

The Rudd-Rhea Signaling Report of the Pennsylvania

Investigation made in 1905 established basis of aspects
and fundamental practices

IN 1903, the management of the Pennsylvania realized that the signaling in service on that road should be harmonized by establishing standards for aspects as well as for the type of protection afforded under various conditions of track layout and train operation. A committee of two was appointed to investigate the system of signaling then in service on various railroads and to formulate standards and requisites for an ideal system of signaling, recommending such changes as were necessary to harmonize the signaling practice on the entire Pennsylvania System. A. H. Rudd, then assistant signal engineer of the Pennsylvania Railroad, and Frank Rhea, then engineer of maintenance of way, Logansport division of the Pennsylvania Lines West of Pittsburgh, were appointed by their respective general managers as a committee to make an investigation and prepare a report.

Mr. Rudd and Mr. Rhea made a detailed study of the signaling on numerous roads in the United States, and this data was combined with information which Mr. Rudd had gathered during a recent trip on the important railroads of Europe. After several months of intensive work, a report was completed and submitted to the two general managers and to the Association of Transportation Officers of the Pennsylvania. Although several counter proposals, as to the system of aspects, were presented, the report, as prepared by Messrs. Rudd and Rhea, was adopted in 1906, and has been the basis of the standardization and development of signaling on the Pennsylvania System since that time.

On account of the plain statements regarding conditions then existing in the signaling system, the Rudd-Rhea report was kept strictly confidential

through the succeeding years since it was prepared, and now on this, the thirtieth anniversary of its completion in August, 1905, release has been given to make public the essential portions of the report.

The Rudd-Rhea report was an outstanding accomplishment in that it recommended and forced the adoption of many important practices which later were adopted so extensively as to be accepted as a matter of course, especially by the men of the younger generation, without realizing the efforts required years ago to establish these standards. On the other hand, certain practices established as being essential on the Pennsylvania in 1905 have not as yet been adopted on some roads. For example, some railroads still use white for clear. Likewise, the necessity for an operative distant signal is not appreciated as extensively as it should be.

EXHIBIT A—COMPARISON OF PRACTICES

SUBJECT	IDEAL	PENNSYLVANIA PRACTICE	LINE WEST PRACTICE	RECOMMENDED
Position of arm for Stop.....	Horizontal.....	Horizontal.....	Horizontal.....	Horizontal.....
" " " " Proceed.....	Vertical above horizontal.....	45° to 85° below horizontal.....	Vertical below horizontal.....	Vertical above horizontal.....
" " " " Caution.....	45° below horizontal.....	Fish-tail arm at horizontal {	45° below and fish-tail arm } horizontal.....	45° above.....
Position of arm for Clear—	45° above horizontal.....	Fish-tail arm at 45° to 85° } below horizontal.....	Vertical below horizontal.....	Vertical above.....
Caution.....	An illuminated arm.....	Red.....	Red.....	Red.....
Color of night Stop signal.....	" " " " ".....	White.....	White.....	Green.....
" " " " Proceed ".....	" " " " ".....	Green.....	Green.....	Yellow.....
" " " " Caution ".....	" " " " ".....	White.....	White.....	Green.....
Color of night Clear—Caution signal.....	" " " " ".....	White.....	White.....	Green.....
Location of signal.....	Masts to right of track.....	To right, on bridges and on } brackets.....	To right, on bridges and on } brackets.....	To right, on bridges and on } brackets.....
Advance block signal.....	Yes.....	Use interlocking.....	Generally.....	Yes.....
Dummy arm.....	Yes.....	No.....	At interlockings only.....	Yes.....
Number arms on high inter- locking signals.....	3.....	1 to 4.....	2.....	3.....
Number arms on Telegraph and C. M. block.....	2.....	1.....	1.....	2.....
Number arms on Automatic.....	1.....	Home and distant.....	1.....	1.....
Number lights on high inter- locking signals.....	3.....	1 to 4.....	2.....	3.....
Number lights on Telegraph and C. M. block.....	2.....	1.....	1.....	2.....
Number lights on automatic.....	2.....	2 and illuminated "A".....	1.....	2.....
Semi-automatic.....	Yes.....	Only in automatic districts.....	Only in automatic districts.....	Yes.....
Route signaling.....	Yes.....	No regular practice.....	High speed only.....	High speed only.....
Speed signaling.....	Yes.....	Partially.....	High and low only.....	High, limited high and low.....
Distant signals.....	All signals (no T. O. used).....	Generally for int. and auto.....	Generally for int. and auto.....	For all except T. O. signals.....
Distant switch indicator for day.....	Should be no use for it.....	Regular fish-tail dist. signal.....	Regular fish-tail dist. signal.....	Special signal.....
Home " " " " ".....	" " " " ".....	Regular switch target.....	Regular home signal.....	Special signal.....
Distant switch indicator for night.....	" " " " ".....	Green and White.....	Green and White.....	Yellow and Red and 2 Lunar White.....
Home " " " " ".....	" " " " ".....	Red and White.....	Red and White.....	2 Red and 2 Lunar White.....

In view of the fact that the subject of signal aspects is now again being studied so extensively on many roads, *Railway Signaling* is pleased to have this opportunity to present an abstract of the essential features of the Rudd-Rhea report, in order that those interested may have an opportunity to benefit from this record concerning the fundamental features of signal aspects and practices.

When studying the following abstracts of this report the readers should keep in mind that, in 1905, the standardization of signal aspects and practices was in its infancy. At that time interlocking and manual block signaling formed the major part of signaling work. On the Pennsylvania, the same as on certain other roads at that date, the signaling represented an aggregation of dissimilar devices which had been installed according to no particular standards. Aspects and indications were, in some instances, conflicting in meaning. As a general rule, lower-quadrant, two-position semaphores were in use. Semaphore blades were of various shapes, sizes and colors. Fish-tail blades were used for distant signals, square-end blades for other purposes. The position aspect of the blades did not in all cases correspond with the color aspects at night. On some home signal masts the blade for the through main route was longer and wider than those for diverging routes. The blades were located on the mast on the basis of top-arm to the right, so that the blade for the through route might be at the top in some places, but at the bottom or intermediate at others. Furthermore, the colors used for night aspects were fundamentally wrong, white being used for "clear," green for caution and red for "stop," this system having the defect that a broken red roundel resulted in the display of a false-clear night aspect.

Changes Recommended

The more important changes recommended in the Rudd-Rhea report were:

1. Discontinue the use of two-position, lower-quadrant signals, and adopt the three-position, upper-quadrant signal.
2. Eliminate the use of white for the "clear" aspect for night indications, and adopt green for "clear," yellow for "caution" and red for "stop."

For the "stop" aspect of dwarf signals at night, Mr. Rhea recommended a dark red (photometric value 50 to 75), while Mr. Rudd suggested the use of blue-purple. One reason advanced for the use of the blue-purple was to prevent confusion with other signals and to eliminate chances of dwarf signals being mistaken for red lanterns carried by flagmen.

(Blue-purple was adopted for this aspect

and was used for years on this road.)

3. The system of aspects and indications included in the report is reproduced in an accompanying illustration. This system was based on the use of a one-arm, three-position, upper-quadrant semaphore, with a marker light for all automatic block signals, except for the use of a two-arm signal for an approach signal for an interlocking.

The home interlocking signals were based on three arms each. The fundamental feature of the interlocking signals was "speed-signaling" in contrast to "route-signaling," the top arm directed train movements on the through high-speed track, the second arm governed for medium-speed movements over crossovers or turnouts, and the bottom arm governed low-speed movements.

General Principles and Requisites

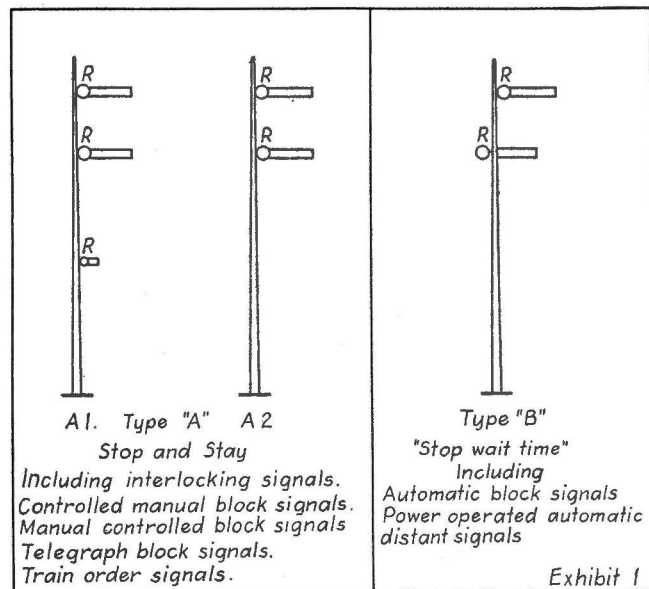
The essential part of the report was given under the heading "General Principles and Practices," the portion

lights and arms giving same aspect = "Stop" and "Proceed" signals. Color of light always corresponds with position of arm.

(b) The arm of a high or limited-high-signal in the "Caution" position is a distant signal, is used in connection with a home signal for a high-speed or limited-high-speed route, and regulates the approach thereto. A high-speed signal inclined at an angle of 45 deg. above the horizontal indicates "Caution; proceed prepared to stop at next home signal." Inclined at an angle of 90 deg. above the horizontal indicates "Proceed at speed." High-speed signal at 45 deg. and a limited-high-speed signal at 90 deg., indicates "proceed on the limited-high-speed route."

(c) The arm of a low-speed or dwarf signal in the "Caution" position indicates that movement is to be made against traffic, or into a siding where no other signal is provided, or with traffic, with the advance signal at "Stop." In the "Clear" position, it governs a movement with traffic, with advance signal "Clear."

2. The construction must be such that



General types of signals recommended

of the report applying to wayside signals for directing train movements being given as follows:

1. All interlocking and block signals must be of the regulation semaphore pattern, to consist of a mast with movable arm or arms pointing to the right. The position of the arm indicates how trains shall be governed, as follows:

(a) An arm in the horizontal position indicates "Stop;" inclined at an angle of 45 deg. above horizontal indicates "Caution;" inclined at an angle of 90 deg. above horizontal indicates "Proceed." At night these indications will be shown by colored lights as follows: Red for "Stop," Yellow for "Caution," and Green for "Proceed."

Two full-size lights and arms, and no more, are to be displayed on all signals except dwarf signals, the absence of either showing on the signal itself that it is improperly displayed.

Lights in vertical line and full-length arms "Stop" and "Stay" signals. Staggered

any failure of part or parts controlling a signal shall cause it to display the "Stop" or "Caution" indication as necessary to protect the point where failure occurs.

3. All semaphore arms must point to the right, as viewed from the track signaled in the direction movement is to be made.

4. A separate mast must be used for each track signaled.

5. Each signal must be placed, whenever practicable, on the right-hand side of the track signaled. Where this is not practicable, a bridge or a bracket post may be used, but the latter must not be used where more than one track intervenes between it and the track signaled, and, when a bracket post is used, it must be placed to the right of the track signaled, and a short mast must be used to indicate the intervening track which is not signaled, and this mast must be provided at night with an illuminated white disk displaying the letter "S."

6. Advance signals must be used for

High, limited and low speed signals						
Stop and stay	Proceed with caution to next signal on high speed tracks.	Proceed at speed on high speed track.	Proceed with caution to next signal on limited speed tracks	Proceed at limited speed on limited speed tracks.	Proceed with caution on low speed tracks.	Proceed at low speed on low speed tracks.
Dwarf signals			Telegraph and controlled manual block signals and train order signals.			
Stop and stay.	Proceed with caution on low speed tracks.	Proceed at low speed on low speed tracks.	Stop and stay	Permissive train in block	Proceed with caution to next	Proceed at speed
Note:- Train order signal in block limits to be an illuminated letter "O" displayed on post of home interlocked or block signal as convenient.			Exhibit 2			

block signals at interlockings which are block stations.

USE OF HIGH SEMAPHORE SIGNALS

1. High-speed or limited-high-speed semaphore signals must be used at interlockings to govern movements from main or running tracks in their right direction to main or running tracks in their right direction, except where low speed is required.

2. Low-speed semaphore signals must be used at interlockings to govern movements from main or running tracks in their right direction to all other tracks where low speed is required.

3. High semaphore signals must be used to govern trains at telegraph and controlled-manual-block stations.

4. High semaphore signals must be used to govern trains at train-order stations which are not in block limits.

5. High semaphore signals must be used for automatic block signals.

6. High semaphore signals must be used for all distant signals.

USE OF DWARF SIGNALS

1. Dwarf signals must be used at interlockings to govern main or running tracks in their reverse direction, and all other tracks in either direction.

2. Dwarf signals may be used at interlockings to govern main or running tracks in their right direction at terminal points.

USE OF DISTANT SIGNALS

1. Distant signals must be used to repeat the indication of all interlocked, telegraph-block and controlled-manual-block signals, except where the speed of trains is restricted to slow movements by local conditions, and must indicate "Proceed"

for high-speed or limited-high-speed routes only, and the distant signal in every case must be controlled by the advance signal and all intervening signals.

2. When interlockings are absolute block stations, the interlocking must be so arranged that the cleared distant signal will indicate that the block is clear.

3. When interlockings are permissive block stations, the interlocking must be so arranged that the cleared distant signal will indicate that the block signal is "clear" or "permissive," and if permissive that the track is clear a sufficient distance in advance to allow a train to be brought under full control.

4. Distant signals should not be used with train-order signals which are not in block signal limits.

NUMBER OF ARMS AND LIGHTS

1. Three arms must be used on all high home interlocked signal masts, the top arm to govern the high-speed route, the middle arm to govern all limited-high-speed routes, the lower arm to govern all low-speed routes. Where there is no high-speed route, the top arm must be fixed in the horizontal position; and where there is no limited-high-speed route, the middle arm must be fixed in the horizontal position; and where there are no low-speed routes, the lower arm must be fixed in the horizontal position. One light of proper color shall be used at night to indicate the position of each arm on the signal mast. No more than the high-speed, the limited-high-speed, and the low-speed signal arms shall be used on a home signal mast. Our recommendations require dummy arms to be used throughout.

2. Two arms must be used on all telegraph block, controlled-manual block, and train-order signals, the top arm giving the right to proceed, and the lower arm to be fixed in horizontal position. One light of proper color shall be used at night to indicate the position of each arm on the signal-mast.

3. One arm only will be used on automatic signals, excepting at the first automatic signal approaching an interlocking; and one light of proper color shall be used at night to indicate the position of the arm. In addition there shall be a second light six feet below and two feet to the left in staggered position, to indicate an automatic signal.

The aspects for automatic block and power-operated distant signals are shown in the four aspects 15, 16, 17 and 18, Exhibit 3. These results are accomplished by placing the lower staggered light six feet below and two feet to the left, and adding thereto a second arm on all signals of the "Stop" and "Proceed" type; thus making the aspect of automatic and distant signals uniform and further enabling us to carry out the principle that one light or standard arm displayed alone on high-speed signals indicates "Stop." For regular automatic signals, aspects 15, 16 and 17 only will be used. For automatic signals approaching an interlocking where a medium speed movement is made, the lower arm and light will become operative and aspect 18 will also be displayed. At outlying power-operated automatic distant signals, aspects 16, 17 and 18 will be shown. This makes all distant signals uniform, and classes them under their proper type.

4. No back light shall be used on any

interlocking, telegraph, or controlled manual block, or train order semaphore signal.

LOCATION OF SIGNALS

1. Interlocking home signals must not be placed in advance of the first fouling point or point of danger which they protect. When desirable, they may be placed in the rear of such fouling point. They must be located on the right-hand side of the track which they signal, or, if on a bridge, over the center of the right-hand inter-track space.

2. Telegraph and controlled manual block signals must be located on the right-hand side of the track which they signal, or, if on a bridge, over the center of the right-hand inter-track space. When connected with an interlocking, they must be located as advance signals.

3. Distant signals must be placed a proper distance in the rear of their home signals to allow the fastest train to stop before reaching the home signal, and must

semi-automatic, and so arranged that they would indicate "Stop" as soon as the front end of the train passes.

2. All high semaphore signals, mechanically operated to be pipe-connected.

3. No high-speed interlocking signals should be worked through mechanical selectors.

4. Approach locking should be used in connection with all high-speed signals at interlocking.

5. All distant signals should be power-operated, semi-automatic.

PERMISSIVE TELEGRAPH OR CONTROLLED MANUAL BLOCK

Although provision has been made for the permissive telegraph, and controlled manual block, it is our belief that the permissive block under manual control should be abandoned as soon as practicable, for the reason that it is wrong in principle, and impossible to signal properly. All manual blocking should be made absolute.

4. At each signal an indication must be given for at least two blocks in advance.

5. Track circuits must include all turn-outs up to the fouling point.

6. All switches in turnouts, and both ends of crossovers, must set signal to "Stop," when moved from their normal positions.

Spacing of Automatics

Your committee believes that one mile is the proper spacing of automatic signals at ordinary high-speed points; that there are some exceptional high-speed points where it will be advisable to extend the "Caution" indication over two miles. Usually at such points the movement in the opposite direction is slow, and it is frequently desirable to space signals closer, which, whenever conditions will warrant, should be one-half mile apart, thus enabling the signals to be kept in groups. There are special situations, however, of some extent where your committee feels that the signals in one direction should be a mile apart, and on account of the condition of grade in the opposite direction should be some regular distance greater than a half-mile, but less than a mile to provide properly for the traffic, and, therefore, we feel that the spacing of automatic signals should have special consideration for each installation. Particularly on single and double track where ordinary poles are used, when the location of signals brings them at a curve, we think that it is very desirable to break the spacing sufficiently to give a good view in approaching the signal, even at the sacrifice of some irregularity in spacing.





With proper placing of signals, it is as a rule unnecessary to have more than two block indications. If it becomes necessary to provide more than three aspects, this can be done by the addition of another arm, which can be made, if desired, to indicate the condition of four blocks; but the committee believes that it would be better to keep the trains apart by extending the "Caution" indication over two blocks instead of one.

Although it has been stated that permissive automatics are necessary at some points, this is not concurred in by the committee. If it becomes necessary to provide for them, we would suggest that a yellow light be substituted for a red light in the staggered position for the night "Stop" indication, and the placing of a letter "P" immediately above this staggered light, thus indicating the permissive signal by day with the arm in the "Stop" position and the letter "P" displayed, and the permissive indication at night by a red light above the yellow staggered light.

Aspects of Type "B" or "Stop, Wait — Time Signals.

Automatic Block Signals

Power operated Automatic Distant Signals.

 <p>15</p> <p>Stop and proceed after waiting-time.</p> <p>Not to be used for distant signals outside of automatic block signals.</p>	 <p>16</p> <p>Proceed to next signal prepared to stop.</p>	 <p>17</p> <p>Proceed at speed next high speed signal at caution or clear.</p>	 <p>18</p> <p>Proceed at limited speed, next limited speed signal at caution or clear.</p> <p>Not to be used except when limited speed movements occur. Exhibit 3</p>
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be located on the right-hand side of the track which they signal, or, if on a bridge, over the center of the right-hand inter-track space.

4. Train-order signals must be located on the right-hand side of the track which they signal, or, if on a bridge, over the center of the right-hand inter-track space.

A train-order notice in block districts, when necessary, is to be provided by displaying an illuminated "O" on the home interlocking signal between the limited-speed signal and low-speed signal, when orders are to be delivered. When the "O" is displayed, the block signal will indicate "Stop." When orders are to be delivered at a block station which is not an interlocking, the illuminated "O" will be displayed below the lower arm, and the block signal will indicate "Stop."

All signal arms must be painted a color which will show most conspicuously against the background. It is desirable to keep this color as uniform as possible, but, when adverse conditions prevail, the most suitable color should be used. The square end arm in present use should be continued.

MANUALLY OPERATED SIGNALS

1. All interlocking high and limited-high-speed signals, telegraph, and controlled manual, block signals should be

It is the feeling of the committee that, with rearrangement of some points, it would be practicable to eliminate in the near future permissive blocking, and that this end should be worked to as fast as possible, but where used it should be only for a freight following a freight. The block signal should be made semi-automatic, controlled with a track circuit at least three-quarters of a mile long, to permit trains to be brought under full control after passing the permissive signal. If the first train is inside of these limits, a block cannot be made permissive, and, if necessary to have a train enter the block, it will have to be done by a hand signal.

AUTOMATIC SIGNALS

1. All automatic signals must be one-arm three-position provided with an additional light three feet below the regular semaphore lamp, and staggered two feet to the left, except at distant signals approaching an interlocking where two three-position signals will be used, with a light staggered two feet to the left, three feet below the top semaphore lamp, and three feet above the lower.

2. All automatic signals must be operated normally clear.

3. Track circuit must be used to control all automatic signals.

The rules requiring a train to stop for an interval when encountering an automatic signal indicating stop and then proceed, should be restored; the present rule to simply "stop and proceed" should be discontinued. This interval, we think, should be at least one-half a minute, but would recommend the old rule of one minute.

At night, when a signal light is extinguished, but the position of the arm can distinctly be seen, it is unnecessary to have this interpreted under Rule 27 as an imperfectly displayed signal, requiring train to stop. It would be well to revise the rule accordingly.

Supplementary Report

Realizing that arguments might well be presented for or against certain of the suggestions in the report, the committee prepared supplementary comments, which were attached to, and formed a part of, the complete report. This supplementary report gave detailed arguments on certain subjects such as, green vs. white for "clear," upper-quadrant vs. lower-quadrant, normal-clear vs. normal-danger, and the use of electric locking controlled by track circuits. As several of these practices, as recommended in the report, have long since been adopted on practically all of the roads, some of the discussion as given in the report on these subjects is omitted in the following abstract. However, those discussions applying to certain fundamental practices are given herewith in extended abstract form, as follows:

1. *Non-uniformity of indications:* Fundamentally the square-end semaphore arm, horizontal, and a red light in addition, meant "Stop." At present it may mean "Stop for orders"; "Stop, the block is occupied" (absolute telegraph block); "Stop, and proceed, the block is occupied" (automatic block); "Stop, the route is not clear"; "Stop, and look to a cabin for order, flag or light"; "Stop here if you can, but if not, stop anyway at open drawbridge a thousand feet or so ahead"; "Stop, open switch."

The fish-tail arm was introduced to give advance information. In the horizontal position, with a green light, it may indicate "Caution, switch is open ahead"; "Caution, block signal is at 'stop'"; "Caution, block signal is at 'permissive'"; "Caution, interlocking signal is at 'stop'"; "Caution, automatic signal is at 'stop'"; and a green light may also mean, enter block permissive.

On the Lines West, a square-end arm, inclined downward 45 deg. means next signal is red; so does a

fish-tail, in the horizontal position. On the Lines East, a square-end arm, inclined downward from 20 deg. to 45 deg. is taken as a permissive signal, while any angle between 30 deg. and 85 deg. is considered clear; in fact, we have seen distant signals accepted as "clear" on a hot day when inclined 15 deg., and rejected on a cold day in the same position. As home signals are displayed "clear," they may indicate (except on the Lines West within automatic limits) that a block four miles long is clear, or that the route is set up (though there may be a train within one hundred feet or a signal at "Stop" within three hundred feet).

In each case it may be argued that the red light means "stop" and the green light "caution," and, if these indications are decided to be all that are necessary, a large part of our work has been useless; but we have felt it necessary to provide for the different indications noted above, as far as possible, without undue complications, as will be seen in our recommendations.

2. *Signals sticking in clear position:* Such failures can never be entirely eliminated in any automatic system, but improved apparatus is constantly reducing the chances, and we believe the semaphore casting recommended is a further step in this elimination process.

3.—*Broken glasses, white light where red should be displayed:* Covered by recommendations that white light be eliminated as a clear signal.

4. *Signals over-run on account of light out:* Practically eliminated by use of two lights on each signal, and the increased reliability obtained by improved burners protected with chimneys.

5. *Signal connections out of adjustment, resulting in wrong or indistinct indications:* Eliminated by power-operated signals and almost eliminated by use of pipe connections to home signals.

6. *Distant signal clear, home signal at stop:* An unusual case, but a possible one, closely related to defect No. 2, with like remedy. Eliminated at interlockings by use of properly installed approach locking.

7. *Tail lights mistaken for dwarf signals:* Eliminated by use of different color or shade of light for dwarf signals in "Stop" position.

8. *Power-operated switches thrown under trains, through detector bars being valueless at high pressures:* Eliminated with proper maintenance by use of electric locking.

9. *Operators changing route, after train has accepted clear signals:* Elim-

inated by use of approach locking.

10. *Clear signals given with switch locked in wrong position, through breakage of connections:* Reduced to a minimum by use of electric locks on switch levers, or special arrangement of bolt locks.

Three-Position Signal

The square-end home signal with fish-tail distant arm underneath (the usual form of automatic block signal on the Lines East) is difficult to distinguish at any distance from a two-arm home signal; the shape of the arm is not sufficiently distinctive, and colors are hard to maintain on a road using bituminous coal. At night, separate and distinct indications are given for "Stop," "Caution," and "Proceed." We, therefore, believe the reasons are sufficient to warrant a distinctive position for the "Caution" arm by day. The arm extended is the natural "Stop" signal; the "high-ball" is universally used for "come-ahead"; the logical and natural indication for "Caution" is half way between "Proceed" and "Stop"; lastly, to be consistent, the position for "Stop" should not be used for the position for "Caution."

The determining factor, however, which has led one of the committee to his decision, is the peculiar function of the three-position home signal at interlockings where, by its use, traffic may be facilitated and a bad practice removed, which now prevails over the system, except within automatic signal limits on the Lines West. This function would be of the greatest value at large terminals, and consists in displaying the home signal in the caution position when the route is clear and next signal at "Stop," thus carrying the distant indication through consistently, instead of, as is our practice, holding the distant at "Caution" and then displaying the home "Clear" with the advance at "Stop," instead of showing the home also in the caution position. It is true that this indication might be given with the home and distant two-position system, but another arm or arms would be required.

Location and Number of Arms

At the first interlocking installed, the old English system of top arm governing to track farthest to the right was employed, and is now used on one important line in this country. Any one of four arms may govern the high-speed route, depending on the locality. A longer arm is used for the main track, but at night a longer light has not been found practicable. This requires an engineman

to carry a map of each place in his mind. The next development was the use of the top arm for the main running track, second arm for diverging to the right, third to the left, etc. In many cases there was no route to the right, and sometimes none to the left.

Speed-Signaling Developed

We developed various arrangements when we got to four-track working, preserving the feature of top arm for main route, and other arms as convenience or special conditions dictated, except that, until recently on the Pittsburgh division and for some time uniformly on the Lines West, two arms only were used, the lower governing to all diverging routes. Other roads, notably the Chicago & North Western, Erie, Delaware, Lackawanna & Western, introduced a dwarf signal at the foot of high posts, when needed to govern slow-speed routes, as into sidings or against traffic. This was most fully worked out on the Delaware, Lackawanna & Western; the top arm governing the main running track, second high arm to any other running track, and "route signal" (so called to distinguish it from the dwarf standing alone) to sidings and reverse direction tracks. Finally, this system has, within the last two years, been fully developed at some points on the Pennsylvania Lines East, establishing the principle of signaling speeds, instead of tracks.

The top arm governs the movement at the highest speed possible at each place; the second arm to all diverging high-speed routes, that is, over No. 15 and 20 cross-overs; and the low-speed arm, or route signal, to all diverging routes over turnouts where low speed is required.

The committee endorses this scheme, but goes farther and recommends that instead of one, two or three arms only, the two high-speed and one low-speed arms shall always be provided, whether or not the routes exist, so as to differentiate between the different signals, and suggests further that in reality by use of the three-position signals, six speeds are signaled.

Power Distant Signals

The use of power-operated distant signals is regarded as almost a necessity by nearly all signal engineers, and it should be insisted on in all cases. A pipe-connected distant signal is as expensive as a power-operated one, if located at any distance from the cabin; a wire-connected one, if located more than 1,200 ft. from

the cabin, cannot be relied on, and must have inspection on each change of temperature to keep it in proper adjustment. The connections are easily interfered with, and if back wire breaks, signal may go to "Clear," while if the front wire fouls, the lever may be put normal by stretching the back wire with the signal remaining at "Clear"; besides this, distant signals, to be effective with our high speeds under all conditions, must be located anywhere from 3,000 ft. to one mile from the cabin, and cannot be operated mechanically. Power-operated signals always give a uniform throw, and proper electric locking prevents a change of route, if by any possibility they should stick "Clear."

Use of Advance Signals

The use of advance signals at all interlockings is necessary if the remainder of recommendations for permissive signals and order notices are adopted, for two reasons:

1. The present method of indicating "orders" in block signal limits is crude; it requires an engineman to look to two different places for orders to proceed, and finally leads to confusion on a three or more track line.

The scheme is to stop a train at the home signal, then display an illuminated letter "O," and, after the engineman has acknowledged it, to clear the home signal, and allow the train to proceed to the cabin, or, if route is not clear, to hold it at the home. If engineman should disregard the "O," and proceed past the cabin, he would be held by the advance block signal, and it is, therefore, necessary. In automatic limits, the advance signal is generally now provided, and in such cases it would have to be made semi-automatic, and placed under control of the operator.

2. The proposed permissive cannot be given at the interlocking signal if there is a diverging route, and, as a matter of principle, should be given at the block signal only, although, as another matter of principle, it should not be given at all. This phase is, however, discussed later.

An engineman running 80 miles per hour, with mile blocks, must pass a signal every 45 sec., must be continually on the lookout, and must think and decide on the instant. With matters on the engine itself requiring constant attention, it is not fair to expect him to attend to them, watch his track, switch lights, etc., and then take in the entire landscape hunting for signals, sometimes on the left of the tracks, and sometimes outside three or four tracks on the right. Signals should be located, whenever prac-

ticable, on the right-hand side of the track signaled. In the opinion of the committee, it should always be practicable.

Mr. Rudd's recommendation is that a rule be made, requiring room for a ground post or bridge leg next to the main track, and that, without any exception whatever, sidings must be thrown out to proper centers, and no blind, bracket posts be allowed, and he further believes that signals on bridges, bracket posts and ground posts should be as nearly as possible of equal height for further uniformity.

Permissive and Automatic Blocking

These subjects are so closely related that they will be discussed together. As an ideal system of blocking, your committee would recommend the manual-controlled block with continuous track-circuit protection, and blocks approximately one mile long. This would embrace all the advantages of the automatics, while retaining the absolute block feature, policing the railroad every mile, checking the men in disregarding signals, and, in case of failure, removing the trouble at the earliest moment. The cost, however, would doubtless be considered prohibitive, but the fact remains that the absolute block, fully observed, is the only entirely safe way to handle trains.

Theoretically, the automatic block is absolute, yet we make it permissive for all trains alike after one minute, and lately we have gone still farther toward the permissive feature, by eliminating the one-minute wait; the next logical move would be to eliminate the stop, thus making the automatic system completely permissive. We hope the wait-a-minute rule will be re-adopted: (1) it gives a man time to look about and get his bearings; (2) it gives time for the block to clear, and a man can make better time through the block if he knows it is clear than if he is running on sight; (3) it is safer, as, if there is a breakdown, the flag has more time to get back.

Increase Waiting Time

Failures are few, and if all trains were run at equal speeds, we should recommend at least a five minute stop, but, with varying speeds, the blocks must be long enough so that the fastest light trains, and heaviest freight trains on grades, with low-braking power, can be stopped between signals, and this means that slow trains must follow in under the red automatics, in order to get over the road; we must, therefore, recognize that the

permissive feature is necessary in the automatic system, but let us make it permissive after a stop and wait of one minute, remembering that if two trains do get together they endanger not only themselves but fast trains on adjoining tracks.

The automatic gives definite notice that a train is in the block and generally within less than a mile; the telegraph block, as we use it, shows that one may be within 50 ft. or away four or five miles; the privilege is abused, the speed is entirely too fast "under the green," and, on the Lines East, passenger trains are allowed to follow freights permissive under certain conditions. Finally, all depends upon the operator; he may give a permissive signal to a passenger train, thinking it a freight, and the engineer, knowing that he generally receives this signal only when a freight is to take a siding with time to do it and 10 minutes beside, runs at his usual speed under such conditions. This danger could be eliminated by not allowing passenger trains to accept the permissive signal. Again, the operator may leave his signal clear for three or four trains; this could be prevented by making the signals semi-automatic, as recommended. Lastly, he may give a clear signal with a train in the block; this can only be prevented by extending the track circuit clear through, and so arranging the circuits that signal shows "stop" until the train has passed a prescribed point, then may display green until another train enters, but cannot be cleared until the block is clear. This is the only reasonably safe way to operate, but if we go that far we might as well shorten the blocks, install automatics, and enforce discipline.

Final Conclusions

It is true, we have not had wrecks daily, but we have had good men and good luck. The change may come any time, and it would seem safe to stop against it. Trains are now stopping at signals westbound between Altoona and Gallitzin; this we think proves that they can stop and start anywhere, and the "permissive automatic" will not be needed. As to giving more than two block indications, we are opposed to it, and believe it would be better and safer on heavy descending grades to make the blocks so long that trains may release and recharge between signals, even if this requires signals two miles apart.

Our last conclusion is that the spacing of block signals is a matter to be studied in each particular case; that no hard-and-fast rule can be laid

down; and that sufficient expert work has not been done on this important matter in the past, with the result that at many places the blocks are en-

tirely too short for fast running. They should be spaced to meet not only our present but our future needs as far as we are able to gage them.

Rules for Federal Grade Crossing Work

THE GOVERNMENT rules and regulations to control the federal railway-highway grade crossing elimination and protection program proposed under the Emergency Relief Appropriation Act of 1935, which rules and regulations were prepared by the U.S. Bureau of Public Roads under the Secretary of Agriculture, were approved by the President on July 12 and were promptly released by the Division of Applications and Information of the National Emergency Council.

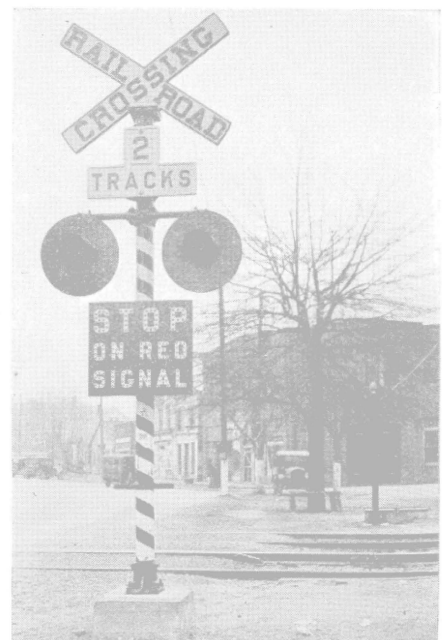
As expected, the rules and regulations have been built around the central thought behind the Emergency Relief Appropriation Act—employment for those on the relief rolls of the country—and thus they call for the expenditure for labor of so large a percentage of the money made available, that in this respect they may handicap or block entirely many projects, unless, as specifically provided for, the individual states agree under an alternate plan to assume the cost of added unemployment relief, in which case their grade crossing work will be relieved of the high labor-materials ratio stipulated. (For details of this plan see page 81 of the *Railway Age* for July 20).

Grade crossing protection is approved in lieu of grade separation for certain classes of crossings, and decision in this matter is left with the state highway departments, except that it is pointed out that the federal bureau may require, as a part of the federal program, the protection of specific important crossings, not already protected by acceptable devices, if it is found that elimination or separation of grades at these crossings cannot, for one reason or another, be accomplished with the federal grade crossing funds. Wide latitude is given in the matter of grade crossing protection, it being stated specifically that flashing-light signals, crossing gates, barriers, or other similar devices, satisfactory to the state highway department and the railroad affected, may be recommended.

The three following requirements are set up as regards acceptable flashing-light-type signals: (1) Recommended standards for flashing-light signals adopted by the Joint Committee on Grade Crossing Protection of the Association of American Railroads; (2) flashing-light signals con-

forming essentially to the standards recommended by the Joint Committee on Grade Crossing Protection of the Association of American Railroads which carry additional features such as a rotating disc or other devices which do not impair the operation nor detract from the uniformity or utility of the signals; and (3) wig-wag signals of the magnetic type having standard signs and mounting height, a balanced outline reasonably in keeping with stationary lights with backgrounds, and an aspect, when operating, essentially the same as flashing lights.

As regards protection installations, it is required that, before federal funds may be used for any such installations, a definite agreement must be entered into by the state highway department and the affected railroad with respect to the maintenance of the installations. It is also required that plans and specifications for work of this character shall be in sufficient detail to define or describe the exact kind and quality of materials required, or in the case of an operating mechanism, to cover fully the essential requirements of the operating parts so that there may be effective competition in the purchase of materials or parts going into such installations.



Signal at crossing of Highway 21 and Southern track at Pineville, N. C.