

American Signal Practice as compared with British Practice.

MR. RUDD'S REPLY TO THE DISCUSSION.

I WAS greatly interested in the reception of my paper on signalling practice. The success of a production of this kind is measured largely by the amount and quality of the discussion it brings out, and the result is certainly very satisfactory.

First, I want to thank the members for the kindly manner in which they received my suggestions. I had expected more or less adverse criticism, such as I generally get at home, and its absence was most flattering.

Second, I thank you all for your words of commendation, and your cordial expressions of friendship and good-fellowship. The engendering and establishing of such a kindred spirit between us is more valuable than any other result which could possibly be attained.

The discussion shows that you have studied the signalling scheme carefully, and that many of you have an amazingly good grasp on the proposition, considering the short time you have had to consider it. The questions asked and some of the statements made, however, show that some points are still a little hazy, and I will try to clear away the fog as best I may at long range.

The entire problem requires careful and deliberate consideration before changes are decided on, and perhaps a plan of having several meetings for discussion, giving me a chance between times for explanation of points not thoroughly understood, would be of advantage.

I am glad Mr. Insell approves of the three-position signal, and considerable of the discussion seems to be on that proposition. I was a "home and distant" man when we started our investigation, but, being convinced by facts

that I was wrong, my conversion to the three-position signal has been complete and lasting.

The use of three-position signals is especially valuable in terminals where signals should be located at short intervals to permit of short shunting and where, at the same time, through trains should be able to move at speed. By having each signal indicate the position of the next one ahead, facility not otherwise attainable is obtained in both features. Also, out on the road, as brought out by Mr. Bound, traffic is facilitated and, what is more important, it is safeguarded.

With the two-position signalling, the distant and starting signals may be "on" and the home signal "off." With the three-position signalling, if signals are located as noted by Mr. Bound (braking distance between home and starting) the distant would be clear and the home at caution with the starting at stop. If, however, there is less than braking distance between the home and starter, the distant would indicate caution and the home would also indicate caution (instead of clear) with the starting at stop. In other words, after receiving a caution signal, the driver would not encounter a clear signal and, immediately beyond, a stop signal, but would receive all signals at caution leading up to a stop; thus relieving him of the necessity of remembering that his caution indication covered two or possibly three signals and carried through.

I think few of us here have realized the reason for your use of ramps or trips instead of track circuits, and Mr. Insell's statement in regard to your wheels is enlightening to us. Further, I imagine you would have trouble with your light "goods wagons" in getting a good shunt on your track circuit, especially on rusty or sanded rails. Considerable change would have to be made in your rolling stock to make track circuits properly available.

Answering Mr. Insell: We have read of the Great Western Railway audible signal and automatic stop in detail. We appreciate that a *reliable* cab signal would obviate the danger of drivers misreading signals at

junctions, etc., but still doubt whether it will ever replace outdoor signals, with its inherent disadvantage in case of failure, *i.e.*, the absence of information from point of failure to end of run.

We believe we shall eventually develop a genuine speed control with three elements: First, a reliable speed recorder; second, an induction or Hertzian wave arrangement to transmit the impulse from the roadway to the locomotive, and, third, a speed control operated in combination with the two, which will in no way interfere with the driver's control if he does his work, but will check him if he exceeds the authorized speed. Two of these three elements have been developed to such a stage as to convince us that they will be successfully perfected eventually, and we hope to have them ready by the time we have our lines adequately signalled.

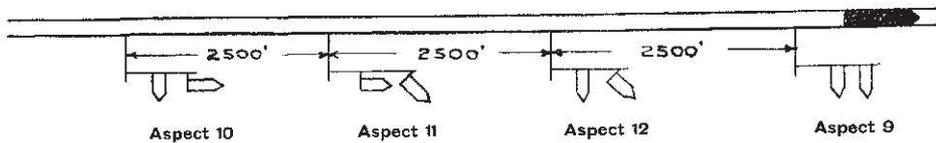
Answering Mr. Bound: "We desire and should be able to institute a system that makes it unnecessary for a driver to have had previous experience of the road over which he has to run." Simple and readily learned as our system is, it will not enable us to attain this ideal; no system will unless the road is placarded with instructions from one end to the other, and we have not attempted it.

Our position is that a given signal aspect must transmit the same information at all times, at all places, and under all conditions, so that a driver will know instantly what it means and whether or not it is properly displayed, but he *must* be familiar with the *physical characteristics* of his road, curves, grades, stations, water pans, grade crossings, speed restrictions, etc., etc., and the *location* of his signals, and then, by furnishing him with uniform aspects, he can run confidently, and run over a new line with *much less instruction* than if he also has to learn and *remember* the track layout at each place. Here speed signalling has decided advantages over route signalling.

As to the use of the middle arm, examples 1 to 8, sheet 4, and especially examples 4, 5 and 6: The proposition for the elimination of the middle arm and the utilization

of the 45° position of the top arm to give its information was very strongly advocated when the matter was under discussion here, and, in fact, one road has installed several plants in this way. It has the advantage of simplicity, but the disadvantage of not giving adequate or definite information. As used in the instance referred to, it indicates "caution." The driver does not know whether he is to run cautiously because the next signal is at stop, or because the block may be occupied, or because he is to diverge to another track at the location of the signal, or at some point, say, 4,000 feet beyond, and must continue to run at caution until he comes to the next clear signal; whereas aspect 4 tells him definitely that he is to diverge and, having done so, that he may resume speed as the next signal is at proceed. Aspect 5 tells him that he is to diverge at a point some distance beyond with his starting signal (if there is one on that route) at proceed, and aspect 6 that he is to diverge but his next signal beyond the diverging switch is at stop, thus leaving a distinctive meaning for aspect 3, proceed on through high-speed route, next signal at stop. In short: The top arm governs the through route and indicates Stop; Proceed, next signal at stop; or Proceed, next signal at proceed. The middle arm governs a high-speed diverging route or routes definitely established, and the positions of the arm are identical in meaning with those of the top arm (except as to route), while the bottom arm indicates low speed. The higher the arm, the higher the speed. The greater the upward inclination of the arm, the greater the permissible speed. As you will note from the diagrams, this middle arm is omitted on branches where there is no medium-speed divergence, but, in that case, the significance of the top arm is not altered in the least, and, in all cases, a divergence from the main line is indicated by the location of the arm on the mast and *never* by the angular position of the arm itself. The use of the middle arm has another advantage, an added significance in actual practice, which was not touched upon in my original paper: Given a congested district where blocks are necessarily short (to handle the traffic) but where high speeds are requisite;

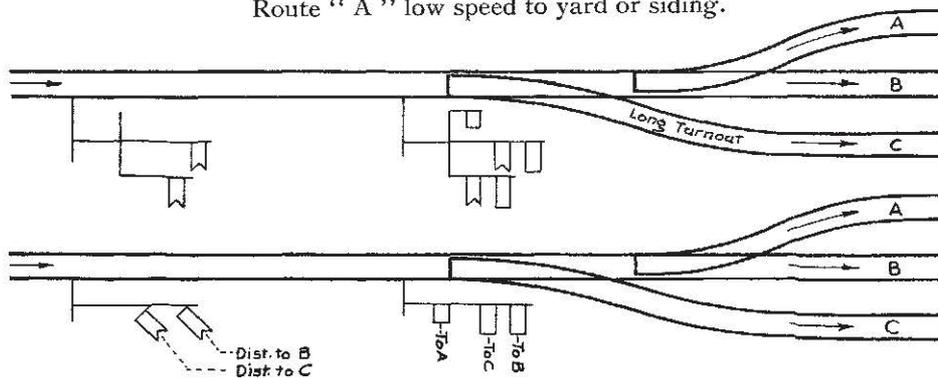
obviously, if blocks are full braking distance for high-speed trains (say, 4,500 feet on level) the numerous stops will congest traffic. Obviously also, if the blocks are less than braking distance, dangerous conditions are introduced, especially during fogs. Our solution of the problem is shown on diagram below, and it works out very well. Aspects and their meaning are shown on sheet 4 of my paper :



—from which it will be seen that a fast train, receiving 11, can and will slow down to medium speed before reaching 12, and, running at that speed, will be able to stop at 9 (which would not be possible if he received his first warning at 12), while a slow train need not reduce speed until it reaches 12; thus short blocks and long approach information are provided simultaneously.

As to the aspects 20 to 24 : The use of these is explained on page 75 of my Paper. With your English practice, using gantrys, 23 and 24 would be all that are required. See diagram below, comparing your practice and ours :

- Route " B " through high speed.
- Route " C " through medium speed.
- Route " A " low speed to yard or siding.



Mr. Bound is entirely correct about the lights, and especially, in my opinion, about the value of the marker light as a means of contrasting red and yellow, as a means of locating the signal when the active light is extinguished, and as a means of classification between "stop and stay" and "stop and proceed" signals.

Mr. Irving's remarks are right to the point and explain our system very effectively. I would say, however, that on January 1st, in the States, of 185,986 miles of road on which passenger trains are operated:

26,569	had automatic block signals
60,168	,, manual ,, ,,
99,249	,, no ,, ,,

and of 214,071 miles of track:

44,461	had automatic block signals
68,849	,, manual ,, ,,
100,761	,, no ,, ,,

It will be seen, therefore, that the use of automatic signals is not exactly *usual*, as Mr. Irving states. Where three-position signals are used, the blocks are generally a mile or less—ours average, probably, 4,500 feet. On some roads, where two-position signals are used, blocks are sometimes three miles long, with distant signal approximately 4,000 feet from the home. This also answers Mr. Sayers' statement. Replying to his question as to the use of absolute and permissive block in same territory: Evidently there is some confusion in your minds as to the term "permissive" as used in my paper. It is true that automatic block signals, indicating "stop and proceed," are, in a sense, permissive in that trains are permitted to stop and then enter the occupied block, but, with us, the term "permissive" is confined to manual block territory. It is the general practice to permit slow trains to enter a block occupied by other slow trains, either by order, rule, caution card or by a distinctive signal; the Pennsylvania R.R. practice is as outlined at bottom of page 74, my Paper. Note aspect 14, which we call our "distinctive permissive

signal." Passenger trains and certain others are run under absolute block. They cannot (except, of course, in an emergency and under orders) enter an occupied block, nor is any train permitted to enter a block occupied by such class of train, and, if aspect 14 should be erroneously displayed to a passenger train, the latter must stop and advise the Superintendent before accepting it. But a freight may follow a freight into the block *without* stopping on receiving aspect 14, looking out for train ahead. This is what we term permissive blocking. Further, on the heavy descending grade of 12 miles from Callitzin to Altoona in the Allegheny Mountains, where we have automatic signals giving three-block indications, the signalmen have orders to protect passenger trains by holding them or trains following them until the track is clear between interlockings. So that, while the automatic signals space the freights and must be obeyed also by passenger trains, as a matter of practice, the latter generally find them clear except on approach to an interlocking—that is, such trains are spaced about three miles apart.

Answering Mr. Jacobs: I believe you could greatly simplify and clarify your system by the adoption of the three-position signal generally and by the use of our three-arm interlocking signal in place of your gantry.

Replying to Mr. Berry: It is true that the three-arm signal is capable of giving eight different aspects, but it should be remembered that some of them are seldom used and practically never will all of them be required on any one signal; further, only one is displayed at a time. Take, for example, the signals near Rugby which I cited in my paper; the right hand has 5 masts and 8 lights and displays 9 combinations, while, with our three-arm signal, we would use 6, viz., aspects 1, 2, 3, 4, 5, 6 and 8, 50% less complication. If you will signal two or three typical places with both systems, you will see that the scheme is simpler and easier to read and remember, as generally top arm indicates top speed; middle arm, middle speed; low arm, low speed; arm 45°, next signal ahead at stop; arm

vertical, next signal clear; in addition, low-speed arm 45° also means look out for yourself, run with extreme caution.

Answering Mr. Bound: No more signal locations are required with three-position signals than with two-position; therefore, no more fog men would be required. It is not necessary to *use* all three positions on any one signal. For instance, distant signals at your manual block stations would show only aspects 23 and 24, caution and proceed. On a three-arm signal, if there is no high-speed route, the top arm would be fixed in stop position, or, if there were no medium-speed route, the middle arm would be fixed. By a three-position signal, we mean a signal whose arm is capable of assuming three positions: stop, caution and proceed; and only those aspects are displayed which are required to give the particular indications necessary at each particular point.

Answering Mr. Silver: If he will make a list of the aspects on his line, counting each aspect which differs from any other as one, and each arm position as one, and compare with those outlined in the diagram (eliminating such as would not be used in English practice, notably Nos. 10, 12, 14, 15 and 16, sheet 3) he will, I think, find our scheme is simpler. If he does not use automatics, aspects 9 to 15 would be eliminated. He would then have for interlocking (home and dwarf signals) 11 aspects with one (No. 5) rarely used; three or perhaps five distant signals; three block signals, and three or possibly seven automatic aspects—a maximum, if all aspects are used, of 26. As to working mechanical signals: It will be noted that distant signals which, if mechanical, are operated by wire connections, have only two positions. The three-position home signals are pipe connected and properly compensated, using "lazy jack" compensators. As to our hand signals: The Standard Code, in use on most of the roads, provides that hand, flag or lamp swung across the track indicates "stop;" signal raised and lowered vertically indicates "proceed," and, swung vertically in a circle at half arms length across track, indicates "back"; held horizontally at arms length, "reduce speed," not stop, as I stated.

As to aspects 13, 14 and 15, sheet 4, where he fails to see diagonal lights illustrated, the circles shown on all the signals (except the painted circles on the arms themselves in aspects 10, 12 and 14) represent lights. The diagonal lights referred to are shown, top light on right side of mast, being in the spectacle which holds the arm, bottom light on left side of mast and 7 feet below the top one. These lights are mounted 9in. and 13in. respectively from centre of mast, giving a horizontal spacing of 22in. and a vertical of 7 feet, making the diagonal about 15° from the vertical. As this stagger only comes into use after train has stopped, it being authority for it to proceed after stopping, it is adequate for the purpose and there is no need for splitting the lights or placing them side by side. As to the flash-light: One or two roads are trying it, but I have not heard that any has adopted it yet.

Answering Mr. Downes: I think your signals clear to about 75° or less; the mid position is not very distinct. The positions, horizontal 45° and 90° , are very distinctive. While we do not use three-position indicators, using the "clear" position to indicate 45° or 90° and the "stop" position to indicate horizontal, I presume three-position indicators could be designed if really required. We have not found them necessary. The scheme of utilizing upper-quadrant for caution only was tried out here. It is not feasible. As a signal, moved from caution to clear, would pass through the stop position, a very undesirable proposition would result if made in view of the driver. Further, the counter-weighting cannot be accomplished satisfactorily and no stop lug can well be provided for the stop position—that is, if the connections and stop lug break, the arm which should be horizontal would indicate proceed.

Answering Mr. Carslake: Aspect 5, sheet 3. The use is shown on plan for Southwest Junction, which I sent you. It would be displayed on 44L, for instance, if route was made and was clear straight through to 16L and 16L showed aspect 4—that is, with crossover 13 reversed and 11 normal, track clear to signal "A" and signal "A" at proceed, there being full braking distance between signals 44L and

16L. In short, distant signal aspect 22, sheet 3, or 11, sheet 4, as the case may be, is applied to the home signal 44L, which is a distant, in this case, for the medium-speed home signal 16L. As you will note, there are few instances where this would be applied. In your practice, it might be used when you have two interlockings located so close that there is braking distance only between their home signals, without room for a starting or distant signal between them.

Answering Mr. Addis: On our line, we do not instal any mechanical wire connected signals more than 1,500 feet from source of operation on account of snow and other adverse conditions; consequently we do not use slotted wire connected signals. If we slot a mechanical home, with a track circuit, we provide an electric distant so that, if the slot kicks off, the distant will automatically show caution. We do not slot through from two boxes as you do. We would generally use a power operated plant and reduce number of operators or signalmen. If, however, two cabins were in such proximity as to require joint operation of a signal, we might control mechanically from the nearest cabin and electrically from the other, but, by preference, would use an electric signal. I hope this covers the question. You may, however, have some other feature in mind; if so, come again.

Answering Mr. Glenn: I see his explanation of the use of aspect 5 is clearer than my answer to Mr. Carslake. However, mine may help as a concrete illustration. Mr. Glenn is correct that 3 or 6 would be used to lead up to 7 or 8—the high-speed signals are at stop, the low-speed arm gives permission to pass them at low speed, therefore the distant signals are at caution. His grasp of the general scheme is fine.

Answering Mr. Morgan: I cannot improve on Mr. Glenn's reply to him, but might add that, if distances were such that the arrangement in figure 1 were justified, the two stop signals would operate 0° to 90° and the middle (distant) 45° to 90° only, but, having these three signals provided, power-operated and capable of three positions, with, say, two or two and one-half miles between the home

signals, it would be good and economical practice to make all three three-position and so provide an additional block without any additional expense of installation and practically none in maintenance and operation.

I note a short article "communicated," I judge by Mr. Morgan, and, taking America as a whole, we must plead guilty to his soft impeachment. On page 69, you will note, I stated that I presented "for your consideration a comparison of your practice and that which I consider to be the *best* American practice—because my road (the Pennsylvania) had adopted it." Keeping that in mind, you will see that I was not attempting to compare America with Great Britain, either as to the amount, quality or efficiency of equipment or in any other way, and I did not mean to make any invidious comparisons, as they surely would have reacted.

The figures given in my reply to Mr. Irving show the block situation in the States. The situation on the Penna. Lines East of Pittsburgh and Erie, of which I am Signal Engineer, was as follows on January 1st:

PASSENGER LINES

AUTOMATIC BLOCK SIGNALS.					
Double Track	Three Track	Four Track	TOTAL		
			Miles, Road	Miles, Track	
264·6	37·4	389·2	691·2	2206·0	
NON-AUTOMATIC BLOCK SIGNALS.					
Single Track	Double Track	Three Track	Four Track	TOTAL	
				Miles, Road	Miles, Track
2964·8	894·2	21·7	49·7	3930·4	5029·1

GRAND TOTAL.

Miles—Track 4621·6 Miles—Road 7235·1

In addition to the above, 163.1 miles of road and 244.4 miles of track used exclusively for freight service are block signalled.

Total miles road	5349.3	Total miles track	8298.9
Total block signalled	4784.7	Total block signalled	7479.5
Total non block	564.6	Total non block	819.4

All the non block is on freight lines or where not more than one train is run per day. In the above 21 miles of road and 43.6 miles of track is operated by the controlled manual (lock and block system) with continuous track circuits for reversal of traffic under signal.

An official statement recently issued to the public press is quoted below :

“ With the completion on September 1st of an elaborate plan of improvements in its automatic block signal system, the Pennsylvania Railroad will have more four-track lines operated under automatic signals than any railroad in the world.

At a cost of \$6,000,000, the Corporation has in the past three years equipped 253 miles of its main lines with automatic signals.

On September 1st the main line between Pittsburgh and New York, and Philadelphia and Washington will be equipped with automatic block signals.

The signal system on the railroad east of Pittsburgh and Erie represents an estimated investment of approximately \$18,000,000. The difficulty in arriving at more than an approximate figure is due to the fact that many changes have been made in the signals from time to time in the past thirty years.

It requires a normal force of 1,800 men to maintain the Pennsylvania's signal system. It costs to keep these signals in order no less than \$1,500,000 a year.”

I note in a recent English publication that the Great Western Railway of England has on its 3,007 miles 1,611 signal towers, 43,456 working levers, 20,430 signals, 3,191 interlocked switches, and 682 crossing gates. The Penn-

sylvania Lines East has on its 5,349.3 miles of track approximately 1,160 signal cabins, 11,150 working levers, 18,860 signals, 5,500 interlocked switches, and 682 crossing gates. The comparatively small number of levers is due to the large number of automatic signals instead of manual blocks, and of power plants where in some cases six or more signals are operated by one lever. The comparatively small number of signals is due to difference in practice, as noted at Rugby in my paper, you using more arms than we do. Our interlocked switches compare favourably with those on the Great Western.

As to the "train order" system, it has and still does serve a useful purpose, and has been the only salvation of a lot of small roads on which the installation and operation of the block system at our prices for labour would have spelled bankruptcy.

Unquestionably the controlled manual in its most approved form, with continuous track circuits for head-on protection on *single track*, with automatic signals for protecting following movements, is the safest and most flexible system obtainable, far outdistancing the staff, tablet or automatic protection alone, but it is also beyond the means of many roads, a number of which in this country are completely signalled with automatics for single track working, although we have in service in the United States 409 miles of road with electric train staff, and 428 miles of track.

I must take issue with the statement that the controlled manual "with replacers" is the "best system in the world." It is for single track working, if equipped with continuous alternating current circuits; if not so equipped, a train may break in two, the rear portion remain in the block and the passage over the "replacer" will release the apparatus, or you may have the collision at Shepherds Bush Station, C.L.R., September 30, 1913 (as reported by Major Pringle) duplicated. It is not any better than properly installed automatics (with all switches interlocked) for double and more track roads, and it is slower in operation.

I believe generally we have provided some safeguards you do not use, but am not well enough acquainted with your practice to be authoritative, and so may perhaps have to "back water" on that statement. However, in my reply to Mr. Ellison, I will outline them and you will decide for yourselves.

Replying to Mr. Ellison: The electrification of our four-track lines is the first instance of our using the overhead trolley for passenger service, our previous electrifications having been third-rail installations. One of the first American railroads to instal overhead was, I believe, the Denver and Interurban in Colorado; 49 miles were electrified, over one-half being steam road, it was a single-phase system, using 11,000 volts on the trolley. The New York, New Haven and Hartford now has overhead between Woodlawn Junction and Stamford, and is extending it to New Haven, a stretch of over 60 miles of four-track main line.

I would recommend that Mr. Ellison read the various reports of Committee No. X of the Railway Signal Association beginning in the Journal for 1910, Volume VII, and continuing through subsequent volumes, which reports describe the various signal installations on electrified lines and show the progress of the art very clearly.

The remark ascribed to me, "we try to make our signalling fool proof; the English eliminate the fool," was a quotation, as I stated. It sounded well and made quite an impression here, and, while I am sorry you have not been successful, I am glad to have your testimony as to its inaccuracy, for your statement bolsters up my position here, which is that, instead of better discipline and *personnel*, *versus* additional safeguards, we should try to improve both, and I note you are proceeding along these lines also.

Now as to the safeguards we are installing to guard against errors—

- 1st—By enginemen,
- 2nd—By signal operators,
- 3rd—By maintainers—

1st—We have *not* provided automatic stops, cab signals, audible signals, etc., but we *have tried* to design a system so simple that its principles can be readily memorized and in which a given signal aspect always means the same thing regardless of its location. We have tried to make the aspect show in itself if it is improperly displayed, and if a light is extinguished to still show its location. With the principles thoroughly understood less effort of memory is required on the part of the driver, and the signals are more quickly and accurately read. We try to give approach indications of conditions ahead and continue the caution warning at each succeeding signal until the restriction is removed, and finally we try to locate the signals so they will not be confused with others.

2nd—We are providing approach locking as rapidly as possible at all interlocking plants, so that if a route has been made, the signals may be set at stop, but the route itself cannot be changed if a train has approached within a certain distance of a clear distant or home signal, until a certain time has elapsed. In automatic territory all interlocking signals are semi-automatic controlled by the signalman and by continuous track circuits, and in three-position territory the clear position is also controlled by the next signal ahead, so that no high signal can be given if track it protects is occupied; this includes even the terminal plants. Further, at all our power plants and, with very few exceptions, at our mechanical plants, through electric switch locking is provided controlled from the track circuits, so that if a signal is given for a route, and the train protected by approach locking up to the signal has passed the latter and entered the route, the latter cannot be changed until the track circuit is free. In terminals we go even further; the clearing of the signal and entrance of train locks up the route to which the signal then governs (10 or 12 in some cases are governed by one signal), but each switch is released as rear of train passes the clearance or fouling point so that quick routes can be made, and this is done for movements in either direction.

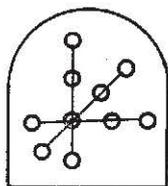
Small electric lights mounted on the machine over the levers glow if switches or signals are free, and are extinguished when they are locked. Again, calling-on arms may not be displayed at proceed in terminals unless a push-button is operated in addition to the signal lever, and in some cases these push-buttons are under the control of the director, thus requiring joint action of director and leverman; at other points these push-buttons are used to release for certain routes only, such as to short spurs or for unusual movements.

3rd—In power machines "SS Relays" are provided so that if a switch does not correspond in position with its lever, through serious but very unusual disarrangements of the circuits, the signal cannot be cleared, and so that if a switch is inoperative and the maintainer disregards the rules which adequately cover such a condition, and operates the switch by hand without taking proper precautions, the signal will indicate stop. Of course back locks are provided on all power operated signals so that if they stick clear the combination on machine is locked up.

I believe that the approach locking and its substitute, "time locking," which is cheaper to instal and is used at plants of light traffic, together with through and route electric locking, is further advanced here than with you, and these are the safeguards to which I particularly referred.

In general, throughout the United States we depend on the men as much or more than you do. Under the train order system we depend on several men—none of whom must make a mistake: the dispatcher, the operators, and the train crews. Under controlled manual the same, but with an additional check imposed by the apparatus. Under the automatic block system, on the train crews and the signal maintainers. Everywhere in the last analysis the human factor enters the equation to greater or less extent, but at our interlockings on the P.R.R. and other trunk lines generally, we do, I believe, provide *automatic* checks to a greater extent than you do. Collaring a lever, for instance, is a check, but it requires the action of the man to check himself.

On pages 73 and 78 of my Paper I touched on the light signal for day and night use. Since the paper was written we have developed what we call, for lack of a better name, the "beam-light" signal and will instal it between Overbrook and Paoli, in connection with our new electrification, about 16 miles of four-track road with five interlockings and signals giving three-block indications and located approximately 3,500 feet apart—and if it proves as satisfactory as anticipated its use will doubtless be extensive, especially where A. C. track circuits are installed, as with it the only moving part in the system is the control relay, which is necessary with any system. As designed each unit is generally as per sketch:



Four fixed lights in a row, one light being common to all—the containers for the lamps, lenses, etc., are adjustably clamped to steel tubes diverging from a centre casting—the background being attached to the centre support but back of and separate from the tubes supporting the lamps.

The lamps are spaced 18 inches centres and are 12-volt, 4-candlepower, 5-watt Mazda concentrated filament with adjustable base, burning at 11-volts in bright daylight or in fog, 6-volts at twilight and 3-volts at night. Current consumption will average up about 10-watts for the four lights. Special inverted 5- $\frac{3}{8}$ " lenses and very light yellow cover glasses are placed in front of the lamps and a reflecting mirror above the latter to throw some of the rays down for close range—and hoods provided over each unit. These are readily seen in brightest sunlight at 4,000 feet or more. Scareheads of newspapers can be read 1,000 feet from them at night with full day voltage, hence the necessity of dampening down at night.

Voltage will be controlled from nearest signal cabin by the signalman on duty. The entire arrangement is immovable—the rows of lamps being lighted as conditions require—two units will be used on all signals, thus making a uniform system, the aspects corresponding to the position

of the arms as shown on diagram in my paper, with the following exceptions:

Interlocking Signals.—The bottom (low-speed) arm will not be displayed in stop position at all but when required for use two short range lights will be shown diagonal or vertical in addition to the two upper arms horizontal (aspects 9 and 10)—a decided advantage, as the driver will know that unless two full size beams appear, the signal is improperly displayed. Obviously the shape of the arms cannot be simulated—distant signals in manual block territory and not showing conditions as to occupancy of track between them and their home signals, now have different angular positions of arms from distants with pointed arms, except that aspect 22, sheet 3, shows same angle of arms as No. 11, sheet 4. Aspect 22 will therefore not be displayed unless *track is clear* and next signal at medium speed. Permissive aspect 14, sheet 3, will probably not be required, but if used will be shown by row of lights diagonal (45 deg.) in *lower* right-hand quadrant.

The staggered light effect to distinguish stop and proceed signals from stop and stay will be produced by having the bottom horizontal beam moved to the left one light, as  the difference being required only in the stop position.

Owing to sun on the dwarf signals which cannot be hooded lest close range reading be obscured, frosted white cover glasses and higher candle power lamps will be used.

Other points may have to be covered but the development will be interesting.

As stated, this arrangement will eliminate all failures due to moving parts of signals and mechanisms (except the relays), all chances of freezing or sticking clear, and from our records, should reduce all failures with their consequent delays, at least 10%, and all dangerous failures 40%—and it solves the coloured light problem for night indications completely by eliminating all colours and establishing signalling by position only.

When a power line is provided it enables cheaper generation of current as there is no "peak of the load" to be provided against as in motor signal work, thus reducing cost of operation. The initial cost of installation is less; the cost of maintenance aside from necessary policing should be less; the cost of delays will undoubtedly be reduced; and risk to employes reduced, as all their work will be on the ground except occasional inspection of wires, adjustment of lights, renewal of lamps and cleaning lenses.

Think it over; it *looks* attractive.

In closing, I thank you all again for your generous treatment of myself and my remarks, and note with great satisfaction Mr. Ellison's statement about Mr. Thornton. May success attend your Association collectively and as individuals, and may the piping times of peace soon return to your war-troubled nation.

DISCUSSION.

Mr. J. SAYERS: Gentlemen, as you are aware, this is rather an unusual Paper. Mr. Rudd was good enough to offer us a Paper and it was read over here. We discussed it, then Mr. Rudd took the unusual and extremely generous action of replying to the discussion. Mr. J. Sayers

The Reply is certainly equal to the original Paper. As a matter of fact, I think it is more illuminative, particularly so to anyone who has not been in America, and it is rather difficult to agree that the whole thing is settled and finished by the reading of his Reply.

With your permission I should like to ask anyone who has been referred to in this Reply to make any remarks they desire that would be of interest to the Institution.

I think Mr. Rudd is far too good a man to leave, and we might as well get a little more out of him.

Mr. R. G. Berry Mr. R. G. BERRY: Mr. Chairman, there is one little point arising out of Mr. Rudd's answer to my question. The last sentence of the last paragraph on page 105 reads thus: "If you will signal two or three typical places with both systems, you will see that the scheme is simpler and easier to read and remember, as *generally* top arm indicates top speed; middle arm, middle speed, etc." It is the word *generally* I am not quite sure about. Does not the top arm always indicate top speed? What are the conditions under which the top arm does not indicate top speed?

If I am in order in referring to a reply not addressed to me, I would like to call your attention to the first complete paragraph on page 101. Mr. Rudd says: "We believe we shall eventually develop a genuine speed control with three elements: First, a reliable speed recorder; second, an induction or Hertzian wave arrangement to transmit the impulse from the roadway to the locomotive; and, third, a speed control operated in combination with the two, which will in no way interfere with the driver's control if he does his work, but will check him if he exceeds the authorised speed. Two of these three elements have been developed to such a stage as to convince us that they will be successfully perfected eventually, and we hope to have them ready by the time we have our lines adequately signalled."

I think it would interest us if Mr. Rudd would let us have the result later of their experiences in so far as this control is concerned.

Mr. E. C. Irving Mr. E. C. IRVING: Mr. Chairman, I do not know that I have much to say except that in making my remarks at the previous discussion I was thinking more particularly about the New York division, where the automatic signals are in use all the way from New York to Philadelphia. Not being so well acquainted with the other part of the line I did not think of there being so many hundreds of miles of block signals in use as well.

Mr. R. J. Insell Mr. R. J. INSELL: Mr. Chairman, Mr. Rudd talks about

the Great Western audible signal. He says he does not like the idea of dispensing with stop signals or visual signals. The cab signal does not necessarily replace any outdoor signal, but there is no reason why it should not replace the distant signal. Mr. R. J. Insell

With regard to the speed control and Hertzian wave arrangement, I think we have a long, long way to go. I did see in New York an arrangement whereby the driver and the speed was controlled, but I think it will be a long time before they will be able to do much with it.

I think the figures Mr. Rudd quotes in reply to Mr. Irving are very interesting. They have a lot of scope in America. There is plenty of work to be done, and I think it will pay us well to watch what they do. They are very inventive, and although they seem to have plenty of dollars, they are out for doing the thing in the best and cheapest way, and as they have got something like over 100,000 miles to equip with signals, we ought to see some very interesting developments.

I should like to mention that the Great Western now have a three position signal in use at Paddington. It was brought into use last Sunday week, and if any members are interested in three position signals they can walk down No. 1 platform and just watch how it works.

Mr. C. H. ELLISON : Mr. Chairman, Mr. Rudd has given us a very ample reply to the few remarks I made on his Paper, and I think I have nothing to say further except to thank him for so kindly and fully replying to the points I raised. Mr. C. H. Ellison

There is one thing I might mention, however, and that is, Mr. Rudd recommends that I should read the various reports of Committee No. X of the Railway Signal Association beginning in the Journal for 1910, Volume VII, and continuing through subsequent volumes, which reports describe the various signal installations on electrified lines and show the progress very clearly. I am very much obliged to Mr. Rudd for his kindly interest in me.

Mr. C. H. Ellison (Laughter). The only difficulty is, Mr. Chairman, that life is so short, and I am afraid I shall not have the opportunity or perhaps the time to wade through these numerous American volumes which Mr. Rudd has invited me to peruse. All the same it is exceedingly kind of Mr. Rudd to go to the trouble to point out how I can find the desired information.

Mr. J. Sayers Mr. J. SAYERS: Mr. Rudd shall be acquainted in suitable language of your refusal. (Laughter.)

One gentleman not here at our last discussion but who is here to-day is qualified perhaps more than anyone else here to correlate British and American Signalling. I refer to Mr. Johnson.

Mr. A. H.
Johnson

Mr. A. H. JOHNSON: Mr. Chairman, I should very much like to have taken part in the first discussion on my old friend Rudd's Paper, but owing to illness I was not able to be here. Rudd and I were youngsters together in America, and I know him very well. He is a very capable man, and when I first knew him he was Assistant to the Signal Engineer on the Pennsylvania. I read his Paper and I thought over the three position signal scheme a good deal. In England in the old days something was done in three position signalling, but it was given up mainly, I think, from what my father told me, because it was considered in practice to be too indistinct. It was found that the drivers did not appreciate the distinction between the "Caution" signal and the signal to go ahead. I think that objection was very real, and it appears to me to be an inherent difficulty that no amount of ingenuity will get over.

I take the opposite view to my friend Insell. I think the idea of the three position signal is basically wrong. It is a very difficult thing to argue about. The idea is basically wrong for this reason: the use of the word "Caution" is misleading; it is very easy to be misled by names, as you, Mr. Chairman, being a philosopher, will agree. (Laughter.) The meaning of the word "Caution" is a vital thing to an

engine-driver. They use the word "Caution" as applying to the Distant signal when it is in what we call, and very aptly, too, I think, the "On" or "Danger" position. They call that the "Caution" position. Now what are the actual facts? Say, a train is speeding along at 60 miles an hour on a declivity. It perhaps goes round a sharp bend and the driver suddenly finds the Distant signal "On." Well now, if you study any reliable brake diagram you will find that a train running at this speed will take a very long distance in which to pull up, with either ordinary or emergency brakes, and to let the driver think that is merely a "Caution" signal is, in my opinion, entirely wrong. What it actually means is "Stop." It does not necessarily mean "Stop here," but it really means, to a very fast train, "*Stop as soon as you can*;" but with this three position signal you are letting the driver get into his mind the idea of "Caution." I know what "Caution" means: it means, in effect, shut off steam a little, apply the brake a little. These are wrong terms, and from wrong terms or words you get wrong practice. I can, however, see their mode of thought. I knew them very well as a young man, and I can follow their reasoning. They made their Distant signal in the "On" position at 45°, and so doing they made that signal of secondary importance because they made it in an inclined position. I notice the yellow light is referred to. I was responsible for first suggesting that in America. (See files of *Railroad Gazette*.) But as regards the Distant Signal, they have given it secondary importance, and that is my quarrel with them. Whereas, I say the Distant signal is of the first importance. It is "On" when in the horizontal position just as much as the Home is "On" when in a similar position, for the Distant is simply a reflection of the Home.

A moment ago I referred to the yellow light. They bring in the yellow light to make three signals at night. The yellow light is usually safe, but in some conditions of atmosphere it is not. There is not that vital distinction

Mr. A. H.
Johnson

Mr. A. H.
Johnson

that you have between red and green, and under some atmospheric conditions such a light may take on a greenish hue.

Then they say that one great feature of the one arm signal is its simplicity. You have first got to find simplicity. What it is you are principally concerned about is simplicity in the engine-driver's understanding, not simplicity in the apparatus. It is true that the three position signal has got only one arm, but it has got many arms in the driver's mind. You can draw a rough simile between a one-armed clock and a two-armed clock. You can make a one-armed clock—it would be a very simple thing—but you won't read the time by it near as well as you would by a two-armed clock.

Now Mr. Rudd, to strengthen his thesis, brings in the difficulties we have in our Distant Signal system. No one told him that the signalman does not pull his Home signal off if his Starter or Advance is "On"—until the train approaches it.

It would take a month to discuss Mr. Rudd's very able reply. He has touched in a very interesting way on many points.

There is another point I would like to mention. Talking about *route locking*—we call it by different terms—they are under the impression they were first to do these things. We know—I have not seen it in the Paper—that "approach" locking is in use here. We have had this system in use on the heavy suburban lines round London for the last 30 years. It is extensively used on the L. B. and S. C., on the South Eastern and Chatham, and on the London and South Western, and the G. E. R.

Referring to route locking. Some route locking has been done mechanically in the old days. In connection with "Lock and Block" working route and approach locking have been the rule. The Americans have done the thing more expensively by track circuits. One will grant the track circuit is efficient and does more, but in this country they had to do things before track circuiting was developed.

The safest development of track circuiting is in combination with "Lock and Block."

I would like to remark again that having found the American Railway Officers good fellows, I am sorry you cannot all know them. They will be glad to see the generous way in which Mr. Rudd's Paper has been received and discussed by you.

Mr. A. H.
Johnson

Mr. J. SAYERS: Gentlemen, I think you will agree with me that it is undoubtedly a great loss to the Institution when Mr. Johnson absents himself. (Hear, hear.)

Mr. J. Sayers

There is nothing that is really better for us than to get an argument on sound basic principle. Mr. Johnson, undoubtedly, has a good deal of reason for what he says. Referring to the basic principle of the Distant signal, I do not think it is quite so far away from the three position arm as Mr. Johnson imagines. When a driver comes up against the "On" Distant signal in England it is *not* a loud voice for him to stop. The Rule Book does not say he is to stop but to proceed to get the train under control ready to stop at the next signal if necessary. He may not stop at all, in fact. (*Vide* Rule 36 of Rule Book dated August, 1904).

Mr. A. H. JOHNSON: The Rule to which the President has referred has been criticised by very practical and experienced men. The Rule in connection with the Distant signal is, to my mind, inadequate to meet the actual practice. To say that a Distant signal at "Danger" does not mean "Stop" requires a lot of proof.

Mr. A. H.
Johnson

Mr. J. SAYERS: I still do not understand Mr. Rudd's statements on Pages 104 and 105 *re* permissive working. Apparently it is as I suggested, and I do not think it is according to our practice.

Mr. J. Sayers

You will see on page 105 he says: "But a Freight may follow a Freight into the block *without* stopping on receiving Aspect 14, looking out for train ahead. This is what we term permissive blocking." This is exactly what we should not allow. We should neither allow a Freight to follow a Freight or a Passenger train into an absolute block section

Mr. J. Sayers

unless the section were clear. If that practice is carried out on the Pennsylvania how do they know the section is clear of Freight trains before they allow a Passenger train to come in?

I should like to say we shall forward this re-discussion to Mr. Rudd, and if he has any further reply we shall not call a special meeting for it, but shall take an opportunity of acquainting the members of its substance.

I have a very serious statement to make. We are not getting Papers from Associate Members. There is a good deal of reason for it since August, owing to the war; people's minds have been away from this sort of thing, but Papers were falling off before that. The Council at the beginning of this year decided to offer two prizes. They were for ten guineas and five guineas, the former open to Members and the latter to Associate Members and Students. The idea of offering Prizes, of course, is not simply to give money or value itself, but to indicate to the winners they have given Papers of value. In making this appeal to the members we proposed to indicate the lines on which we thought they could give useful Papers, and the following were suggested:—

1. Standardisation of Signalling Plant;
2. Automatic Train Control;
3. Signalling Aspects;

together with one supplied by the *Railway Gazette* last week in which they have asked this Council if we would invite a Paper or series of Papers on "Signalling Alterations which have led to saving of delays."

I ask the members to see whether they cannot aid the Council in providing Papers. It does not much matter about their length. We can take two at a meeting. The information derived from the discussion is sometimes greater than that to be obtained from the Paper.

I wish it to be quite understood that the subjects mentioned are only suggestions. We do not limit the title of any Paper or subject, and we do not mind what it is so long as it comes within the four walls of this Institution.

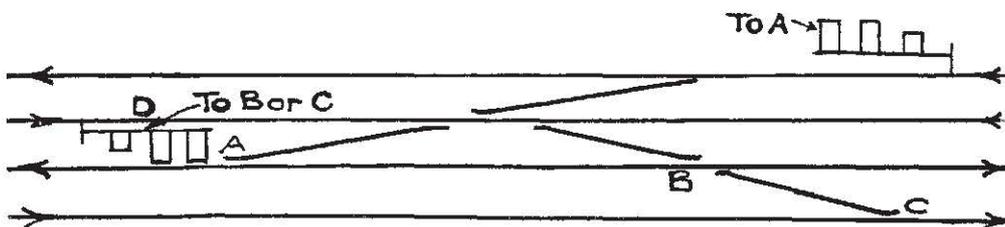
We only suggested those as titles which would be of great interest to us at the present time. Mr. J. Sayers

We intend at the next meeting to try and initiate a sort of social gathering so that the members may have the opportunity of becoming acquainted.

Mr. A. H. RUDD'S SECOND REPLY TO THE
DISCUSSION ON HIS PAPER.

Replying to Mr. R. G. Berry :

First: My English was faulty. All roads in the States do not use the top arm to indicate top speed. The top arm universally, I believe, governs the main route, but, at some locations, this main route may be over a cross-over, *vide:*



This is a common practice, but generally (commonly) the top arm carries to the straight track and, in the system we have adopted on the P.R.R. and are working to, the top arm would always govern the top speed, and signal D would have top arm fixed, second arm governing to B or C if the crossovers were 15's or better, and bottom arm to all other routes; if crossovers were 10's, top and middle arms would be fixed and bottom arm would govern to all routes.

Second: I shall be glad to give you the results with the speed control system which we are now installing for a few blocks on our Maryland Division, and which should

be in operation in a few weeks, as soon as we have arrived at definite conclusions. Meanwhile, it will interest you to know that the Brooklyn Rapid Transit Company has received a proposal from one of our signal companies to instal cab signals and speed control on one of its underground lines now under construction.

Answering Mr. R. J. Insell :

“ It's a long way to Tipperary—it's a long way to go,” but I don't believe it is as far to the speed control proposition as most of us have heretofore believed.

I have a “ hunch ” that it will be some time before we do away with the outdoor signals at interlockings. I would not be surprised, however, to see cab signals substituted for automatic block signals in the not far distant future.

I appreciate his expression of belief that we are doing our work economically and on good engineering principles, and that means getting the greatest possible benefit for each dollar expended.

I congratulate him as being the pioneer in the movement to at least try out the three position signal with the positions horizontal, 45°, and vertical.

Answering Mr. C. H. Ellison :

I lost sight of the fact that perhaps he was unfamiliar with our Signal Association literature, and am not surprised that he was appalled at the evident magnitude of the task I suggested. In explanation, I might say that the reports make easy reading, comprise only small portions of each volume, and much of the information may be obtained by looking at the pictures and glancing superficially over the text.

And now we come to my old (but not elderly) friend, Arthur Johnson. Arthur has been so long away from the States that his memory plays him tricks. When we first knew each other I was a draftsman on the P.R.R. We became very well acquainted when I was on the New York

Central back in 1893, and I presume he still remembers the Hudson River shad, just out of the water, that we shared with him in Tarrytown or Yonkers. His statement that we were and are very good friends is accurate and exact. Nevertheless, I shall try to "take a fall out of him."

First: The old three position signal tried in England was the same, I presume, as the one tried in America (as we followed your practice almost exactly), largely through the influence of such able and brilliant men as Mr. Henry Johnson (Arthur's father) and Chas. R., his uncle (both of whom I knew well and greatly admired). And that signal showed: 1st, horizontal; 2nd, 60° to 75° below the horizontal, with the mid-position 30° to 40° below the horizontal. It *was* too indistinct. The three position, horizontal to 45° to 90° does not have that defect. "The proof of the pudding is in the eating." Look at the one at Paddington and be convinced.

Second: The idea of the three position signal is *not* basically wrong, but Mr. Johnson's interpretation of its meaning certainly *is*.

With us, the caution signal does *not* mean in effect to "shut off steam a little, apply the brake a little." It means just what the instructions say it means, as shown on diagram submitted with my first paper, "Proceed, prepared to stop at next signal."

He admits that the distant signal "on" does not mean "stop here;" then why show the same aspect as the next signal that does mean stop here? And, if you *do* show a *different* aspect, why is the distinction made? Simply because you want to show the driver as well as you can that it does not mean stop here, but reduce speed so you can stop short of the potential danger point, *i.e.*, the stop signal. Further, if your signals are properly located, your distant signal "on" (arm horizontal, light red) does not require the use of the emergency brake to "stop as soon as you

can," but rather requires reduction of speed for a stop at the home signal. Our Code says of this signal :

SIGNAL	OCCASION FOR USE	INDICATION	NAME
Color	The signal will be displayed when :	For enginemen and trainmen.	As used in the Rules.
	Home (or advance, if used) signal is at stop.	Proceed, prepared to stop at home (and advance, if used) signals.	Caution signal.

If it will be any more easily understood, it may be called the "stop-at-home-signal" signal, or approach signal, or anything you please, to fit in with your practice, but the meaning is *exactly the same* on both sides of the Atlantic, and we, too, regard it as the most important signal of the lot. I agree with Mr. Johnson that it is a stop signal, but it indicates stop at a fixed spot beyond, and the home signal locates the spot. But it is unfair to the driver if you give the distant signal the appearance of a "stop here" signal when you and he both know that, if he is running at any great speed, he cannot "stop here" and that he is not expected to. It immediately weakens instead of strengthens the indication, for it does not tell him the truth, and he knows it.

Third: As to the yellow light. On the greater portion of our road we use white for clear, green for caution, and red for stop, so the yellow is not, of necessity, an inherent factor in a three position signal system. Lunar white may be used, or, as on the Chicago and North-western, a combination lamp showing red for stop, green for clear, and red and green side by side for caution (or stop at next signal). Again, red and green are not unmitigated blessings in the light line. To the great majority of color-blind men, red and green look alike—that is, they look brown. Few men

are color blind to yellow and blue. I have never seen a good yellow that looked greenish, although your atmospheric conditions may have the peculiarity of changing it to such a hue.

I have seen yellow look reddish as in smoke and sometimes in fog, but have never seen red look like yellow under any conditions, any more than it looks like green to the *normal eye*. Perhaps Mr. Johnson has unwittingly disclosed a defect in his vision and is color blind to yellow and green—(A. H. J.—A. H. R. is smiling as he writes this)—although he apparently saw yellow as a distinctive color when he first suggested it in America, or was he handling his American cousins a lemon in several of its attributes besides color? Now it would appear he is “seeing red!”

In any event, if the beam light signal we are now developing proves a success, we shall have our position signals night as well as day, and the colour problem will be solved by the process of elimination.

Fourth: “Thrice armed is he who hath his quarrel just!” Perhaps a three-arm signal would be preferable to the two-arm which Mr. Johnson apparently advocates, and, if the two-arm system is, as he implies, simpler than the one-arm, how much better the three arms would be, and what a further impression of simplicity on the engineman’s mind a four-arm signal would convey, and so on *ad infinitum*, or, *per contra*, if the one-arm signal “has got many arms in the engineman’s mind,” how many tentacles hook into it from a four-arm signal? How old was Anne?

Mr. Johnson’s simile of a one-armed clock and a two-armed clock is a good one—for his opponent. A child learning to tell time has his troubles, not so much with the twelve divisions for the hour hand, as with the sixty divisions for the minute hand, and the one thousand, three hundred and twenty *combinations of both* (omitting any further subdivisions of minute fractions), and further, if the only real use he makes of it is to indicate meal-times and bed-time, how well a one-armed clock with four positions

would serve his purpose and save his little brain. Why furnish a split-second watch to a man whose only interest in time is the signal to knock off work? No, gentlemen, if you can give precisely the same information with three distinctive positions of one arm alone that you can give with two positions each of two arms in combination, the former is the better way. If you could give all the information necessary with a one-arm clock, would you use the two arm? The minute hand of the clock gives *added* information which it is impossible to convey accurately and definitely with the hour hand. The two-arm two position signal gives no information which cannot be given by the one-arm three position signal as well and even better.

Fifth: If your "signalman does not pull his home signal 'off' if his starter or advance is 'on' until the train approaches it," you are on pretty safe ground—provided he never makes a mistake. You would be on safer ground perhaps if you required the train to stop at the home before it were pulled "off." You are in a *very comfortable* position, however, if you have your home arranged just as you have your distant, so that the signalman *cannot* make the mistake of clearing it at all if the advance is at stop, but can give the indication in such case "Proceed prepared to stop at the advance signal which is at danger," and also are able to give the additional assurance to the driver that, when he receives the home clear, the advance signal must be at proceed; certainly a desirable aid in facilitating traffic in heavy fogs and the like.

Sixth: I am glad to know you were pioneers in route and approach locking—I think I claimed no priority for "us fellows." Our development has been on different lines than yours, however, and whoever started it, we seem to have installed it to a greater extent than you have.

Finally, I agree with Mr. Johnson that the American railway officers are, in the main, good fellows, and you know how we feel about you all. The generous way in which you have received my contributions is highly appreciated. You

might have criticised them so differently and so severely had you so desired; there were plenty of openings left unguarded.

Answering Mr. J. Sayers:

His understanding of our "permissive" practice in manual block signal territory, and in train staff territory is correct. I do not advocate it. I do not defend it, except to say that it has worked very well with us, and that we could not have afforded the block system at all, and so obtained absolute blocking for passenger trains, unless we had employed it, as on roads of thin traffic our pocket-books were too deflated to permit the expenditures necessary to establish and maintain the number of block stations requisite for absolute blocking of freight trains. However, it is done away with on the Penna. main lines where we now have automatic block signals from New York to Chicago and New York to Washington. In manual block territory, a train record is kept at each block office from which it may be seen at a glance which trains have cleared, and passenger trains are blocked against all trains and freights against passenger by reference to this record. In staff territory, the "permissive staffs" or rings make their own record on the same general scheme as the Tyer Tablet System.

Again thanking you for your courtesy, may I express the hope that the conditions which have so greatly restricted the attendance at your meetings may be speedily eliminated to your full satisfaction, and that your absentees may all return unscathed and well, and possibly made better men by their experiences?