	130,000	6,233,573	60	18,117,249	·21	M. S. & L. Ry.
Per Mile						1·5		147	5,751							*Per Mile.*
S. E. Ry.	377	3,345	223	3	669	335	100	33,500	1,736,483	1·9	124,633	8,320,095	·40	19,706,101	·17	S. E. Ry.
Per Mile						·9		102	4,600							*Per Mile.*
Highland Ry.	335	1,205	80	2	160	80	100	8,000	283,254	2·8	23,214	1,688,441	·47	3,522,060	·22	Highland Ry.
Per Mile						·24		36	844							*Per Mile.*
Metropol. Ry.	7½	400	25	3	75	..	120	9,000	466,976	1·9	68,595	4,308,370	·21	8,359,655	·11	Metropol. Ry.
Per Mile								1,200	62,263							*Per Mile.*
Total Miles of Line.	10,160	97,145	6,478	..	..	..	..	918,700	41,755,190	2·2	3,178,888	164,419,070	·56	409,084,577	·23	Total Miles of Line.
Per Mile	..	9·3	·64	..	1·8	·9	..	90	4,110	..	313	..	.	..	..	*Per Mile.*
Percentages if cost of half the accidents is taken into account (Page 51).										·8			20		·08	

to face p. 50.

The annual cost of attendance and maintenance, based on the busiest parts of two of the busiest railways, would then stand as follows:—

	Per Annum. £.	s.	d.
Wages of signalman at 24s. per week	60	0	0
Cost of maintenance of apparatus 10 per cent. on £250	25	0	0
Five per cent. interest on first cost	12	10	0
Total .	£97	10	0 per annum per mile as an average cost.

Table 149 gives the probable maximum number of signalmen per mile, the probable additional number, and the cost of wages and maintenance per mile, compared with the gross traffic receipts.

It is observable that the railway which has nearly twice the average need of protection, viz. the Lancashire and Yorkshire, and which would require nearly twice the average number of men per mile, shows a lower percentage of cost compared with traffic receipts than some of the other lines. This is a satisfactory feature as showing that the more business there is on a line, and the more need it has of safeguards, the better worth while is it to provide them.

The gross traffic returns of the twelve railways in the Table amounted to £41,755,190 last year. This sum, divided by the number of miles, gives an average of £4,110 per mile per annum.

The cost of the block system, being £100 per mile per annum, would thus be 2·2 per cent. of the total receipts.

It is also fair to take into account that more than half the accidents of recent years would probably have been prevented if the block and interlocking system had been universally in use. For some years the fourteen railway companies mentioned in the tables have paid as compensation for injury to passengers and goods the sum of £430,700: to this may be added at least a like sum for destruction of the companies' own property. The accident account would probably then be as follows:—

Annual sum paid as compensation . . .		£430,700
Loss by destruction of companies' property . .		430,700
Loss by delays—50% on the money paid as compensation		215,350
Law expenses, including cost of companies' own board investigations . . .	25% on the money paid as compensation	107,675
		£1,184,425

The Author submits that at any rate half of this sum, viz.,

£592,212, may be set off against the annual cost of the block system, £928,700, and this leaves £336,490 per annum as the net annual cost.

Compared with the gross traffic receipts, this gives the insignificant percentage of ·8 per annum. This may be said to represent the demands of the Government upon the railway companies whenever any compulsory law on the subject of interlocking, &c., may be passed.

It is noteworthy that, whilst such a law is talked of, the Railway Companies are at the same time making a demand on the Government for the repeal of the passenger tax.

The Author would suggest that any compulsory law on the one subject should be accompanied by a just relief on the other. The Companies would thus be enabled to carry out these improvements without loss to themselves, to the great advantage of the travelling public, and with only the slight sacrifice which the public revenue is now so well able to afford.

As another source of ways and means for reimbursement for the cost of the universal adoption of the improvements indicated, there is given in Table 149 a column showing the average annual increase of traffic receipts,—an increase at an *annual* rate of about ten times the net cost of the block system.

The Author has thus endeavoured to fulfil the task of describing the various steps by which the present fabric of railway signalling has been built up; and in travelling over forty years of time, and over ground on which such varied opinions are found, he cannot but feel that the result of his labours must necessarily be far from perfect.

In estimating the cost of accidents he has omitted to speak of the destruction of life and limb which might be mitigated, for the simple reason that he wished to steer clear of what may be called the sentimental part of the subject, and to keep rather to the facts easily ascertainable and to arguments easily demonstrable.

Careful and dispassionate examination will assuredly show, that, on the one hand, much more has already been done by the railway companies than the travelling public have any idea of—as witness the Great Northern, the London and North-Western, the Metropolitan and other leading railways—and, on the other hand, that the most extreme demands of the public will be found after all to be no very serious tax upon the railway property of this country.

The Paper is illustrated by a series of diagrams, from which Plates 27 to 31 have been compiled.

[Mr. RAPIER