Editorial COMMENT

A Simplified Signaling Arrangement
For the Direction of Trains by Signal Indications

MUCH of the automatic block signaling on single-track lines is out of date today because of the increased speeds of long heavy trains, and because of the necessity of complying with the new I.C.C. signaling regulations, regardless of whether the railroads are convinced of the justification of the changes required. Furthermore, from the standpoint of economy in operating expenses and efficiency in train operation, single-track automatic signaling as a *system* has been outmoded by systems for directing train movements by semi-automatic signals, the indications of which take the place of time-tables and train orders. The purpose of this editorial, therefore, is to arouse interest in and encourage the development of a simplified re-arrangement of signals such that "office" control to make the system semi-automatic can be installed and justified economically on a large percentage of the 38,600 miles of single track now equipped with straight automatic block, as well as on a considerable proportion of the 45,000 miles where no automatic block is now in service, but where manual block is used. The significance of this latter item is evident from the latest proposed I.C.C. rules, on page 80 of the February issue.

Time-Table and Train-Order Operation Is Obsolete

Single-track automatic block signaling is designed to prevent head-on collisions, and to permit as close spacing between following trains as is consistent with safety. Such a system, however, does not provide means for directing trains to move from one station to another, this authority, in automatic signal territory, being given ordinarily by time-table and train orders. During the 1930-1940 decade, many train-order offices were closed, and at others, agent-operators are now on duty only during the day trick. As a result, some sections of rather busy single track are being operated at night with no open office on 50 to 75 miles or more of line. When one or more scheduled trains lose time somewhere, the dispatcher is not in sufficiently close touch with the circumstances, and has no opportunity for changing orders to make the best out of bad situations. Under these conditions, and especially when extra trains are being handled, excessive train delays occur in too many instances to insure on-time arrivals of important trains. Thus the continued use of time-table and train-order operation, involving either an increase in operating expenses for more open offices, or the acceptance of serious train delays, is not consistent with efforts to control operating expenses, and also to keep modern trains moving on schedules which have been established on the basis of using new locomotives and modern tracks at the speeds for which they are designed. The schedules are "tight;" in other words, no time is allowed for "running out" unanticipated delays.

Automatic Block Requires Expensive Revisions

Disregarding, for the moment, consideration with reference to time-table and train-order operation, much of the automatic block signaling on single-track lines is out of date because the spacings between signals is not adequate for the braking distances of trains operated at modern speeds. This applies especially to freight trains and to passenger trains using standard equipment operated at high speeds. Railroads which have increased the speeds of heavy freight trains and do not know the braking distances, may be surprised, when making tests, to learn the actual practical effects of the square in $\frac{Mv^2}{2}$. The new light-weight passenger trains, especially those hauled by light-weight diesel-electric locomotives, can be stopped in relatively short distances because the weights involved are comparatively small and special braking systems are used. At speeds over 100 m.p.h., however, the braking distances for these trains increase surprisingly. The problem is further complicated by the necessity for complying with the new signaling requirements of the I.C.C. Many railroads are reluctant to make expensive, permanent and complete changes, because they know that even after spending all this money, the *system* will be the same, and will not include means for obviating time-table and train-order operation.

Two Birds With One Stone

On the other hand, during the last decade, numerous extensive installations of modern centralized traffic control, including power-operated switches and semi- automatic signals, have proved the advantages of directing train movements by signal indications which take the place of time-tables and train-orders. In installations of this character, the signals, which authorize trains to enter upon and make movements through the single track between passing tracks, all normally display the

Stop aspect, and these signals are interconnected so that only one can be cleared at a time. For these reasons, head-on protection is provided and, therefore, special arrangements of intermediate signals and overlap controls need not be provided to insure head-on protection. For example, on the Rock Island and on the Pennsylvania, when an office-controlled station-leaving semi-automatic westbound signal is cleared, the eastbound intermediate signals are controlled to their most restrictive aspect, and the westbound intermediate signals can display proceed aspects, depending on track occupancy by leading westbound trains. Another possible arrangement is to use Normal-Stop intermediate signals, and clear the signals for the direction to be used when the corresponding semi-automatic station-leaving signal is cleared.

Thus any arrangement of Normal-Stop interconnected station-leaving semi-automatic signals for directing train movements by aspects of these signals, not only obviates the use of time-tables and train-orders, but also permits the elimination of many blocks which are too short to comply with I.C.C. Rule 204, and, furthermore, the combined complications, required by I.C.C. Rules 204 and 207, as applying to intermediate signals, can be obviated. In other words, there always would be an Approach aspect. An additional advantage is that the intermediate signals can be located on a train-time-distance basis to provide the most efficient operation of following trains.

Better to Use Normal-Stop

Special note may well be taken of the term Normal-Stop, which is used here instead of the equivalent term "normal-danger." Complete safety rather than any item of danger is provided by a signal displaying the Stop aspect. Especially when discussing signaling with operating and executive officers, the term Normal-Stop should be used. Emphasis is here placed on the fact that all of the semi-automatic signals in the proposed arrangement are Normal-Stop. When converting a normally-clear system of automatic block signals to an arrangement in which certain signals are made semi-automatic, a temptation may be to use normal-clear signals throughout, or for one direction, or in some other manner. Approach control similar to automatic interlocking is likewise intriguing. I.C.C. Rule 405 should not be overlooked.

In-so-far as we have knowledge, however, Normal-Stop semi-automatic signals are used in all phases of interlockings and systems for directing train movements by signal indications, which involve controls by a person. The Normal-Stop principle is not necessarily good because it is old, but it is old because it is good. The point of importance is that other than Normal-Stop aspects, when considering three entire station layouts and intervening single track, bring I.C.C. Rule 207 into consideration. In any system of Normal-Stop semi-automatic signals, the improbable hazard in a normally-clear automatic block system, (two opposing trains, having overlooked orders, and passing opposing station-leaving signals simultaneously) is entirely obviated. Any extra expense to control Normal-Stop semi-automatic signals will no doubt be more than offset by the possible simplicity of the intermediate signaling, and the advantages of this simplified intermediate signaling, in increasing track capacity, as compared with automatic block in which overlap controls are used.

Consideration to date indicates that any attempt to "whittle" out any of the Normal-Stop aspects or allow a signal to clear without action on the part of the leverman, would be expensive economy, as would be realized later. At any event, the job ought to be based on recognized standards of interlocking practice, and should adhere to basic principles of signal aspects. Stick or non-stick controls can be used, or the controls can be stick except when specially set up as a non-stick. This is a detail to be decided by preference.

A Solution Proposed

All of the advantageous results of Normal-Stop semi-automatic signaling can, of course, be accomplished by installing centralized traffic control. Funds are not available, however, for complete systems of this nature, including power switches and semi-automatic signals for directing all possible train movements on the extended mileages explained previously, on which something should be done within the very near future.

Serious problems are involved, however, in attempting to provide centrally-controlled, semi-automatic signaling at a cost which can readily be justified on many of the extended sections of medium traffic lines. The following discussion is an attempt to explain how this difficult objective may possibly be attained. For the most part, the proposed arrangements represent an assembly of ideas which are in service on certain railroads, and which have been explained in articles published in *Railway Signaling* during the last 20 years, references to these articles being given in the footnotes herewith. The proposed system is not being advocated as something finished and perfect. It is, however, the result of co-operative thinking by a number of railway men and others, who have read preliminary drafts of this discussion, and have offered constructive suggestions. Further co-operation of readers is solicited in sending us still other constructive criticisms or suggestions, in the hope that this effort of all may lead to the development of a solution for a problem that is common to many railroads.

In a changeover from ordinary single-track automatic block signaling, it is proposed that the existing hand-throw switch stands are to be retained in service, and that such of the existing signals as are to be retained are not to be moved unless absolutely necessary. From this point on, the crux of the problem is to design a signaling arrangement which will serve to direct all the necessary train movements, and, at the same time, require a minimum of apparatus at the control office and at the field stations for the control of the semi-automatic signals, and for the return to the office of indications concerning the approach and departure of trains at passing track layouts, as well as to show when a train which is entering a passing track is clear of the main line. Automatic track-occupancy information of this nature is adequate for the handling of trains, and in reality affords much more information than is provided by OS reports from operators, especially when few offices are open on extended territories. Indications of more main line sections can be provided, if desired.

Can The Number Of Signals Be Reduced?

A first consideration is to determine whether the number of semi-automatic signals at each passing track can be reduced, and also whether the number of field stations at a passing track can be reduced. The signaling arrangement used on many existing installations, as shown in Fig. 1, includes a total of eight operative signal "arms" at each passing track layout. A separate local "field station" at each end of the passing track includes the controls of the four arms at that location, so that there are two field stations for each passing track. If a signaling arrangement can be developed for each passing track layout such

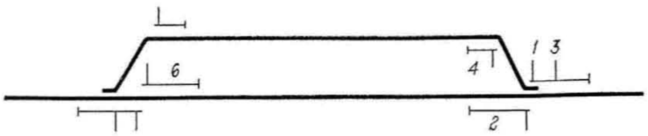

Fig. 1—The customary arrangement of semi-automatic signals includes four "arms" at each end of a passing track. It is proposed that signals such as 2 and 6 be removed. If the passing track is less than braking distance in length, the change proposed would eliminate one short block for each direction, thus obviating duplicate Approach aspects on two successive signals in approach to the layout, or the requirement of four-aspect signals

that only one of a total of six signal arms need be cleared at any one time, one field station rather than two would serve each passing track. With this thought, the signaling arrangement shown in Fig. 3 is presented for consideration.

Omit Two Signals By Moving Two Insulated Joints

A special feature of this layout, shown in Fig. 3, is that the equivalent of station-leaving signals, such as signals 2 and 6 in Fig. 1, are not used. This is accomplished in an ordinary layout by moving the two insulated rail joints now in the main track rails in approach to the facing-point of a switch, to a new location beyond the heel blocks of the switch. The approximate locations of insulated rail joints for the track circuits in the vicinity of each switch are shown in Fig. 2, with approximate dimensions which would apply at a standard A.R.E.A. switch layout using a No. 10 frog and 16-ft. switch points. As switches are actually installed, using 39-ft. rails, the rail joints, A and D, are now located approximately as shown. Where automatic signaling is in service, joint D and a joint in rail Z are now insulated as a part of the fouling protection track circuit.

On some roads, a section of rail shorter than half a rail length in the main line is objectionable from the standpoint of track maintenance. In the layout being discussed, the distance between the heel-block and the frog in main line rail X is about 57 ft., or approximately a half rail plus a full length rail. Approximately the same applies with reference to turnout rail Z between the heel-block and the frog. Usually the approximate half-rail sections are to the right toward the frog. By interchanging the rail sections, i.e., to put the long rail sections to the right toward the frog, the joints would then come about 19 ft. further to the left, thus bringing them approximately in line with joints A and D. Joint A, as well as joints B and C, in their new locations, would be insulated by using insulated joints previously in service in the main line and in rail Z. This rearrangement of the rail sections obviates the complications involved in insulating rails from heel blocks, and, furthermore, no rails need be cut or new short sections introduced. Insulated joints are to be installed at G and G on the wing ends of the frog in the turnout rail Z so that the track circuit on the turnout is completely insulated from the main line track circuits. Insulated joints would be used at the fouling, as ordinarily installed.

Protection of the Switch

A signal, such as AL1, is located approximately opposite the four insulated joints A, B, C and D. The switch points are not actually in the track circuits controlling signal AL1, but the circuits are arranged so that if the switch is not normal, or is normal but "cocked," the signal AL1 will display the Stop aspect, and the distant signal will display the Approach aspect. Where 39-ft. rails are used on a No. 10 turnout with 16-ft. switch points, the signal, AL1, would be about 39 ft. "beyond" the points. If a train, when approaching signal AL1, with a Stop aspect displayed, runs exactly up to the insulated rail joints, the switch points would be passed, although at a very low speed. Since the exact point at which long heavy trains will stop cannot be determined in advance, an engineman encountering an Approach aspect takes the safe course, and usually stops 100 ft. or more from the signal indicating Stop.

Border line cases are taken care of by the aspect of the take-siding signal, the feature being that if the switch is "cocked," an aspect to stop is displayed at the *switch* by the equivalent of a standard switch target aspect. A single red light aspect on a signal or on a switch stand means to stop. In this case, the distant signal gives advance information so that a train can be stopped short of the switch.

The important objective of this special track circuit and signaling arrangement is to permit the omission of the two so-called leave-station signals at the leaving ends, and at the same time, for example, allow a westbound

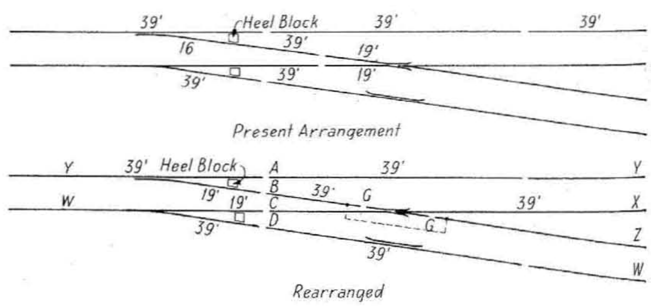

Fig. 2—Showing how to move two insulated joints

train to enter or an eastbound train to depart from the east end of the passing track, such as station A, while an east bound train is proceeding from station B toward signal AR1 at the west end of the station A layout. If the westbound train does not get into the clear before the eastbound train arrives at signal AR1, that signal cannot be cleared, and, therefore, protection is provided for the move being made through the turnout.

A train using the turnout track circuit D does not occupy the opposing-train track circuit control of signals BR1 and BR3 at station B. The "space," but not the track circuit controls, is occupied. *This* is the feature which permits consolidation of signal checking and lock-outs, of signals AL1 and AL3, as well as the opposing signals BR3 and BR1, into two, or maybe one, interconnected field circuits. This would permit the use of one lever to control six signals in a manner which should meet the requirements of I.C.C. Rule 412, which is quoted in the reference notes. The principle on which Rule 412 is based was adopted, years ago, as a standard requisite by the Signal Section, A.A.R. The rule is important in that adoption of previously recommended practice is now required. In the proposed arrangement with no other trains in the territory between AL1 at station A and BR1 at station B, it is necessary, in order to clear signal BR1 at station B, that all the main line and fouling turnout track circuits, except the fouling track circuit D at the east end of station A, must be unoccupied, that signals AL1, AL3 and BR3 are checked in the Stop position, and that energy is cut off to prevent the clearing of any of the four remaining signals.

Approach Locking

If a proceed aspect on signal BR1 is "taken away" as an eastbound train is approaching, that train would have to overrun a Stop aspect to enter the overall block BR1 to AL3-AL1. In the period of time between the "taking away" of BR1 and the entrance of the eastbound train into track circuit R, the leverman, by purposeful and expedite action, might possibly clear either AL3 or AL1. On the basis that the engineman of the eastbound train sees signal BR1 "taken away" and applies the brakes to stop as soon as practicable, this train is taken care of. If the leverman were fast enough to clear AL3 or AL1 during the time between the "take away" of BR1 and the entrance of the train on track circuit R, any westbound train accepting and passing either AL3 or AL1 would be stopped at the intermediate signal (not shown on the plan), or would not overrun it far enough to hit the eastbound train, which, supposedly, had been stopped because it overran a Stop aspect on signal BR1. The possible hole, therefore, is very small and this can be "plugged" at the control machine by a time-element feature such that a "take away" and a clearing of an opposing signal cannot succeed each other for a specified time. The possibility of such procedure may be evident from the explanation of the control machine to be given later. If this arrangement is satisfactory, no approach locking in the field is necessary, although approach stick locking or time locking could be used if preferred. Time locking should be applied for the leave-siding signals so that if such a signal is "taken away," a period of time must elapse before an opposing or conflicting signal can be cleared, the time being sufficient for the train to stop short of the signal or enter the track circuit controls, thus holding out other signals.

At a location where the passing track layout is shorter than maximum train stopping distance, using the service brake application, the I.C.C. Rule 204, as applied to normally-clear three-aspect automatic signaling, dictates one of two answers; either four-aspect signals must be used or else two successive signals in approach to such signals as AR1 must display the Approach aspect when a Stop aspect is diplayed by AR1. The pitfalls, as well as the train delays in connection with the use of duplicate restrictive aspects on successive signals, are subjects which were covered in detail in the editorial in the February issue. Therefore, if the two short blocks at short passing tracks can be eliminated by the proposed signaling arrangement, this feature alone deserves serious consideration as an offset to some of the disadvantages.

Advantages and Disadvantages

An obvious objection to the elimination of "station-leaving" signals is that if a westbound train is pulling into the passing track at station A while an eastbound train is approaching closely for a meet, the eastbound train would have to be stopped short of signal AR1, rather than being advanced for the major portion of the length of the passing track. *However, if one cannot have cake with frosting,* perhaps it may be better to have the *cake.* If the maximum actual speed of a train is 60 m.p.h., and the passing track layout is one mile long, the second train would lose only one minute net in a situation in which the two trains occupied respective approach sections at approximately the same time. This minute would be reduced by the difference in the time of entering the approach sections; therefore, the loss of time in this layout would be one minute or less for trains operated at 60 m.p.h. The time loss would increase for trains of lower speeds.

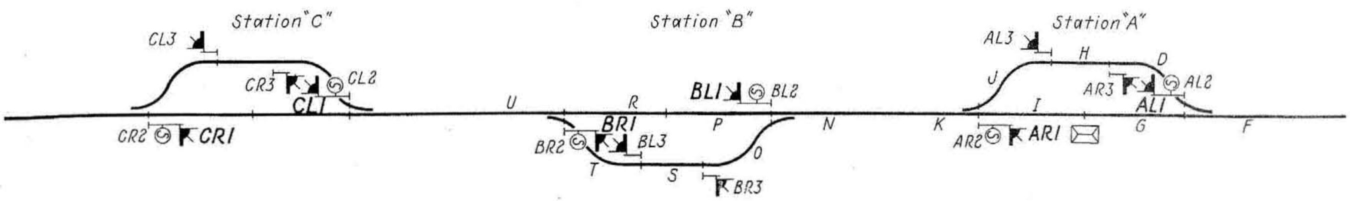

Fig. 3—Proposed arrangement of semi-automatic signals, no intermediate automatic signals being shown

Another consideration is the fact that with a westbound train on the passing track at station A for a meet with an eastbound train, the westbound train should be able to get signal AL3 to pull out as soon as the rear of the eastbound train passes the point opposite signal AL3. This can be done by using an additional track circuit, but in the scheme shown, the eastbound train would have to clear track circuit I. Directional sticks for both directions could be provided for operation by track circuits I and G. A point could be raised that the eastbound train might stop with the rear in track circuit G and then back up to foul the turnout. The same is true in many large interlockings where sectional release route locking is in service. In other words, a train cannot be allowed to back up without special authority, if it is stopped with the rear end part way through the home signal limits of an interlocking. The same applies in automatic block signaling. The practice and rule therefore, are applicable to this new layout of signals.

At a layout such as A, where the passenger station building and platforms are on the south side, and the passing track is on the north side of the main line, a point might be made that a westbound passenger train should be brought up to the station, and *later* get authority by signal aspect to proceed to station B. In this layout, the train would get authority at signal AL1 when entering the layout as a whole. This would introduce a delay equivalent to the time consumed while pulling from AL1 to the station and making the station stop.

Bringing Trains Up To The Station

Now-a-days, the short-scheduled through passenger trains stop only at the larger towns and cities. If a westbound local passenger train is due at station A, and is approaching at a time when an eastbound fast freight train should be moved from station B to station A, the westbound local passenger should be held short of signal AL1 until the freight train gets in the clear on the passing track at station A. Then the passenger train can get a clear aspect at signal AL1 to move up to the station, and later proceed to station B. The net result of this operation is that the passenger train would lose only the station stop time, plus the time to pull up from signal AL1, as compared with a layout using a station-leaving signal, because the passenger train could not leave the layout until the freight is in the clear, regardless of what signaling arrangement is used.

At the larger towns, the local conditions may be such that passenger trains must be brought up to a station, and at the same time other opposing trains be advanced to that station layout. If a signal can be re-introduced into the proposed signaling arrangement in such a manner that the number of semi-automatic signals would not be increased, such a change would not defeat the ultimate objective. This can be done by using a station-leaving semi-automatic signal at a location such as that of signal 6 in Fig. 1. As a part of this proposition, the top arm of a station-entering signal such as AL1, in respect to display of Stop, Approach or Clear aspects, would be entirely automatic, depending on track occupancy and the aspect of a newly introduced station-leaving signal such as 6 in Fig. 1. The most restrictive aspect of signal AL1 in this application, however, would be Stop, and the control of the display of this aspect by semi-automatic, this control being established as a part of the setup for a preliminary take-siding aspect. Therefore, no additional office-controlled field station equipment is required.

The importance of this conclusion, therefor, is that, where desirable from the standpoint of passenger stations, or for other reasons, the standard arrangement of signals shown in Fig. 1, can be provided and controlled similarly to the scheme herein discussed, without requiring an increase in the office-controlled equipment.

When switching moves are to be made, the conductor informs the leverman accordingly by telephone. Signals, to hold other trains out, are left as they were with the Stop aspect displayed, until the conductor informs the leverman that his train is in the clear or ready to go. This is standard practice in systems using aspects in place of train orders. Water columns are usually arranged so that locomotives can take water when on either the main track or the passing track. Therefore, the proposed signaling arrangement should not cause any extra delays when making water stops.

The lower "arm," signal AL2, is a "Take-Siding" signal, somewhat the same as used on the Erie, the Central of Georgia, the Bingham & Garfield, the Missouri Pacific and the Michigan Central. A typical operation, when a westbound train is to take siding at station A, is that the top arm, AL1, is red, and the lower arm, AL2, displays an illuminated letter "S," which is an aspect directing a train to stop short of the switch, and directing that the switch is to be reversed, after which the aspect changes to direct the train to enter the passing track.

Another idea is for the "take-siding" and switch protection signal to be a "switch signal," somewhat the same as is used at spring switches on one road and in part on another road. The lamp in the target could be normally extinguished to prevent confusion with the aspects of AL1. If the filament in the lamp of AL1 is broken, the target would display red. This requires "lamp out" checking circuits, similar to those used on several roads. When the switch is not fully normal or is normal but "cocked," AL1 would be red and the target would be red. When a preliminary take-siding aspect is displayed, AL1 would be red and the target purple. With such controls in effect, with the train on the approach stopped or practically stopped, and the switch is then reversed, a lunar white aspect would be displayed in the target. This aspect is authority for the train to enter the passing track and stop short of signal AL3. After the train is in the clear and the switch returned to normal, the controls revert to normal.

When the westbound train, on the passing track, is to be directed to pull out and proceed to station B, a letter "S" is illuminated on dwarf signal AL3, which directs that the switch is to be reversed, after which the signal displays an aspect to direct the train to pull out. The switch is, of course, returned to normal position before the train departs, in accordance with standard practice.

With this or any other ordinary system of Normal-Stop semi-automatic centrally-controlled signals at the passing tracks, the controls of intermediate signals on the single track between two station layouts can "follow" the controls of the semi-automatic signals, as well as be controlled automatically by track occupancy. In order to simplify the explanations of the proposed arrangement, the diagram and the explanations are confined to the controls of the semi-automatic signals at the passing tracks.

Circuit Interlocking In The Field

Years ago when recognition was given to the fact that all the necessary interlocking between a group of "arms," such as 1, 2, 3 and 4 at the east end of the layout in Fig. 1, could be accomplished by interconnections of circuits locally at the signal locations, it was possible to eliminate mechanical locking between the levers for the control of such semi-automatic signals. On this basis, the operation of a lever, with the "thought" of clearing the corresponding signal, is in fact nothing more than an "invitation" for the signal to clear, depending on whether the conflicting and opposing signals are displaying the Stop aspect, whether trains are occupying track circuit control limits, and whether approach or time locking or equivalent protection is in effect. In other words, the lever control is not a vital circuit. Although these facts are well known, they are stated here because of their peculiar significance with reference to the proposed signal arrangement.

Referring now to Fig. 1, showing the usual arrangement of four semi-automatic arms at each end of a passing track, an important feature is that interconnections between the controls of these four signals can be accomplished locally so that, before any one signal is cleared, the opposing and conflicting signals are checked at the Stop aspect. And as the one signal clears, energy can be cut off to prevent any other signal from clearing, even if the semi-automatic control sends an "invitation."

In a set of opposing signals, such as station-leaving signal 6 and its opposing station-leaving signal at the next town to the left, here referred to as signal 9, the interconnections to check the opposing signal at the Stop aspect before signal 6 can be cleared is effected through line circuits, the equivalent of which would be used in at least one form of existing purely automatic signaling.

On some installations, however, the clearing of signal 6 does not open the controls of the opposing signal at the next town. The result is that if signal 6 is displaying a proceed aspect, careless or inadvertent operation of the lever for the control of the signal at the next town might "kick off" signal 6 in the face of an approaching train. This situation is overcome, for all practicable purposes, by a lockout through the approach locking circuits. These circumstances are of no importance here, except for the fact that no power switches or approach locking are to be proposed for the signaling layout suggested, and this brings us face to face with the requirement of I.C.C. Rule 412, which reads, "Means shall be provided to insure that after signal has been cleared, it cannot be restored manually to Stop by the operation of any lever other than its controlling lever."

The circumstances involved include no hazard of a possible head-on, rear-end or conflicting move of trains. Adequate lengths of track are in all such cases available in which to stop a train with the service application of the brakes, but an engineman may not know this. If he sees a signal change from the Clear to the Stop aspect as he is approaching closely, he may use the emergency application of the brakes, and thus grind spots on the wheels. Strictly speaking, therefore, Rule 412 is not primarily a safety measure, but rather has reference to possible circumstances which involve train delays. Nevertheless if the full and complete intent of this rule can be attained, without extra expense, such an objective would be desirable. With reference to the proposed signaling, the provision of approach locking would give the equivalent of what is now in service on some semi-automatic projects, with respect to Rule 412. Approach locking circuits, however, cost considerable.

For these reasons, unless some practice is used to effect the checking and lockout interconnections in the field, which will be the equivalent of that at an all-relay interlocking with complete interconnections and lockouts, as well as to effect the equivalent, i.e., comply with Rule 412, the control machine required must accomplish the objectives stated. If this result could be accomplished both in the field and in the control machine, the signal arrangement would indeed be "buttoned up," as well as "zippered" to the closed position.

The Signal Group To Be Controlled

If one imagines himself on a track layout, as shown in Fig. 4, and saunters about thoughtfully until he finds a spot to which a maximum number of routes lead from signals, he then can get the idea. In brief, he would be on the single track between two passing tracks, as, for example, between stations A and B. The signals which would control routes leading to a common "spot" would be AL1, AL3, BR1 and BR3. Only one of these signals need be or should be cleared at any one time, and, therefore, this is a group, all of which could be controlled by one lever, with a left and a right position to establish control of the respective eastward or westward signals. Trains can be operated in one direction, or the other, but not both directions. When a westbound train passes signal AL1 or signal AL3, that train is going to station B, either to get high-arm BL1 to keep going, or else get BL2 to enter the passing track. By making this decision before clearing either AL3 or AL1, subject, of course, to a change of mind later, a selection may possibly be established.

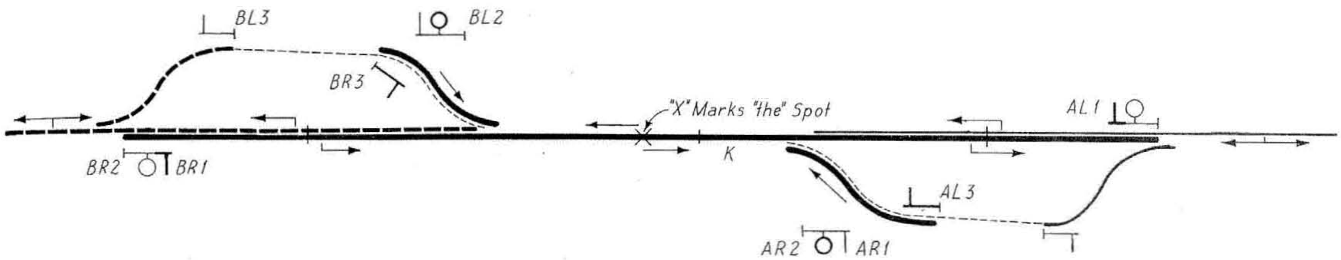

Fig. 4—Showing method of determining the group of signals to be controlled by one lever in the central office machine

Why The Take-Sidings Are in This Group

The next step is to include in this group, the two take-siding signals, AR2 and BL2, so that a total of six signals can be controlled by one lever. A take-siding signal is in a class by itself because the preliminary aspect is in reality the equivalent of the absolute Stop. Not until the switch is thrown by a trainman, does the signal display an aspect to authorize the train to enter the passing track. Is there any harm in displaying the equivalent of a Stop aspect on one signal in a group, and at the same time display a proceed aspect on a certain signal also in the same group, if the train controlled by the first mentioned signal is protected by semi-automatic signals displaying Stop aspects governing head-on and conflicting moves, and by automatic block signals governing following moves? The answer is no. Therefore, referring now to Fig. 4, if an eastbound train is occupying approach section K, and is to take siding at the west end of station A, the take-siding signal AR2 could, with safety, be set up to display the preliminary take-siding aspect, while at the same time eastward high signal BR1 could be cleared for an eastbound train to proceed. This is with the understanding that intermediate signals are provided as rear-end protection for the train entering the passing track. Provisions must be made for such circumstances; otherwise in setting up for a *pass,* the second train might be delayed unnecessarily. The control, therefore, should be such that the take-siding preliminary aspect on AR2 and a proceed aspect on BR1 could be established simultaneously, and at the same time lock out AL1, AL3 and BR3. Without going into further details here, the necessary interconnections and lockouts of signals evidently exist to afford complete protection.

Consideration is now given especially to the fact that eastward take-siding signal AR2 is in the same group with its opposing leave-siding signal AL3. When an eastward train which is to take siding is approaching, it is going to have to stop; therefore, AR2 need not display the premlinary aspect until track circuit K is occupied by an eastbound train. On the other hand, AL3 cannot clear with an eastbound train on K. Likewise, AL3 need not operate or display any aspect unless a westbound train is occupying the passing track. All this is true, and the two signals are controlled by the same lever. In Fig. 4, the track and signals involved in the AB group are indicated by heavy solid lines. Part of the track and signals of the corresponding group to the east are shown in light lines, while the group to the west is dotted.

Two Groups Considered

The next step is to consider possible interference between the control of signals in one group as compared with those of the second group. The track circuits between AL1 and AR1 are common to both groups. These two signals, however, need not be clear simultaneously to permit train movements, and, therefore, interconnections can be made to check and lock out locally. Various selections can be included in these interconnections.

Westward take-siding signal BL2 is in the "heavy-line" group, while eastward take-siding signal BR2 is in the "dotted-line" group. Obviously two opposing trains should not be headed into a passing track at the same time, and, therefore, local interconnections are suggested which may include other selections. Consideration indicates that the grouping shown should be practicable, although, of course, other groupings might be used, as, for example, the six signals at a passing track.

Checks and Lock-Outs In the Field

An arrangement of local field circuits has been designed, the objective of which is that, if any one of a group of four signals, such as AL1, AL3, BR3 and BR1, is to be cleared, the opposing high arm and the two leave-siding signals, as well as the opposing take-siding signal, are checked to insure that they are displaying the Stop aspect. Furthermore, when the signal being controlled has cleared, none of the four remaining signals can be cleared, even if the levers are manipulated. To make such a statement is to "stick one's neck out" rather far. Three railroads have offered to connect up an actual test of this circuit in order that more definite conclusions can be drawn. If this local circuit accomplishes all the signal position checks and lockouts equivalent to an all-relay interlocking, existing types of office control machines could be used in connection with the proposed signaling arrangement.

A Control Machine To Do It Alone

In the meantime, however, attention is directed to the construction of a central-office control machine such that a set of six signals as mentioned previously can all be controlled by one lever. This leads to the idea that such a lever might be mounted in the space represented between two passing track layouts on the face of an illuminated track diagram on the face of a control machine. The levers would not be designated with the names of stations, but would be numbered, as for example, lever No. 2 would be between the symbols for the station layouts B and C. This calls for an entire renumbering of the signals on the basis of lever numbers and, therefore, reference should be made now to Fig. 5.

The lever should be some form of practical construction, but, for purposes of explanation, let us say that the lever is in the form of a heavy arrow, pointed upward and pivoted at the middle on a horizontal shaft extending perpendicularly into the face of the machine. The arrow would be pointed straight up when the lever is in the normal position, with all signals having been controlled to display the Stop aspect. The idea of the arrow is that, when positioned to control a high arm signal, the head will point to the symbol which represents the signal to be controlled.

In the "high" position to the left, the high arm main line westward signal 2L1 at station B would be controlled. With the lever in the second position to the left, the westward leave-siding signal at station B would be controlled. So far the two signals controlled have been westward signals, and to be consistent in this respect, with the lever in the "low" position to the left, the westbound take-siding signal 2L3 at station C would be controlled. Similarly, the lever would be operated to any one of the three positions to the right to control the corresponding opposing signals, including the westward main line high arm 2R1 and the westward leave-siding signal at station C, as well as the westward take-siding signal 2R3 at station B. After a lever is positioned, a button or similar device is actuated to cause energy to go out on the line to actuate equipment at the corresponding field station, to cause the signal to display a proceed aspect if the local automatic field controls are complete.

In order that the control office machine may be so operated that the principles of all-relay interlocking, as

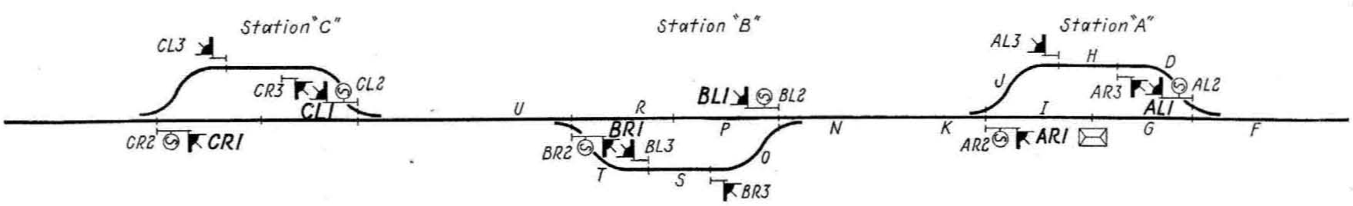

Fig. 3—Showing the proposed signal arrangement is repeated here for ready reference

well as I.C.C. Rule 412, may be met, any one of various mechanical and/or electrical arrangements could be used. The principle involved is that after a lever has been positioned and the control sent out to the field to "invite" a signal to clear, this lever is not effective for the control of any other signal until a control is sent out to "knock down" the control which was established just previously. This objective can be attained by various mechanical and/or electrical arrangements. For example, a knob is mounted on a small plunger extending vertically through a hole in the bottom of the arrow, and perpendicularly toward the face of the machine.

After positioning a lever, the operation to cause energy to go out on the line would consist of pushing the knob to cause the plunger to go through a hole in the face of the machine, as far as the base of the knob would allow. In this movement, contacts would be operated to cause the energy to go out. After removing pressure in the knob, it and the plunger would be actuated to a center position by spring action, but the plunger would not as yet be out of the hole, and, therefore, the lever could not be moved unless the knob is pulled. If the knob is pulled, however, contacts would be operated which would cause energy to be sent out on the line to knock down the control previously established. Therefore, to set up a control, the lever is positioned, the knob is pushed and pressure is removed. The knob must be pulled entirely out of the hole to permit the lever to be moved to a position which would permit any other high-arm signal in the group to be cleared. Such operation would seem to meet the requirements of Rule 412.

How To Clear 2R3 and 2R1

Reference should be made now to Fig. 5, concerning the control machine. In addition to the knob arrangement on the lower end of the lever, explained previously for use in the regular procedure of controls, there could be a second and smaller knob mounted in the lever about half way between the lower end and the shaft. This second knob and plunger are used when setting up for a *pass,* as, for example, to clear eastward take-siding signal 2R3 at station B and also to clear eastward high arm 2R1 at station C. In this case, positioning the lever for 2R1, also places the lever properly to permit also the use of the smaller knob to clear 2R3. In such a setup, both knobs would have to be pulled to release both plungers before the lever could be moved to a different position. The plunger of the smaller knob would not enter its hole unless pushed, and, therefore, would not lock the lever unless the combined control is set up. When 2R3 only

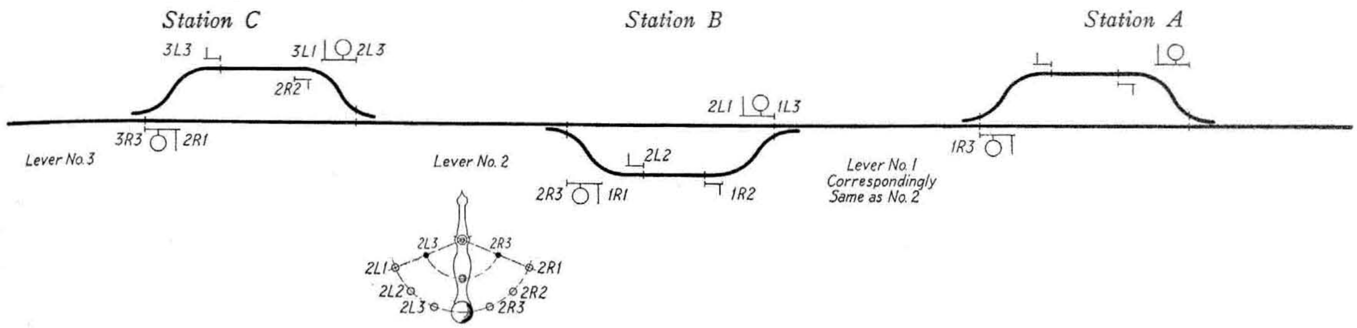

Fig. 5—Seven-position lever, mounted on diagram of control machine between layouts representing stations B and C

is to be cleared, without clearing 2R1, the regular lever position for 2R3 must be used. A lever arrangement constructed as suggested, or similarly, could include other contacts actuated by levers or plungers, and thereby accomplish special directional selections, as well as others, some of which are mentioned later.

Helpful Machine Operation

A characteristic of this type of lever construction is that under no circumstances would it be necessary for any two adjacent levers to be positioned so that the arrows would be directed to any common point above the diagram. This characteristic can be utilized in a special way. For example, in order that the leverman may know that he is attempting to do something that would not be accomplished, an arrangement of mechanical connections could be devised so that the leverman could not position a second lever with the intent of clearing a signal in the "second" group which is opposing to the signal then clear in the "first" group.

As power switches are not included in the proposed signal arrangement, the expense for approach locking circuits should be avoided if practicable, and, therefore, time locking, accomplished in the field with respect to the high arms and the leave-siding signals, should be considered.

As explained previously, non-vital controls can be used between the office and the field, because interlocking, which is the equivalent of mechanical locking, is all accomplished in the field. On this basis, would it be logical to use these non-vital circuits as a basis for accomplishing vital protection such as time locking in the machine? If lever No. 2 has been used to clear 2R1 for an approaching train and the leverman operates the lever with the "intent" of changing the aspect to Stop, but in this case the "invitation" is not received in the field, signal 2R1 would continue to display the clear aspect. The leverman might proceed to operate the lever with the intent to clear the opposing signal AL1. That signal would not clear, however, because its automatic controls are held open by 2R1 at the clear position.

If the "invitations" were both effective in the field, a time locking period should be introduced between the take-away of 2R1 and the clearing of 2L1. The point is that regardless of whether the invitations are or are not transmitted and received as intended, perhaps the "vital" feature exists, in so far as the possibility of accomplishing time locking in the machine is concerned. Time locking can, and no doubt should be provided in the field, but the objective of this thinking is to enforce logical operation of the control machine. For example, it might be a good idea to introduce a period for the leverman to do some thinking, between the time he takes away a signal and has the opportunity to start to clear another one. This provision may or may not be wanted, but if so, it can be provided. One means, by which this could be effected, would be to have the shaft, on which the lever is mounted, connected to the equivalent of an electric lever lock. When the knob is pulled, a second set of contacts are operated which initiate operation of a time-element relay, and, therefore, a specified time must elapse before the electric lever lock is released so that the lever can be moved.

Machine Indication

As information to the leverman concerning what he is doing and has done, a small lamp in the symbol for a signal could be illuminated when control goes out on the line to clear that signal. Also lamps behind the track lines could light up one color to indicate the track lineup to be used, this being accomplished through lever selections. When the train occupies the approach section, the color of the track indictaion would change, but when the train departs from that section, the lamps would be extinguished.

These track-occupancy indications would come in automatically, the same as in ordinary practice. Track occupancy indications, the equivalent of those now used on many other semi-automatic installations, can be provided. Ordinarily these include the track circuits in approach to a distant signal, track circuits up to a station-entering signal and the detector section at the switch. Through selections of lever contacts, arrows could show the direction in which a train is headed, if it is moving on the authority of the signal aspects.

Reference to Articles in Previous Issue of Railway Signaling

PASSING TRACK LEAVING SIGNALS

T. & P., page 294, August, 1930.
C. M. St. P. & P., page 568, October, 1940.
D. & H., page 495, September, 1939.
M. P., page 100, March, 1930.

TAKE-SIDING SIGNALS

Bingham & Garfield, page 172, May, 1930.
M. C., page 157, May, 1931.
C. of Ga., page 248, July, 1927.
M. P., page 100, March, 1930.
Erie, page 198, May, 1925.
C. & O., page 462, December, 1925.
L. & N., page 108, April, 1917.

CODED LINE CONTROLS AND INDICATION ON SAME LINE WIRES WITH TELEPHONE COMMUNICATION

L. & N., page 553, October, 1940.
Pennsylvania, page 691, December, 1940.

OTHER REFERENCES

I. C. C. manual-block rules page 80, February, 1941.

I. C. C. Rule 204. Signals shall be spaced at least stopping distance apart or, where not so spaced, an equivalent stopping distance shall be provided by two or more signals arranged to display restrictive indications approaching signal where such indications are required.

Discussion of Rule 204, page 73, February, 1941.

I. C. C. Rule 207. On track signaled for movements in both directions, signals shall be so arranged and controlled that proper restrictive indications will be provided to protect both following and opposing movements.

I. C. C. Rule 405. Signals shall be automatically controlled by continuous track circuits on main tracks and on other tracks where medium speed is permitted, and in addition at controlled point by control operator, and at manually operated interlocking manually in co-operation with controll operator.

I. C. C. Rule 412. Means shall be provided to insure that after a signal has been cleared it cannot be restored manually to "Stop" by the operation of any lever other than its controlling lever.

New Books

Railway Signaling and Communications Installation and Maintenance

Syllabus arranged and text edited by A. E. Tattersall and prepared for publication by T. S. Lascelles, from lectures by Messrs. A. E. Tattersall, M. I. E. E., F. Inst. P.; E. G. Brentnall, M. Eng., A. M. Inst. C. E.; J. H. Devine, B. Sc., A. C. G. I.; G. H. Leversedge; A. Smith, A. M. I. E. E.; W. H. Such and S. H. Barrs, given to members of the staff of the telegraph and signal department of the London & North Eastern (England) when attending some of the training schools which have been introduced in recent years on that road. The St. Margaret's Technical Press Limited, 33 Tothill Street, Westminster, London, S. W. 1, England, First Edition, 1941, 416 pages, illustrated by 339 figures, 59 other diagrams and pictures, 8 shillings.

This book has been written primarily in the interest of telephone, telegraph and signal linemen, installers, inspectors, etc., due to the fact that the maintenance of signal and communications equipment today demands considerably wider knowledge than was formerly the case. The adaption of suitable methods for insuring that those, to whom the care of the various types of apparatus that go to make up a modern signaling and communications system is entrusted, possess a sound understanding of the principles underlying their work has become essential, no less from a practical than from an economic point of view. The text of lectures, presented to the members of the staff of the telegraph and signal department of the London & North Eastern (England), has been slightly modified, where it appeared advisable, to render it more suitable for publication in book form or to give it a somewhat wider application and make it equally useful to those engaged on other railroads where different equipment may be used. There is, however, sufficient similarity of practice today in signaling matters between the principal British railways to justify the belief that the work will prove beneficial to all who are engaged in the installation and maintenance of signal, telegraph and telephone apparatus whether on the British railroads or those in the United States. The book contains 19 chapters, namely, in sequence, "The Necessity for a Signaling System and Its Functions"; Signal Boxes, Signals and Point Detectors"; "Ground Connections"; "Level Crossings and Miscellaneous Apparatus"; "Maintenance of Mechanical Signaling Installation"; "Principles of Mechanics Applied to Mechanical Signaling"; "Mechanical Locking"; "Principles of Magnetism and Electricity"; "Principles of Magnetism and Electricity *(continued)*"; "Telegraphs and Train Signaling Instruments"; "Telephony"; "Telegraph and Telephone Line Construction"; "Maintenance of Telegraph and Telephone Equipment"; "The Simple Direct Current Track Circuit"; "Direct Current Track Circuits *(continued)*"; "Typical Electrical Signaling Circuits"; "Elementary Principles of Alternating Currents"; "Alternating Current Relays and Track Circuits"; and "Modern Development in Signaling."