even when the car has reached 3A. The clearing magnet C in the main relay, being in multiple with magnet F, is therefore continuously energized while the car is on the contactor, having approached it from the end 5A. The divided contact strips and the directional relay magnets E and F thus act selectively, to actuate coils A or C according to the direction of the car.

In the clear block both ends of the signal wire are grounded through the circuit, 1, 9, 8, 7, 2, ground, including coil H, and the red lamp.

A car entering from the left temporarily connects contact strip 3A of trolley contactor with trolley wire, forming a circuit, 4, 3A, 3, 10, 11, 17, 2, ground, passing through coil A. This impulse of current in A moves its plunger to revolve the two-way switch, transferring the end of the signal wire 9 from contact 8 to contact 13. Current then flows from trolley wire, 4, 13, 9, 1, signal wire to other relay to ground as described. When the car leaves the contactor, plunger A drops back into the position shown, while plunger D remains in the retracted position on account of the current in coil D. The white light now burns, since it is in shunt across D by the path 4, W, 6, 14, 13; and the red light also burns in the other relay because of the current in the signal wire. The retracted position of plunger D in the one relay, and that of plunger H in the other, permit the display of the white and red disks, respectively. So long as the red signal continues the circuit of magnet A is held open at 3, 10, preventing change in the left relay by cars entering at contactor 3A against the red signal. The effect of successive entering cars is to revolve the switch so that the contacts overlap further, but not to cause any electrical change in the signal circuit, except that each entering car actuates magnet A so as to break the lamp circuit at switch 13, 14, causing the white light to blink.

When the car leaves the block at the right end it runs under contactor 5A, completing the circuit, 4, 5A, 5, 12, 18, 2, ground. The plunger of magnet C opens the signal line wire circuit at 1, 9, breaking the circuit of magnet D in the entering relay. The plunger of D is restored to its original position, revolving the switch in the reverse direction, one notch at a time for each leaving car. When there have been as many breaks of current in coil D as impulses of current in A, the revolving switch will be in its original position, and the signals will be cleared.

If the car enters the block by contactor 3A, 5A, it will energize magnet A and set the signals; while if it backs out under the same contactor, it will energize magnet C to clear them. If a car should accidentally overrun the contactor against a red signal, then current would flow through signal wire 6A to the distant relay, and through setting coil A there, by means of the color disk switches, one of which will be closed in each signal box. But there would be no effect on the signal showing red, since the circuit of the setting magnet A would be held open at contacts 10, 3, as stated. The second signal wire 6A is, therefore, a means for enabling a car running against the red signal to count in on the distant relay, that it may count out again in backing. It is in use only at such rare instances.

The function of magnet N is to prevent change of signals should the power fail with cars on the block. It is permanently connected across the line in series with a high resistance, 4, 15, 16, 2. Should the current fail while the plunger of D is drawn up, the plunger of N will catch that of D to prevent it from rotating the ratchet.

All the magnets are arranged so that after the stroke is partly completed, the current in the coil is reduced either by insertion of resistance or by shunting current around them. For instance, before the plunger of C moves the current passes through the resistance 18, 2 only, but after it has moved it passes through the additional length 12-18 and is, therefore, reduced in strength. By this means the magnet is operative over a very large voltage range; and is also protected from burn-out should the car remain under the trolley contactor. Magnet C is provided with a dash-pot, to retard its return motion and allow magnet D to act during the breaking of its circuit.

SUMMARY OF RECENT PROGRESS IN SIGNALING

BY A. H. RUDD.*

In the past five years electric traction has been rapidly developed, telephones have been substituted for telegraph in many sections, locomotives of higher power and cars of larger capacity and increased strength built, air brake efficiency improved, greater attention than ever before given to the manufacture of rails, the improvement of fastenings, preservation of ties, and the general betterment of the permanent way, but in no branch of railway engineering and operation, except in government regulations, has such a revolution been accomplished and such progress made as in the signaling of the trunk lines of America.

The development of the motor signal operating at low voltages, and particularly of the top-post mechanism applying the power directly at the point required, has enabled us to place our distant signals at a sufficient distance to give proper advance warning to approaching fast trains, while removing the danger of maladjustment inherent in the old wire-connected signals; while electric back locks insure against dangerous complications in the rare event of false clear failures. Approach locking insures against errors of practice, in the event of an attempt on the part of a signal operator to change a route after clear signals have been displayed. In the automatic field improved apparatus has reduced failures, and notably, the development of alternating-current apparatus has practically eliminated that class of false clear indications, due to stray currents closing the track relays (which are the basis of operation of all improved automatic work), at the same time providing more rugged mechanism, probably cutting down operating expenses considerably, if the same energy is used to operate and light signals, dispensing as it does with the care of oil lamps and storage or primary batteries.

The development of manual controlled block systems has enabled us to operate entirely by signal, without the use of train orders, on single track, with practically the same safety as is insured by the employment of the staff, or staff and tablet system, but without the delays made necessary by these cumbersome methods.

The perfecting of electric and electro-pneumatic interlocking has made possible the control of signals and switches a mile or more from the center of operation, and this has required in turn the development of electric route locking, so that not only are switches prevented from moving immediately under trains, but are locked by the approach of a train throughout its entire route to the next signal, and are released in turn immediately on its passage. If a signal is cleared for an eastbound train, the entrance of such a train upon such a route will hold all switches in front of it and release them as it passes, and the clearing of a signal for a westbound train will lock all switches in the route, and the train will release them in reverse order on its passage. This development has added tremendously to the safety of our large terminals, and, incidentally, as the track circuits are installed, they have been utilized to introduce the semi-automatic feature in terminal stations, by which all signals are restored to the normal position by the passage of the train, a still further safeguard, utterly out of all question ten years ago, and attempted with trepidation first, I believe, on the Pennsylvania some four years ago.

It is not my intention, however, to enlarge upon the engineering features of the profession, but rather to set forth a few of the problems involved in the indications to be given and the aspects to be displayed to the engineman.

The disk signal was the first type of automatic signal. Broadly, it consisted of two kinds, the simple magnet and

*Signal engineer, Pennsylvania Railroad. From a paper recently read before the Canadian Railway Club, Montreal.

the clockwork. The well-known Hall disk was probably the simplest ever designed, consisting of a magnet and a rotating armature. A number of roads, pioneers in automatic signaling, being equipped with such signals before the motor signal was perfected, have continued the installation of such types, but the general trend on most roads is to supplant them by semaphore signals.

About 12 years ago the yellow light was developed for the night caution indication, and since then almost half the mileage of the United States and Canada has adopted green for the night clear indication in fixed signals, and all but two or three roads comprising this mileage are using yellow for caution.

The upper-quadrant arm has only been strongly advocated during the past five years, and on February 1, 1910 (the last date at which I compiled the information), out of 255,357 miles of roads in the United States and Canada, I found as follows:

	Miles.
Lines of road on which it was adopted for all new work and renewals	69,634
Lines on which it was used in part	16,152
Total	85,786

while lines of only 65,520 miles advised they contemplated no change, leaving 12,000 odd considering the change and 92,000 miles not reporting. Since then the movement has advanced rapidly, and it is safe to say that nearly half the total mileage referred to will install the upper quadrant for new work and renewals in the next year or two. Without question, this common-sense arrangement will eventually be universally adopted.

Closely connected with the movement for the use of the upper-quadrant is the adoption of what is known as three-position signaling.

At interlocking our practice is, I believe without exception (at least in the United States), to have the top arm govern the main running track, and the second, and sometimes the third, fourth, and fifth arms, to govern to diverging tracks, while on thick lines where automatic signals are used the home block signal is the top arm and the distant for the next home signal is mounted below it, so that at interlockings one arm governs the straight track, and at the block signal two arms must be observed together. Further, at interlockings where advance signals are used, it is the practice, if the advance signal is at stop, to show caution at the distant and clear at the home, which has led to disaster. Both these conflictions in practice are remedied by the use of three-position signaling. Only one arm is used on the automatic signal, except when it is also used as a distant for an interlocking, and arms are only added where divergencies occur, as at interlockings. All lights except the governing ones are red, so that two lights do not give conflicting information concerning the movement to be made. The arm at horizontal (red light) indicates stop; inclined upward 45 degrees (yellow light) indicates next signal at stop; and upward 90 degrees (green light) proceed, next signal at caution, or proceed; in this way governing trains by the position of the arm rather than by its shape, a decided improvement over the present practice, in which a fish-tail arm horizontal means caution and a square end arm stop, the shape being difficult to distinguish at high speeds.

So far, we have regarded a single arm as the entire signal, as does the standard code, which provides no indications or aspects for "diverge from the main track." Obviously, therefore, it is incomplete.

In practice, of course, as previously stated, we have a multiplicity of arms. Many roads attempt to signal routes; others cover all diverging routes by the use of one additional arm. This carries with it a reduction of speed, and while not so stated in orders, etc., we have really for years been using at interlockings what is known as speed signaling—that is, top arm for main track (high speed), second arm for diverge (low speed), for it is obvious that with such an arrangement it is only safe to permit a speed which will be safe and proper by the most unfavorable route. When such a signal governs to main running passenger tracks and also against the normal current of traffic, or into sidings, and is habitually used by high-speed trains, the habit gradually forms of running at higher than the authorized speed, and if sometime a different route is set, serious results may ensue. This is particularly the case when long cross-overs or turnouts are installed, over which a movement at 40 to 50 miles an hour is permissible, hence the practice is rapidly developing of using, at points where the routes may be changed, as at interlockings, three arms, the top for the through high-speed route, the second for the medium-speed route, and the third arm for low-speed routes, giving it clear if the route is set over a short turnout to a main running track, with next signal in the route at proceed, if within braking distance, and in the caution position if the train may only proceed through the interlocking limits. An additional function is also given to this arm in the caution position, viz., that of admitting trains to an occupied track within the interlocking limits, using it in lieu of the hand signal required by present practice, if the signals are semi-automatic, and thus assuring the runner that the switches are properly set and locked. It has been the general practice to space the upper arms about six ft. apart, and the lower arm about twice that distance below the second arm. It is now recommended by a committee of the Railway Signal Association to have the spacing approximately equal, in which case it will probably be advisable to make the lower light of a color other than red for greater distinction.

A general rule requires that a train must stop if a signal is improperly displayed, or if a signal is not displayed where one should be shown, but this rule is difficult of enforcement. For instance, if one, two, three, or perhaps four lights should be displayed, and one is extinguished, an engineman may mistake a four-light signal, with the top light out and the second light clear, as a clear main track signal. etc. Again, if it is a one-light signal, and that light extinguished, the particular spot of darkness at which the train should stop is not easily located. In the present satisfactory development of signal lamps, cases of extinguished lights are rare; but they do occur, and it is generally felt that an engineer should have two chances, as the extinguishing of both lights in any one signal is very unusual, unless electric lights are used. Again, it is felt that if the same number of lights were displayed on every signal, the absence of any of the lights would be instantly detected. The ideal for economy would be one light on each signal, but obviously this is impracticable. The ideal for safety would be so many lights that at least one would always be burning. On the other hand, the cost of equipping each switch target with two or three lights would be prohibitive. As a compromise, the following has been suggested and put into effect more or less completely on a number of roads, with the hope that eventually the various practices may develop into a uniform system:

Facing switches on high-speed tracks to be equipped with high distant switch signals having two lights. The switch-stands themselves to be short and equipped with one light. All high signals to have two lights of long range, the low-speed arm to be equipped with a short-range light.

This will, in effect, result in two lights on all high signals governing high-speed trains, and one light on all low signals governing low-speed trains.

Taking advantage of this principle, the signals are divided into three classes: "Stop and stay," "stop and proceed," and "stop and investigate." Under "stop and stay" are classified all manual block and interlocking signals, the two lights being placed one above the other and the arms square-ended. Under "stop and proceed" are classified distant signals of all kinds (which require no stop) and all automatic signals, at which the train must stop and if the way is seen to be clear may then proceed, the two lights being placed in a diagonal line, and the arms having ends pointed. Under "stop and investigate" are the switch targets and similar signals or signs. In order to differentiate between a red switch light, which may be passed after stopping, and a light at a dwarf signal or a derail which is open, which may not be so passed, it is proposed to make these latter purple for the stop indication. By the use of this color also dwarf signals will not be mistaken for train tail lights or flagmen.

It is further proposed to make the siding and yard switches lunar white when set for ladder or straight track, and yellow for the reversed position, retaining the red and green for main line indications. There remains still to be provided a permissive signal and a block office closed sign. Several roads, notably the Pennsylvania, give a permissive signal in manual block territory, which permits their heavy freights to enter an occupied block without entirely stopping. At present this is given by the home or advance signal in the caution position, but it is felt that such diverse information all conveyed by one aspect is confusing, and that some other means should be adopted. It is proposed to use, instead of the yellow light alone, a reflecting lamp showing yellow and lunar white in a horizontal line about one ft. apart on centers, with a circular disk attached to the blade.

There are in use several schemes for designating "block office closed." Arms are cleared and lights extinguished, or arms are cleared and lights left burning, or arms are left at stop and lights extinguished, and when permissive block is operated, confusion is avoided only by the use of established rules. In order to carry out the idea of having the signal itself indicate the conditions, it has been proposed to use removable arms, and, when the office is closed at night, to display two lunar white lights on a horizontal plane, about two ft. apart, on the signal mast.

It will be seen from the foregoing that the aspect of the signal has been considered in its entirety, as presented to the engineman, rather than in its component parts, as treated in the Standard Code, and much thought has been given to the problem of so arranging it that two separate signals located close together may not be read as one signal, giving different information.

For the past five years Committee No. 10 of the American Railway Engineering and Maintenance of Way Association has been working on this subject of aspects, and until a year or so ago was most harmonious. Since then some of the members operating their railways have felt that, while the system outlined was applicable to the trunk lines east of Chicago, it was too elaborate and expensive for their own requirements. They differ from the majority of the committee substantially in only two fundamentals. First, they believe there should be only four indications: "stop and stay," "stop and proceed," "caution," and "proceed," caution covering "train in block," "diverge from main track," "next signal at stop," "bad track ahead," or any other condition where caution is required. This would mean that any train receiving a caution signal must reduce speed at once and proceed at low speed, looking out for some danger to stop signal ahead, and be absolutely restricted as to speed until the next signal was reached, regardless of what the conditions actually might be. For instance, even if the route was set over a long cross-over with the next signal clear (a route which could safely be taken at 45 to 50 miles an hour), the train must crawl along because the same signal at the same place might, next time, indicate the train was headed into a siding or an occupied main track.

In the minds of the majority, this practice would restrict train movement, while our desire to facilitate it as much as possible by the use of signals, and not to tell an engineman to use caution when it is not required; for it is human nature, if we are told day after day to run cautiously, and find no reason for such restriction, to take it for granted that the conditions are as usual, and "hit her up," rules to the contrary notwithstanding. Our object is to so arrange the signals that they may accord with the rules to such an extent as to make the observance of the latter almost instinctive, rather than requiring an effort of memory under varying conditions.

The second fundamental (of these west-of-Chicago men) is that the signal governs only to the next, and that, if a distant signal shows clear, the engineer is not thereby told that it means proceed, next signal at proceed, but rather that it may be at stop. The logical result of this is that a distant signal at caution would mean "reduce speed at once and look out for immediate trouble," and a distant signal at clear, "proceed, prepared to stop at the home signal, which may be against you." That is, of course, if the road is operated on a conservative and safe basis. With one-mile blocks and trains scheduled at 60 miles an hour, how many would make time?

The fact that several roads have adopted the principal aspects suggested by the committee and that they are operating successfully, having the testimony of their enginemen that former confusion is eliminated, and that the new system is easier to learn and remember than the old, is sufficient refutation of the plea that it is so complicated that no one can learn it, and the conclusion of a majority of the committee is that the new scheme is applicable to lines of either heavy or thin traffic, tells the engineer the truth, relieves him of the tension of continually guessing what "caution" means at each particular place, and, finally, not only safeguards traffic to a greater extent than formerly, but also expedites it to a degree before unknown.

The impression is abroad that the Pennsylvania and New York Central lines are great four-track trunks, rich and powerful, and that they can afford systems which would bankrupt the thin lines. I can speak for the Pennsylvania alone, and I assure you that money for signaling is not easy to get, and that we have quite a mileage of other than four-track lines.

The points in dispute have been submitted for decision to the Committee on Transportation of the American Railway Association. It is expected it will reach a decision in the near future. If this is done, the report of the committees on signaling of the Railway Signal Association and the American Railway Engineering and Maintenance of Way Association will doubtless be recast along the lines laid down by the Committee on Transportation, and it is to be devoutly hoped that the committee may get together and evolve a system which can be recommended by all three associations for adoption; and can be put in use on all the railways of the American continent, to the end that we may not only have uniformity and interchangeability of material with all its benefits of economy and quick delivery, but that our enginemen may run over our various roads, or shift from one road to another, without the danger of their encountering a new system, mistakenly interpreted perhaps, by sudden mental reversion to the old system of different meaning under which they had been accustomed to operate.

Solder for aluminum can be made of 5 parts aluminum, 5 parts antimony, and 90 parts zinc. To make it harder, the amount of antimony should be increased and the zinc decreased. The aluminum should first be melted, then the zinc added, and when this is melted, the antimony can be put in. Soldering flux for iron can be made of 2 parts zinc chloride, 3 parts glycerine, and 5 parts alcohol.