A COMPARISON OF THE INTERLOCKING LAWS OF THE VARIOUS STATES

BY J. G. VAN ZANDT.

This is the second article on this subject by Mr. Van Zandt.

In a previous article* the laws of the United States and Canada relating to interlocking were compared. Many of the State Commissions have issued "Rules and Recommendations for Guidance in the Construction of Interlocking Plants" as authorized in the laws. From a study of these rules it appears that the first were issued by the Railroad and Warehouse Commission of Illinois about 1892. Since that time there have been many similar rules issued by the Commissions of other states. It is said that some actually adopted the Illinois rules at first and modified them as they found it desirable. The success of these rules as affecting uniform regulation in the state has often been mentioned and it is remarkable that very few changes have been found desirable up to the present time.

It is not entirely clear which of the items mentioned in the various Commission publications are rules and which are merely "recommendations," as there is no expressed indication. But it has been assumed that when the word "must" is used the item in question is a "rule," while all other items where words like "may" or "should" are employed are not strictly requisites. With this as a criterion 13 of the 33 items in the Illinois rules are strictly requirements, or less than 40 per cent. On the other hand, in the rules of Texas where almost every item of the Illinois rules is mentioned, the entire set, or 100 per cent, are requirements. The history of interlocking rules, like that of interlocking laws, appears to show that there has been a tendency to decrease the latitude of reasonable variation every year, and to specify details of construction rather than principles of protection. It appears probable that the success of the Illinois rules is due largely to two important considerations, viz.:

1. Over 60 per cent are recommendations which afford a wide latitude in their fulfilment.
2. There has been a broad-minded interpretation of the remaining rules, which has kept abreast of the development of the art of signaling.

There are so many items variously mentioned in the rules of the different Commissions that it appears necessary to compare some of them separately. Reference has been made not only to the rules of the State Commission but also to the rules of the Commission of Canada, the Standard Code of the American Railway Association, and the recommendations of the Railway Signal Association, the American Railway Engineering and Maintenance of Way Association, and various other organizations. Fortunately many of the Commissions have published their rules regularly in their annual reports, though some have adopted rules as a matter of policy and have not published them.

The Illinois rules are here used as a basis of comparison, with the view of indicating especially the items in which there are important differences in the rules of other states.

PLANS. The laws have in many cases indicated that plans must be submitted for approval. Additional requirements, in some instances, have been made by the Commissions, in which copies of related documents are required both before and after the erection of the plant. The Indiana rules require as many copies of all documents as there are roads interested in the plant, as well as the approval of all of the roads; estimates of the cost of both mechanical and power installations, and "probable cost of the maintenance of the same"; copies of all contracts relating to the crossing; statements of daily train movements; rules governing signalmen, etc.; not to mention the data required on the plans and profiles, dog-charts, manipulation charts, and other diagrams. To some of the Commissions fortunately it has appeared unnecessary that a copy of each document be filed for every road interested, or that the plans themselves actually receive the official stamp of approval. In these cases a statement is made in the permit that it covers the copy on file in the office of the Commission. The rules of Indiana specify that the signatures of the general manager or "other proper officer" appear on the plans to insure authority. In Canada the rules specify that all plans be "dated, certified and signed by the president and chief engineer" of the roads interested. In several cases the rules state that when a plant has been approved "trains may proceed" through it without a stop but it appears that since the law specifically states the same thing there is no occasion for its further mention.

INSPECTIONS. In all cases an inspection of the plans and completed plant is made by the Commission. A "deputy commissioner" or representative is authorized, in some cases, and there is a strong tendency toward expert work by the "consulting engineer" being more uniformly required. While nothing has been found stating the method of procedure in case unsatisfactory work is found upon inspection, it appears to be the custom merely to withhold the permit until the necessary corrections are made.

STYLE OF SIGNALS. The Illinois rules recommend that all signals be of the semaphore type, but require that they fall to the normal position by gravity. The Texas rules not only require that the semaphore be used but also that the colors be "red, green, and yellow" for the stop, proceed and caution indications respectively. The Michigan rules specify that the "signals shall be operated according to the rules of the road." In the reports of the railway associations the colors, though often recommended, are generally left to the railways. Back lights are quite generally specified. It appears, however, from the reports of the signal associations that back lights have been found to complicate signals, and not being essential they are omitted in the best installations. The rules of Canada add that the "normal position of all signals must indicate danger." In Vermont semaphore signals are required at crossings with interurban electric lines also. No other form of signal than the semaphore is specified in any of the rules.

HOME SIGNALS. The distance for the location of the home signal is generally given as "50 to 200 ft. from the point governed." The Michigan rules give the limits as "50 to 100 ft." and add that the posts must exceed six feet from the rail in all cases for clearance. The square end on the arm is sometimes required. The Canadian rules specify that the signals are to be on the "engineman's side of the track" and "50 ft. beyond the point of the derail," and they further state that the speed which the clear position indicates is 35 and 25 miles per hour for passenger and freight trains respectively. Both wire and pipe connections are allowed under the rules of Illinois, and the stipulation that the top arm, in case there are more than one, should govern "main or high-speed routes." is also included. "Pipe connections" are required in Texas "for mechanical systems." The rules of several states specify that "the signal must be inclined at an angle of about 60 degrees, indicating advance." This rule has in several cases been modified to read "60 degrees or more" so as to include upper-quadrant indications using the vertical position.

DISTANT SIGNALS. That the distance from the home signal to the distant signal should be made not "less than 1,200 ft." is the rule of several states. In Michigan the limits make the minimum "1,000 ft." and the maximum "1,500 ft.," whereas in New York the minimum is "1,500 ft." There are doubtless good reasons why the distance should exceed the maximum of the Michigan rules and be less than the minimum of the New York requirements in special cases. It has been pointed out in these columns* that there may be conditions of grade and speed that will so influence operation that the scientifically located signal would come properly outside of these limits. It might be, therefore, a physical impossibility, with present brake equip-

*Interlocking Laws in the United States and Canada, *The Signal Engineer* for December, 1910, Page 270.

**The Signal Engineer* for July, 1910, Page 61.

ment, to bring a train to a full stop at the home signal with the distant signal so located, and thus the rule limits the execution of the very function of the signal it specifies. In yards, and at points where the speed limit is necessarily low, a minimum considerably less than that given in the rules would be more desirable. The arm is usually required to be notched, and the locking with the home signal is generally specified. The rules of Michigan alone provide for "electrical locking."

SWITCH INDICATORS. Technically these can not be considered as a part of the interlocking plant, but they are often included and recommended for separate use.

DWARF SIGNALS. These are uniformly specified for "back-up or secondary movements." The Michigan rules add that they shall be "operated from a tower" and be installed "not less than five nor more than 100 ft. in advance" of the points governed.

TOWERS. The location and height with respect to view are generally included in the specifications. The Michigan rules state that the view shall be "commanding to the signalman while he is moving the levers." It is recommended in the Illinois rules that in case neither the back lights nor front lights are visible from the tower "repeaters or indicators be provided." The rules of Texas and Canada are similar except that these items are strictly required. The installation of annunciators is not uniformly considered as desirable. There is little doubt but that when there is neither telegraph nor telephone connection in the tower and the track is not visible for over 1,000 ft., it is desirable to have an annunciator; but these conditions are hardly sufficiently common to justify the requirement of their installation in all of the towers. The fixed lights are required to be "screened off" in the rules of several states. The Standard Code of the American Railway Association does not specify screens, but simply states, among other instructions to signalmen, that all lights in the tower must be so placed that "they can not be seen from approaching trains."

DERAILS. The original rules in Illinois required 300 ft. on level track between the location of the derails and the crossing. In a few years this was modified by adding that "on lines of fast and heavy traffic the derails shall not be located less than 350 feet in advance of the crossing." At present, however, the requirement is different, and specifies that "derail points on high-speed tracks shall be located not less than 500 ft." away from the crossing, when the grade is level. On grades the distance is required to be such "as to give the same measure of protection." It is not a simple matter to determine exactly what distance would give this "same measure of protection," but it is the practice of the Illinois Commission to alter the distance about "10 ft. for each one-tenth of one per cent of grade." This would make the required distance 600 ft. on a one per cent down grade toward the crossing, and 400 ft. on a one per cent up grade. It has been determined by a study of brake tests that, theoretically, if other conditions are equal, the effect of grade is very close to the conclusions of the Illinois Commission. Other items have so much greater effect on the distance than the grade, however, that it appears that they should be mentioned. The speed of the train is very important, but any speed is called "high" which is between 50 and 100 miles per hour. Allowance is made, in the following rules, for "secondary tracks, spur tracks, and sidings" on which the speed is necessarily lower, irrespective of the grade, and the "same measure of protection" is again specified. The rules of Canada state that derails on secondary tracks shall be so located as to "best accommodate the traffic," and provide the same measure of protection. The Indiana rules specify 500 ft. for steam roads and "not less than 200 ft." for interurban electric roads, though the Commission reserves the right to fix the location of the derail at other distances when "local conditions warrant." In Michigan "at least 300 ft." is the requirement, and on secondary tracks "the character of the business put on such tracks must govern" the location. There is also the further suggestion that "on curves derailers should be located on the inside rails and on double track on the outside of both tracks." This last recommendation is also made in the rules of Canada. The distance for derails in Texas is "400 ft.," and the "same measure of protection" is required on secondary tracks. Back-up derails are required "to be 150 to 300 ft. from the crossing" in most states, though Indiana alone requires "not less than 200 ft." The rules of Canada simply state that "on double-track railroads back-up derails will be necessary," and they require that guard rails be laid nine inches outside of "the rail in which the derail is placed." The rules of Illinois specify guard rails "when the engineer shall deem them necessary." In Michigan it is required that guard rails be laid to "within 200 ft. of the crossing." The rules of Indiana order all guard rails removed except where "in the judgment of the Commission their use is warranted." In most states derails are required to be worked by "iron or steel pipe not less than one inch in diameter," though in the original rules of Illinois "pipe or rod" was specified. In the rules of Michigan the details of the bends, bell-cranks, etc., are specified. The "double-pointed switch-and-lock movement" is recommended in the Illinois rules "in connection with a bolt lock operated with the home signal" for high-speed tracks. The same is required in Texas, but is not mentioned in the rules of many other states.

DETECTOR BARS. In Illinois the length of detector bars is required to be "45 ft. or more." In Texas 50 ft. is the required length, and in Michigan "at least 45 ft." It is the policy of the Illinois Commission to "give the companies the privilege of using electric locking instead of detector bars, as it is often much preferable." The Standard Code suggests "detector bars or their equivalent" as the ideal manner of stating the specification.

ARRANGEMENT OF LEVERS. The Texas rules require that the "levers be grouped in a tower" and "numbered from left to right," but in Illinois this arrangement is merely recommended. The rules of Michigan specify that the "machine must be on a separate foundation," but the towers "may be built according to the standards of the roads."

PRELIMINARY LOCKING. "Latch-locking or its equivalent" is the requisite of the Standard Code. This states in simple terms the principle which is variously described in the rules of most of the Commissions.

LOCKING OF LEVERS. The general requirement in Illinois is that "it shall be impossible to exhibit signals which would lead to a collision." There are similar rules in many other states, but the Standard Code outlines more clearly the "established order of interlocking."

COMPENSATORS. In the rules of Illinois and Texas the compensators are required to "completely provide for expansion." The rules of Michigan specify that every line over "100 ft. in length" shall have a compensator, and an additional one for every "additional 700 ft." The foundations for pipe carriers are required to be "suitable" in the Illinois rules, and in the rules of Michigan it is required that "supports must not exceed eight feet between centers."

GENERAL REQUIREMENTS. Not only is the quality of the material and workmanship generally in state regulations specified but a general statement is made requiring protection "by proper devices against any collateral dangers in the same complete manner," apparently to review the entire scope of the rules and cover any overlooked details. This rule has been repeated verbatim in the rules of Texas and Canada, and in the original rules of Illinois.

MONTHLY REPORTS. Among other more or less related matters mentioned toward the end of the rules of the several Commissions the monthly reports of the condition of the plants are required. The authority of the Commissions to require these reports has apparently never been questioned. In Illinois reports were not required in the original rules, but at present blank forms are sent out for a regular monthly report of each plant. This is the same in many other states. The rule in Indiana specifies that "all companies interested," but not charged

with the maintenance of the plants, shall report "once in every 60 days."

It is quite evident from the comparison of items that the desired result is the same in all cases, i. e., protection. There is this common principle underlying all of the specifications, and it may be read between the lines without difficulty, but there appears to be no definite expression of the principle in any of the rules. The only place where it appears at all is in the general statement of "General Requirements," and here it is inadequately expressed. A simple statement requiring "proper devices" which would "provide completely" against evident and "collateral dangers" would, it seems, cover the entire scope of the rules. The working out of the details would naturally be left to the signal engineers, and in the presentation of their plans it would devolve upon them to prove that they provided completely against the dangers, and gave the desired protection.

THE MECHANICS OF THE COMPENSATOR

BY W. E. FOSTER.

The question has frequently been asked, "Why did subcommittee No. 1 of the Railway Signal Association change the design of the lazy-jack compensator?" No explanation was made in detail to the association and the subject is not generally understood.

It is the purpose of this article to explain, for purposes of comparison, the two designs (old and new) graphically and mechanically, presupposing a slight knowledge of plane geometry on the part of the reader.

Fig. 1 shows the old design in outline. A and B are the centers, X and Y the operating points, XAC the obtuse or 120 deg. crank, YBD the acute or 60 deg. crank, and CD is the connecting link.

The operating arms AX and BY are shown perpendicular to the center line AB. In this position angle EAC = angle EBD = 30 deg. and the link CD bisects the center line AB. Angles ACE and BDE are equal and CE = ED. Angle FAC, being

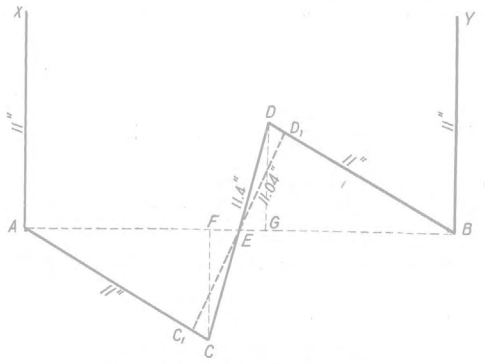

Fig. 1. Arms on Center.

30 deg., then FC, perpendicular to AB, = ½ AC = 5.5 in. (FC = AC × sin 30 deg. = 11 × .5 = 5.5).

Since $(AC)^2 = (AF)^2 + (CF)^2$;

$AF = \sqrt{(AC)^2 - (CF)^2} = \sqrt{11^2 - 5.5^2} = 9.526$ in.;

FE = AE — AF = 11 — 9.526 = 1.474 in.;

$CE = \sqrt{(FE)^2 + (CE)^2} = \sqrt{1.474^2 + 5.5^2} = 5.7$ in.;

DE = CE; CD = 2 × 5.7 = 11.4 in.,

when X and Y are on center as shown in the diagram.

Since the old design had an 11-in. link, if X was put on center, Y would be thrown about ⅜ in. to the left of center, or vice versa.

The first time the writer set a compensator and placed the arms 22 in. apart they did not look right, and he laid it to defective work on the part of the signal company in the usual way, and dismissed the subject from further thought.

In the new design AC and BD are made 10 in. and the link 11 in. as before.

Referring again to Fig. 1, AC_1 and BD_1 represents the new arms and C_1D_1 the link. Working out the length of C_1E in the same way as above we find it to be 5.52 in., or the link is 11.04 if the arms AX and BY are on center. Right here it should be noted that if an 11-in. link is set at right angles to AC and BD it will be right if AC and BD are made 9.526 in. long. If we do not consider the other positions of the cranks this would seem to be the right dimension for the arms.

In Fig. 2 the compensator is shown with AX and BY moved 30 deg. outwardly, which is equivalent to a line movement of

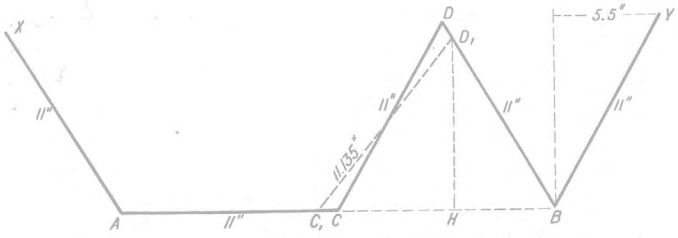

Fig. 2. Arms at 30 deg. Outside of Center.

5.5 in. of X and Y. This would ordinarily be an extreme position for ordinary strokes and considerable variation in temperature. In this position X and Y will be symmetrical, with AC, BD and CD each 11 in. long. With AC_1 and BD_1 each 10 in., we find HB = 5 in., HC_1 = 7 in., HD_1 = 8.66 in., C_1D_1 = 11.135 in. when X and Y are symmetrical, or if X is 30 deg. from center, Y will be thrown about ⅛ in. to the left with an 11-in. link, and vice versa.

It should be noted now that if AC and BD are made 9.526 in. long the link would have to be 11.29 in. long to have AX and BY symmetrical.

In Fig. 3 the compensator is shown with AX and BY moved 30 deg. inwardly, equivalent to a straight line movement of 5.5 in. of X and Y and giving the other extreme position. In

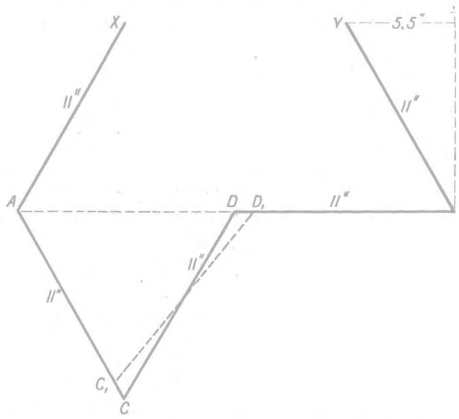

Fig. 3. Arms at 30 deg. Inside of Center.

this position X and Y will be symmetrical with AC, BD and CD each 11 in. With AC and BD each 10 in. the link CD will be the same as in Fig. 2, 11.135 in.

If X is 30 deg. from center Y will be thrown about ⅛ in. to the left with an 11-in. link. If Y is 30 deg. from center X will be thrown about ⅛ in. to the left with an 11-in. link.

SUMMARY.

In the old compensator with 11-in. crank arms and an 11-in. link if we start in the position Fig. 2 and move to position Fig. 3 and set AX at 30 deg., then Y will be 5½ in. off center at the start. When X moves the first 5½ in. Y moves 5⅞ in. and when X moves the second 5½ in. Y moves 5⅛ in. The total stroke of X and Y is 11 in. for each.

If X is moved at a uniform speed throughout the stroke, Y will travel faster during the first half and slower during the second half. The only point where they will travel uniformly will be when angle ACD = angle CDB, which is when the arms are close to center (Fig. 1). The further the arms are off