THE PRINCIPLES OF RAILWAY SIGNALING

BY A. H. RUDD.*

This article is a reply to the paper by L. R. Clausen read before the Canadian Railway Club, Montreal, Que., on March 7, 1911, and published on page 92 of The Signal Engineer for March under the title, "Signaling Practice on Steam Railways". Mr. Clausen's review of the subject and his arguments supporting the minority position were in the nature of a reply to a previous paper read by Mr. Rudd before the same club in November, 1910.

The illuminating treatise on signaling presented by L. R. Clausen at the recent meeting of the Canadian Railway Club, which appeared in *The Signal Engineer* for March, strikes a popular chord. Mr. Clausen's statements are so clean cut and his logic so convincing that it appears almost useless to attempt to controvert it; while his personality is such that he inspires confidence in any audience he addresses. His sincerity is so obvious and his mastery of the subject so great that his statements carry conviction with them, and yet—there are some who disagree with him; and as his paper was presented as an answer to my address before the Canadian Railway Club in November, "so as to remove any wrong impression," its members "may perhaps have gained" from my remarks, I venture to continue the discussion in these columns.

His historical review is most interesting. Two points are especially worthy of attention; one is the statement showing how the various recommendations of the Signal Practice Committees (Committee No. 1 of the Railway Signal Association and Committee No. 10 of the American Railway Engineering Association) changed from year to year, and the other the reference to the paper read by Frank Rhea in Boston, in 1899, before the Railway Signal Association. While it is true that the committee reports changed from time to time, under the influence of continued discussion, the differences were largely of detail, such as rearrangement of indications, one year appearing as primary and secondary, another as requisites and adjuncts, following the American Railway Association forms, and the basic principles have been practically unchanged throughout the discussions and are still considered sound by many members of the committee. The majority, however, has had no monopoly in these changes. The minority has modified its proposals a number of times, and in fact, the clean cut proposition of employing a one-arm three-position signal as representing the acme of signal perfection, and the ideal to which present and future generations may eventually attain, was first presented publicly as its solution of the problem, March 7, 1911, in Montreal. Previous to that a low-speed arm was provided, marker lights were considered allowable, etc., so that it seems to me all arguments, even inferential, that a scheme should be discredited because it has changed in minor details after three or four years' discussion, apply equally to both schemes and should carry weight against neither.

It is certainly a joy at last to behold this one-armed sentinel of the rail in all his purity, pristine freshness, and simplicity uncovered to the public gaze; and we are led, after all this turmoil and discussion, to wonder from what source this gentle being sprang. Was he a product of revolution or evolution? Was he born or "just growed"?

Listen to the voice of the prophet, Frank Rhea, in his Boston paper in November, 1899, who, after advocating a one-arm, one-light, three-position automatic signal, says:

"Let us now consider the three-position signal used in connection with interlocking. It has become the generally prevailing practice to use two arms on all high, home, interlocking signals, where there is a high-speed route and one or more slow-speed or diverging routes, the top arm governing the high-speed route, and the lower arm all the slow-speed, or diverging routes. The proposed arrangement of the three-position signal would govern the high-speed route when the signal is in the vertical position, or shows a white light at night. When the arm is in the 45-deg. position, or shows a green light at night, it would govern the slow-speed, or diverging routes. With this method of signaling we would make a characteristic difference between the high-speed route and the diverging routes, and would carry out in practice, the giving of a low-speed or caution signal, when a movement is to be made at a low speed. At present, the usual practice is such that, if one of the lights goes out at night the engineman has no means of ascertaining when he is approaching a signal, whether he is receiving the indication for the high-speed or the low-speed route, except as he may be able to remember at what heights the respective signals are located.

The three-position signal used in connection with interlocking has decided advantages in the way of economy, as has the three-position automatic system. It would require only one-arm poles which in itself would be a considerable saving. A three-position signal, however, would have to be operated with pipe connections, but as it is the practice on a number of roads to use pipe-connected home signals, this would still effect the saving of the connections to the lower arm. This, of course, would mean a proportionately fewer number of connections to be maintained, and care of the smaller number of lights would mean, in its turn, a corresponding saving."

The subsequent discussion which appears in the Railway Signal Association Digest, Vol. II, pages 33 to 43, inclusive, is well worth reading.

Truly the minority are on a firm foundation, standing now where Rhea stood 12 years ago. I had hoped some common ground could be found on which we could stand in agreement, but now, alas, Rhea has progressed.

Operating conditions have greatly changed in the past 12 years. The introduction of long crossovers has provided a second high-speed route (45 to 50 m.p.h.) which should be indicated if the facilities provided are to be utilized. The greatly increased installation of automatic signals has emphasized the necessity for a differentiation between them and interlocking, or manual block signals, and the recognition of permissive block working as proper practice has further complicated the situation. Was Mr. Rhea's proposal of 12 years ago of such a character as to be considered a finality?

The minority, as Mr. Clausen terms it, has at last definitely set forth its proposition. "The indications, *Stop, Caution* and *Proceed,* given by the three positions of a one-arm signal, are entirely practical, sufficient and adequate to safely control the movement of trains at interlockings as they will elsewhere." Are they? Only two questions are involved. We all want simplicity; we all concede the simplicity of a one-arm signal, but (1st), can we safely use it in connection with signals already installed? and (2nd) can we handle or facilitate traffic with it?

Records show that some railroads in this country have operated for years safely and fairly expeditiously, under normal conditions, without any signals. It would be puerile to claim that they could not operate in the same way if signals at established and well-known locations were substituted for flagmen, and that is exactly what Mr. Clausen proposes, without, however, supplying any substitute for the verbal information so frequently vouchsafed to the engineman by an intelligent flagman, leaving him with even less knowledge of conditions than was supplied by the traditional section man: "Why did you stop us?" "I don't know why, the boss told me to." "Where is he?" "Down below about half-a-mile, where the bridge is washed out." While this procedure might be permissible on a road having no other signals in service, it is questionable whether it would be advisable on one already well signaled with separate arms for diverging routes at interlockings. A practical demonstration would be the most satisfactory means of settling the question.

The second phase, however, is the important one, viz., could we handle or facilitate our present traffic by its use? To operate safely with such a system giving only one caution indication, only one degree of caution would be permissible, and that is the degree requisite for safe operation under the most unfavorable condition for which caution would be displayed. Any exercise of "common sense" or good judgment (?) on the part of the runner might lead to disastrous results.

In view of the change in operating methods in the 12 years since Mr. Rhea first promulgated the proposal the minority is now advocating, while granting for the sake of argument that

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the proposal was sound and adequate for our needs 12 years ago, some of us feel that it is not sufficient for present day requirements. To cite examples:

First: Given a dense, slow, heavy freight traffic interspersed with a number of high-class high-speed passenger trains scheduled for a stretch of perhaps 15 miles at 75 to 80 miles per hour. A safe braking distance allowing for all foreseen contingencies is, say, 1½ miles, but blocks of this length are too long for the operation of the freights, as it would certainly tie up traffic to require the slow freight to reduce speed to the rate required if it were to take a No. 10 crossover and move into an occupied yard at the signal 1½ miles from the point of obstruction. But if the first signal indicated, "Pass next signal at medium speed," and the second signal indicated, "Prepare to stop at next signal," the requisite information would be given and the blockade avoided.

Second: Given a road in which permissive block is used for freights and absolute for passenger trains, either class of trains may accept, as per rule, the caution (distant) indication, but the passenger train cannot pass the caution (permissive) signal and enter an occupied block. Should the engineman be required to remember all the points at which the caution signal is located which he cannot accept, or is it preferable to designate it so he can tell what it is by looking at it? Which practice lends itself better to the enforcement of discipline and which to the promotion of misunderstanding?

Further, with the minority scheme, if the interlocking plant is in permissive manual block territory, advance signals are compulsory, as otherwise the caution position may indicate either block occupied, on one or two tracks; a movement against traffic; into a yard; or to a branch, and while a passenger train would be permitted to accept it for the latter purposes, it could not accept it for the former. How would the engineer differentiate without stopping and examining the position of switches, etc.? Is this a good way to facilitate traffic?

Third: Given a four-track railroad handling all classes of traffic, and the problem of weaving fast expresses in and out to pass local passenger and freight trains on the outside tracks and tonnage trains on the inside tracks, these expresses scheduled 77 miles in 89 minutes, with two or three slow-downs for water and one and sometimes two station stops; place interlocking plants about five miles apart with No. 20 crossovers maintained for a speed of at least 50 miles per hour without danger or discomfort to passengers. Is it good signaling or good railroading to give no advance information to the engineer of the conditions at the interlocking, but to require him, when he comes in sight of a signal located perhaps a mile from the home signal, immediately to reduce speed, examine his track for obstruction ahead, misplaced switch, train in block or bad track, moving at this rate to the interlocking signal, passing it prepared to stop if he is diverted over against traffic or into a yard, and to crawl along at this rate for 2,000 ft. more until he reaches the advance signal, if there is one, and, in its absence, so run clear through the next block? Or is it better to tell him definitely the condition of the interlocking signals and switches and let him run, especially when he may be crossed in and out three or four times on the 77-mile run?

If the minority standpoint is correct, why make a distinction between the main, or high-speed, route and the low-speed, when you make no distinction between the medium-speed route (good for 45 m.p.h.) and the low-speed?

Is the providing of these long crossovers a waste of money? If it is bad practice so to signal that they may be taken at speed, why put them in? They certainly cost more than No. 8's or No. 10's. Or is it intended that the engineman shall "use his judgment," and, having received the low-speed signal, run then at medium speed, having decided that, because that is usually the route set up, it always will be right, and having good luck until some day he is sent into a yard by mistake?

This method of signaling has been used in the past with the result outlined above and its popularity is on the wane.

Many conditions of similar nature might be cited, did space permit.

If I made any unfair statements in my address, they were due to ignorance of the exact position of the minority. I judge none was serious, however, as none is pointed out. Mr. Clausen, with the advantage of a full exposition of both sides, has been eminently fair to us, and I can only take exception to one of his statements. He says that, because of the several proceed indications (proposed by the majority) it is necessary to use three stop aspects, etc. "These aspects are called:

1. Stop until authorized to proceed.
2. Stop and proceed.
3. Stop and investigate."

From our viewpoint the reverse is the case and these three stop indications are necessary in themselves and providing aspects for them increases the number of proceed and caution aspects.

The Standard Code Rule No. 504 provides that, when a train on double track is stopped by an automatic block signal, it may "proceed at once with caution." It is not considered good practice to permit it to pass an interlocking signal in this manner. As some interlockings now cover as much as a mile between home signal limits, or three miles between distant signals, it is considered a safer practice to indicate the difference between these two classes of signals at the signals themselves, rather than to mark them by a signal cabin half-a-mile away.

Further, in manual block territory, it has until now been considered desirable to differentiate between a block signal which a train may not pass without a card, and a switch set for siding, for instance, which it may pass without written authority. This distinction is especially desirable where high switch lights are located close to block signal lights. The manual block and interlocking signals come under the first class noted; automatic block signals under the second and switch-stands, railroad grade crossing signs, stop boards, etc., under the third. The tremendous mental effort necessary to remember these distinctions is about as burdensome as that required by a fair reader to recognize A. B and C. There is no doubt that they all mean "stop."

There are ten principles or fundamentals which succinctly set forth the position of the minority and a claim is made that the signal proposed is in perfect harmony with the Standard Code. Let us examine them in the light of actual experience and in connection with the Code:

"1st. It is impractical to provide a separate signal for each of the conditions on a road requiring cautious running and to maintain the fine-haired distinctions necessary to their interpretation." The majority concedes this, or, at least, feels that it is inadvisable to attempt it. We do claim, however, that the various causes may be so grouped, that we may, by a few simple aspects, give definite information as to the position of the next signal, condition of the track ahead, etc., so that the engineman, required to exercise good judgment and common sense, may have something tangible on which to base the decision governing his action. This being far preferable, in our judgment, to telling him in the majority of cases to reduce to low speed, when he knows perfectly well that actual conditions do not require or warrant such reduction. Human nature is a good deal the same all the world over and a rule is more easily enforced when the occasion for its observance is obvious.

"2nd. It is unnecessary and in fact dangerous to tell the engineman by fixed signal how he shall control his train at some point in advance." This statement is correct provided each signal is so located that it may be seen far enough for the fastest train to stop in the space between it and the first point of view, and requires action not at the signal but *approaching* it. Such locations are impossible on roads of heavy curvature and natural or artificial obstructions perforce reduce this view distance to a few hundred feet. To carry out the minority theory, either train must, under such conditions, reduce speed approaching

such signals, or the signals themselves must be located at some distance from the danger point. This would mean overlaps on automatic signals, and interlocking signals two or three thousand feet from the crossovers and switches they protect, and no discipline could fairly be imposed if they were overrun.

The majority theory is that, unless operating conditions are such that low speeds only are required, approach information should be furnished, so that speed may be maintained.

The minority would require slow speed approaching each caution signal. The majority would require low speed only when it is necessary, and holds broadly that the distant signal as used in common practice today is the key to the situation, and is in effect the *Stop* signal, and the home signal a marker to show the danger point, or, stated in another way, we provide a distant signal at proper distance from the danger point. In the caution position it says: "You must stop (not here, for you are running so fast that it is impossible, but) at a certain point beyond, marked by another signal. Of course, if you find that signal at caution or proceed, you may pass it, but, in any event, you must so control your train that you can stop if necessary. If that point is a mile away and you have a train with high braking efficiency, and you are running at medium speed, it is not necessary for you to slow down to six or eight miles an hour here, but you must stop at the danger point. If you are running at high speed, you must slow down at once and you must know your road sufficiently to be familiar with the approximate distance you have to run." Which is safer? Which lends itself better to the enforcement of rules? Which facilitates traffic and cuts out unnecessary stops? Which reduces the use of the emergency application? And, finally, which credits the engineman with more intelligence?

"3rd. Advance information so given is misleading and unreliable, as it is subject to change without notice, and, therefore, the engineman cannot safely use it. If he does so use it, it is done at the expense of safety." Is it safer to give the stop indication without any preliminary warning, so that the runner is unable to stop before passing it, or is it safer to give preliminary warning a sufficient distance away, so that he may know what to expect at each signal?

Granting that, in the absence of approach locking, routes are sometimes changed after a train has passed the distant signal and that false clear failures sometimes occur, is one practice safer than the other under such conditions? Would men, operating under the minority scheme, reduce speed immediately on seeing a clear interlocked signal, so that, if it were changed to stop, they could stop before passing it, or on receiving the proceed signal at an automatic (not indicating block clear, but that there was no caution signal displayed) immediately reduce speed so as not to overrun the next signal? Would they reduce speed at each clear signal for fear the next might be at stop?

It seems to me that the rules governing the proceed indication, as outlined by Mr. Clausen, would bear a close resemblance to the instructions reported to have been issued by a superintendent on a road having a ferry connection, in the good old times when signals were a novelty. His two verbal orders are reported to have been as follows. "Don't you fellows race the Pennsy trains, but don't let them beat you," and "I want you to stop at these new signals, but *don't miss your boat!*"

Great stress is laid on the claim that the proposed scheme is in "harmony with the Standard Code," and yet the standard Code especially provides for giving this "dangerous" and "misleading" advance information.

Under Rule No. 501 appears the name, "caution signal," occasion for use, block is clear, second block in advance is not clear; indication for enginemen and trainmen, approach next home signal prepared to stop.

"4th. The conditions of modern railway operation do not require trains to run at full speed past caution signals and that any time gained by this practice is gained at the expense of safety." What is full speed? What is a caution signal? If the distance between a distant (caution) signal and its home is more than full normal braking distance of the highest speed trains which it is possible to operate, modern conditions require that such trains must reduce speed *in passing the signal,* but do not require such reduction for trains of slower speed and higher braking power. Is it more dangerous to say "prepare to stop at the home signal," as given in the Standard Code, or to say nothing in regard to the next signal?

"5th. Each signal should indicate stop, caution or proceed, and have no relation to signals in advance or in the rear." This statement, fundamental in its nature is one of the severest strictures ever passed upon the Standard Code, and stamps our present railroad practice as basically wrong. It is almost incredible that any intelligent operating officer has the temerity to preach it in this the year of Our Lord one thousand nine hundred eleven.

The Standard Code of the American Railway Association, authorized edition, February, 1911, page 326, says:

DISTANT BLOCK SIGNALS.

Indication for Enginemen and Trainmen.	Occasion for Use.
Proceed with caution to the home or advance signal.	Home or advance signal at stop.
Proceed.	Home (and advance) signal at *Proceed.*

The minority, if it had its way, would wipe the distant signal off the map and give no approach information of the condition of the block signal.

The majority has held and still holds that the Code is incomplete, and that it should provide indications covering divergence from the main tracks at interlockings, differentiating between those over long crossovers and over short crossovers and between a caution signal indicating block clear and one indicating block occupied, but it also claims that the Code, as far as it goes, is founded upon absolutely correct basic principles, and that the American Railway Association has legislated conservatively and safely rather than recklessly and ignorantly.

"6th. That each signal should be observed in turn as the train comes to it, and not at some point in advance at the option of the engineer." The majority endorses this proposition, but differs with the minority on the interpretation of the word "observe." The minority interpretation of "observe" carries with it immediate action, in fact, action in many cases before the train comes to it. The majority interpretation is that, if the signal is observed—that is, if its indication is properly conveyed to the engineman's mind—the action may be immediate or it may be deferred depending upon the running conditions.

If all caution signals look alike, it is necessary to reduce speed not on passing them, but *approaching* them, for there may be a short crossover just ahead leading into a crowded yard; there may be a train a few hundred feet ahead, (if permissive blocking is in force) or there may be bad track ahead. If, on the other hand, distinctive signals are provided for:

(a) diverge at low speed,
(b) prepare to stop at next signal,
(c) block occupied,

the action required is different. With the majority scheme, a train would receive first (b) and reduce so as to stop at the home signal, then (a) and proceed at low speed. On the other hand, having received the proper distant indication for (c) and given a view of the track for a mile ahead, such reduction is unnecessary, and train may run prepared to stop within the visible stretch of track, slowing down approaching curves and really running on sight. Assuming, however, (if all caution signals have the same aspect) it is supposed that the signal means block occupied some distance ahead, when, as a matter of fact, it means cross over, the results would be serious. Therefore, the use of all caution signals interchangeably, requires always a very slow movement and decreases the capacity of the road. If the function of signals is to impede traffic, the minority has the scheme par-excellence to accomplish it. If

it is to facilitate as well as safeguard traffic, it is a dismal failure.

"7th. That, with signals properly located, it is time a train should be run with caution if it has reached a point so close to trains or stop signals in advance that a caution signal is received." This, I judge, also applies with signals improperly located. This proposition appears, however, to be out of place, as with the minority scheme no caution signal would be received, for proposition No. 5 says: "Each signal should have no relation to signals in advance or in the rear." Can it be possible that there still lingers in the author's mind a feeling that perhaps (although No. 5 is necessary to make the scheme workable) it is a good thing to have the signal in the rear bear some relation to the signal in advance, but that it should be kept a secret from the operating officials and the engineman?

That the intelligence and common sense of the engineman can be trusted to determine the meaning of each caution signal and to know why he is stopped at each stop signal, but that he cannot be trusted to use judgment under the indication "prepare to stop at next signal," and must be required to run at five or six miles an hour for a mile for fear he will pass that signal? This may not be the feeling but it is a reasonable explanation of clause "7."

"8th. That no proceed or caution indication should imply or assure clear track to a point in advance. That railway signaling devices and our methods of communication have not reached the perfection that will admit of this being done. We cannot know positively if the track is clear, and further it may not stay clear. We are under a moral obligation not to give such misleading information." Nothing could more plainly discredit the Standard Code than this proposition. Page No. 327 of the revised Code, previously referred to, shows, Rule 301:

HOME BLOCK SIGNALS.

Name of Signal as Used in Rules.	Indication for Enginemen and Trainmen.	Occasion for Use.
Clear Signal	Proceed.	Block is Clear.

The first sentence of this proposition states that there should be no "occasion for use" of such a signal; the proceed signal should, therefore, in the interest of simplicity, be eliminated, and certainly in the light of the other propositions it should be eliminated for safe operation under the minority scheme, and the indications should be reduced to stop and caution. Then what becomes of our block system? Are we ready to give it up? The statement that signal devices are so unreliable that they cannot properly indicate clear block requires proof—a bald assertion will not suffice. The statement is not justified by the experience of most of us.

It is true that accidents occur on the most fully protected roads and they always will. None of us is perfect, and none of our works will ever be perfect, but actual experience has shown that, on single track, by the use of complete manual controlled block with outlying switches electrically locked, with approach locking at interlockings, and the additional safeguards at our disposal, the integrity of a block may be secured and preserved, and that, therefore, the engineman may properly be assured of it, and further that the same safety may be assured on double or more tracks. What moral right has the public or any management to ask an engineman to proceed at the high speeds now prevalent without such reasonable assurance? This does not imply that he is to shut his eyes as soon as he passes a signal and open them only on approaching the next; it does not imply that he is to relax his vigilance in watching for the results of sudden storms or obstructions such as landslides, etc., and as a matter of fact it does not so result in general practice.

"10th. That it is difficult, if not impossible, to maintain discipline and proper observance of the great variety of caution indications proposed by the majority, because of the fine distinctions involved." What are these caution indications? They are the ordinary distant signal for the main track; a signal for divergence at limited speed (to be used when desired for passage over long crossovers), combined with a distant for the next signal; a distant signal for the medium speed route; a signal for diverging at low speed, combined with a distant for the next signal; a slow sign, and a distinctive mark to indicate "permissive block" or proceed, track occupied. The fact that all these indications, and all the aspects, except the permissive, are being successfully used, not only as a separate system but introduced in connection with the old methods, on some of the greatest trunk lines in the country, as well as on a number of thin lines, with magnificent results and with the approval of the men most concerned in their use, the enginemen, is sufficient refutation of proposition No. 10.

A system conveying no indications other than stop, caution and clear must of necessity be predicated on the principles enunciated by the minority, and the proceed indication serves no purpose except to announce that the caution or stop indication, which might be expected, is not displayed—"absence of restricting signal," as the majority terms it. This indication would be the same in all fixed signals—"slow-boards, stop-boards, yard limits, switch, train order, block, interlocking, semaphore, disc, ball, or other means for indicating stop, caution or proceed," and continuous advance or block information would be impossible. While our enginemen can intelligently grasp but three aspects, they can guess at the meaning of all these enumerated, or else must remember the information each is to convey by associating it with some landmark near at hand.

The time has passed in this country when the block system, as outlined in the Standard Code, can be abandoned for the cow-path principles of running on sight, with stationary mechanical herders, giving two indications, stop and caution, covering conditions only at these particular locations "and not at some point in advance." Progressive managements will not advocate it, public sentiment would not tolerate it, and the government would not permit it.

As W. H. Elliott aptly puts it, "signal indications should not be 'simplified' to a point where definite information is not given to the engineman." It is a good thing to have a simple signal system, but it should not be made so simple that an engineman will have to reduce speed, to insure safety of operation, to a point where trains are run so slowly that full advantage cannot be taken of the track facilities provided. The economy proposed by Mr. Clausen in simplifying the signal system is at the expense of efficiency and capacity.

Finally, Mr. Clausen quotes three letters to bolster up his position, and which somewhat becloud the issue.

The first letter begins: "The very elaborate signaling recommended by some is founded upon the idea that engine-runners, on account of their mental incapacity, must be instructed, by the language of signals, the precise manner in which their trains shall be handled under every circumstance, etc.," and claims that this premise is unsupported by facts, and that their enginemen are intelligent and reliable.

The portion in quotation marks might be criticized were it not begotten in ignorance. Instead of publishing this letter, Mr. Clausen should have advised its author that the majority has always held that the enginemen have at least ordinary intelligence and that, as a class, they are far above the average, and that it is the minority who have always claimed that they were incapable of instantaneous reading of the various "complicated aspects" involved. It is the minority that is belittling their mental equipment, by saying "slow down because you haven't brains or skill enough to stop a mile away unless you do so, nor intelligence enough to carry in your heads 15 or 20 aspects, though we grant you have learned the characters of the alphabet."

The second letter is a complaint of the increased cost of complicated interlockings and two-thirds of it is a plea for the abolishing of derails.

Of course, the cost of derails has a bearing on the cost of the interlocking plant. It has no more bearing on the question

of signal indications and aspects than the frieze of the Parthenon on the price of butter in Oshkosh. It may add to the gaiety of nations, but is not a cogent argument for a one-arm signal. The actual difference in the installation of a plant would be the difference in cost of the high signals only, and those who know anything about signaling can easily figure out at any given plant what the percentage difference would be.

The third letter is a plea for simplicity and (probably unintentionally) a very strong argument for the majority claims. It says: "When a man is running a train at a speed of 60 miles an hour, perhaps on a down grade, a 'stop' signal may mean a very different thing to him from what it means to a man going perhaps 10 miles an hour on a level or an up-grade pulling a heavy train. In other words, the signal may *say* the same thing in both cases, but what it will mean in practice to the man who receives it is a very different thing. Then why confuse the situation by all sorts of absurd requirements?"

The majority says, why not tell the man the truth, simply and plainly, and if it means different things, tell him which it means? Why perhaps mislead him when you can guide him right?

A paragraph is devoted to the instance of a distant signal being habitually left at caution with the home at clear, and it is asked whether it had not better be removed entirely. We reply —yes, but still better it should be made to give accurate information and not be left to indicate stop at next signal when the medium-speed route is made and the next signal may be passed at 45 miles per hour.

Finally, we agree with the writer that every device must be made as nearly fool-proof and as simple as possible and that, if signaling by any means leads to the abolition of grade crossings, it is a blessing even if in disguise.

It is generally conceded that the signaling fraternity is as conscientious and as hard-working as any in the railroad world. Whether its members are broad gauge or narrow gauge is perhaps debatable. They are on trial. It is to be hoped that they may prove equal to the task of harmonizing their differences and recommend, without division, a comprehensive system which, while meeting the most exacting and complicated conditions of the trunk lines, will at the same time supply the simple needs of the smallest and weakest roads safely and economically, and which consequently will be worthy of adoption by all the roads of the country. If they can do this, their recognition as among the most important operating officers, long striven for and so far generally denied, is bound to come through the logic of events and the value of their work.

When cranks and compensators are covered with platforms, they must not be neglected because they are out of sight, but the cover should be removed, and the cranks inspected to see whether the bolts are tight and to be sure that the foundations are not working loose.

STORAGE BATTERIES ON TRACK CIRCUITS

BY H. G. MORGAN.

The use of a storage cell to feed a track circuit necessitates the employment of a series resistance to protect the cell against short-circuit when the section is occupied. The resistance used is usually two ohms. This gives a shunting current of one ampere. With a four-ohm relay and a ballast resistance of four ohms, approximately one volt is impressed on the rails. This corresponds to the condition obtained with two cells of gravity battery in multiple, having a combined internal resistance of one ohm. However, it is evident that in fair weather when the ballast resistance is high, the storage cell will impress a voltage on the track which will be in excess of one volt. Thus a greater amount of energy is delivered to the relay than in the case of the gravity battery. In order to get the equivalent of gravity operation during bad weather conditions, it is necessary to waste energy during normal conditions.

Where track sections are comparatively short and ballast conditions good, this suggests computing the series resistance by

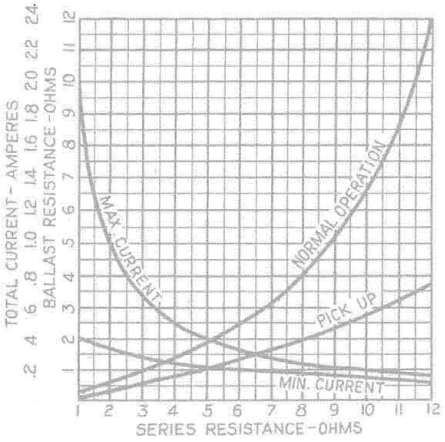

Fig. 1.

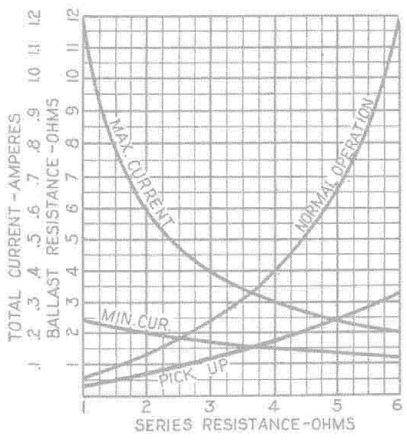

Fig. 2.

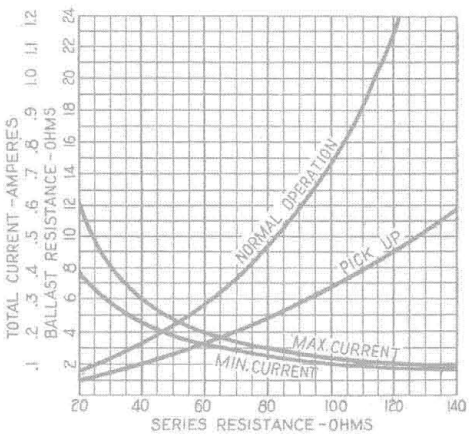

Fig. 3.

formula, and applying a factor of safety as is done on terminals where a central source of energy is employed. Neglecting the resistance of the rails and internal resistance of the battery the formula is:

$$s = \frac{eb - ibr}{ir + ib}$$

where s is the series resistance, e the effective battery e.m.f., b the ballast resistance, r the relay resistance, and i the current required to operate the relay. The factor of safety is applied by increasing the value of i in the formula.

It will be found more satisfactory, however, to plot a curve showing the relation of b and s for the given relay and e.m.f. By plotting a curve of b as ordinates and s as abscissæ, taking i as the pick-up current, and then another curve, taking i as the normal operating current, it may be seen just how the variation of any one factor will affect the others.

Fig. 1 shows curves for a track section with a two-volt battery e.m.f. and a four-ohm relay requiring .070 ampere for pickup, and allowing .100 ampere as a safe margin for normal operation. Suppose that in a given track section the ballast resistance is estimated to have a minimum value of three ohms. Follow the line opposite three on the vertical scale to where it meets the curve of normal operation. A vertical line through this point will cut the horizontal scale of series resistance at about 6.9 ohms. This is the value which would have been obtained by the formula. A horizontal line drawn through the point where this vertical line cuts the pickup curve, will intersect the vertical scale at 1.6 ohms. This indicates that with 6.9 ohms in series the relay will pick up even if the ballast resistance falls to 1.6 ohms.

To determine the saving in current, values of total current delivered to the section may be plotted against values of s. The