Four-Aspect Color-Light Signals Installed on English Road*

New Signaling Completed Recently on the Southern Railway Makes Use of a Novel Multiple Beam Lamp

By W. J. Thorrowgood

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WITH the view of simplifying the signals, as far as the enginemen are concerned, and to add to the efficiency of the signals as regards the greater capacity of the lines, the Institution of Railway Signal Engineers has taken a great interest in the four-aspect color light system of signaling. A system of four-aspect color light signals, similar to that recommended by the committee, is about to be introduced on the Southern Railway. Their use appears to meet the requirements, but the conditions met with in practice in running call for some alterations and additions.

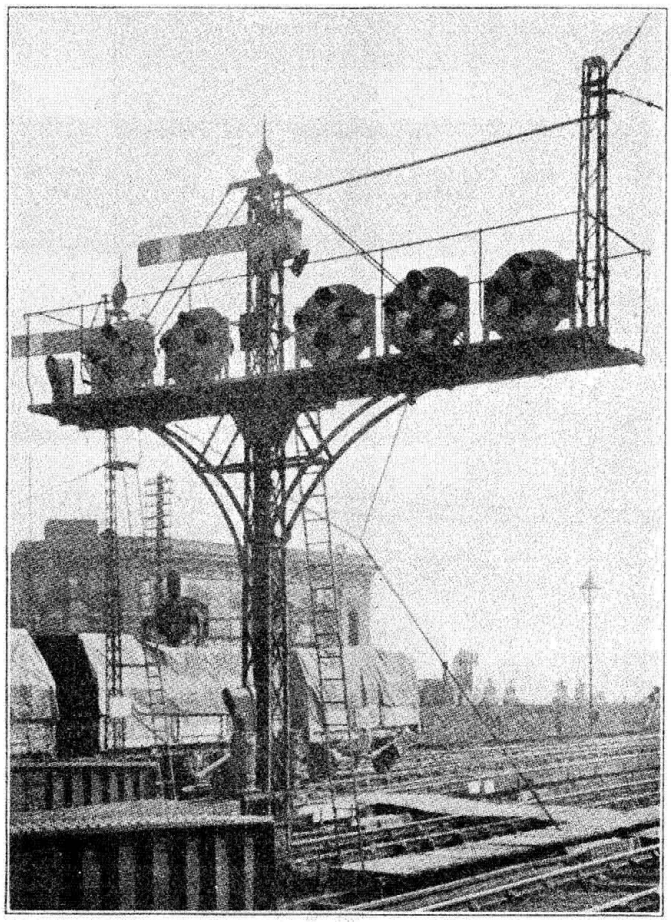
The four aspects in the color light system the Southern is adopting are: green to indicate "Clear"; double yellow for "Warning"; single yellow for "Caution"; and red to signify "Stop."

A green aspect will tell an engineman going at any speed that he has a clear road and that the next signal ahead at that moment is either a double yellow or a green, and he will be sure to find one of the two when he reaches it, except under emergency conditions, when, of course, any signal may be exhibited. Passing a double yellow aspect he receives a warning that he has full braking distance, and that the next signal ahead is at that moment in the "caution" condition, i.e., exhibiting a single yellow aspect. Under such conditions the engineman will take steps to get his train under control. The single yellow aspect cautions him that at that moment the next signal ahead is in the "stop" condition and he must be prepared to stop at that signal. He always comes to a double yellow and a single yellow before he reaches a red or "stop" aspect.

One of the problems that arises is how to deal with junctions and diverging lines. The author strongly advocates one four-aspect color light signal and a route indicator in every case. It is simpler and, if adopted, would be uniform and the number of lights exhibited would be less, which all tends to economy and, in my opinion, efficiency. But the objection is raised that the engineman cannot see the route indicator as clearly as he can the colored aspect itself, or in other words, he can see the colored aspect farther away than he can see and read the route indicator. That may be so, but it would appear that so long as he can see the route set up for him to run over for, say, 450 to 600 ft. before he reaches the junction, that should be sufficient. However, to meet these objections it has been arranged that at slow speed diverging junctions, such as the starting signal from a platform, or for a home signal for entering a station, where there are two or more diverging routes, one four-aspect color light signal and a route indicator shall be used. In the cases of diverging junctions where trains run at speed, a four-aspect signal should be provided for each route.

The Problem of the Repeater

It has often in the past been necessary, owing to the curvature of the line or other reasons, to provide repeaters for the signals which an engineman may be approaching, and which he cannot see in time to act upon. If the signal is "on" (stop) the repeater, as a matter of course, shows "on" also, and the driver has to pass it, although it indicates "stop" and shows a red light.



Five Cluster Signals at Blackfriars

The four-aspect color light system has been designed so that a red light for the road ahead on all occasions shall be an absolute "stop" signal. In order to comply with that stipulation a repeater of a signal ahead cannot be used. This difficulty has been overcome by providing an auxiliary signal instead of a repeater in such cases. It has been arranged that the auxiliary signal shall show three aspects—green, double yellow and single yellow—and have a white

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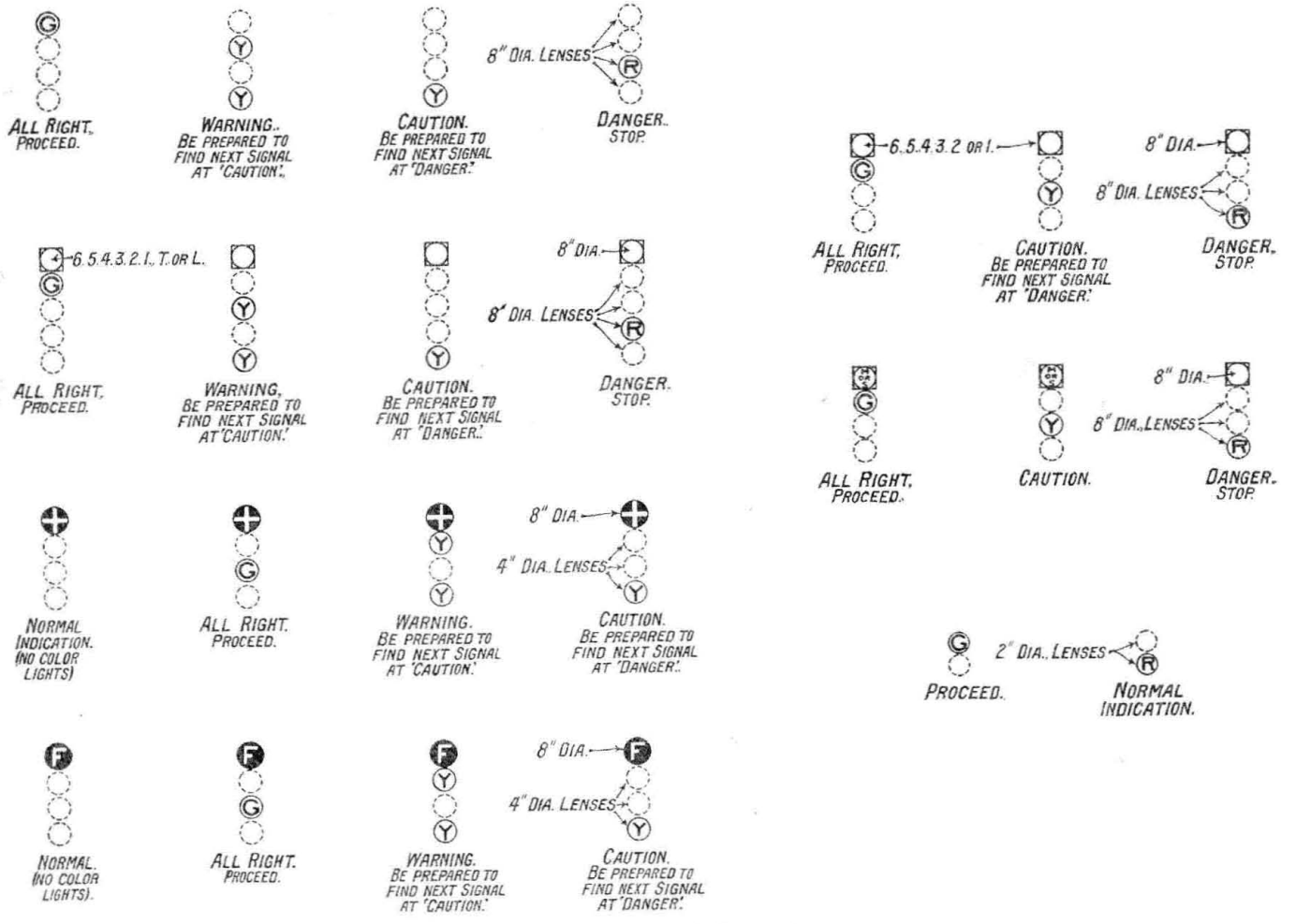
light brilliantly illuminated on a black background immediately above the color light aspects. Normally the auxiliary signal would show the white cross only to avoid any risk of the aspect, if it were provided, conflicting with the signal behind.

It is hoped that fog repeaters of the signal ahead will not be required, but in case they are wanted it has been arranged to use a three-aspect color auxiliary signal with the letter "F" brilliantly illuminated on a black background. These, if used, will be controlled by the signalman. Shunt signals will have lenses 2 in. in diameter and be two-aspect light signals, either red



Representative Applications of Color-Light Signals

Ordinary Four-Aspect Signals
Four-Aspect Signals With Route Indicators
Auxiliary Signals
Auxiliary Signals for Foggy Weather
Three-Aspect Signals With Route Indicators
Intermediate Platform Signals at Terminals
Shunting Signals

or green. The green will probably be a brilliantly illuminated green "S" on a black background. The letter "S" would be 1¾-in. on a 2-in. lens.

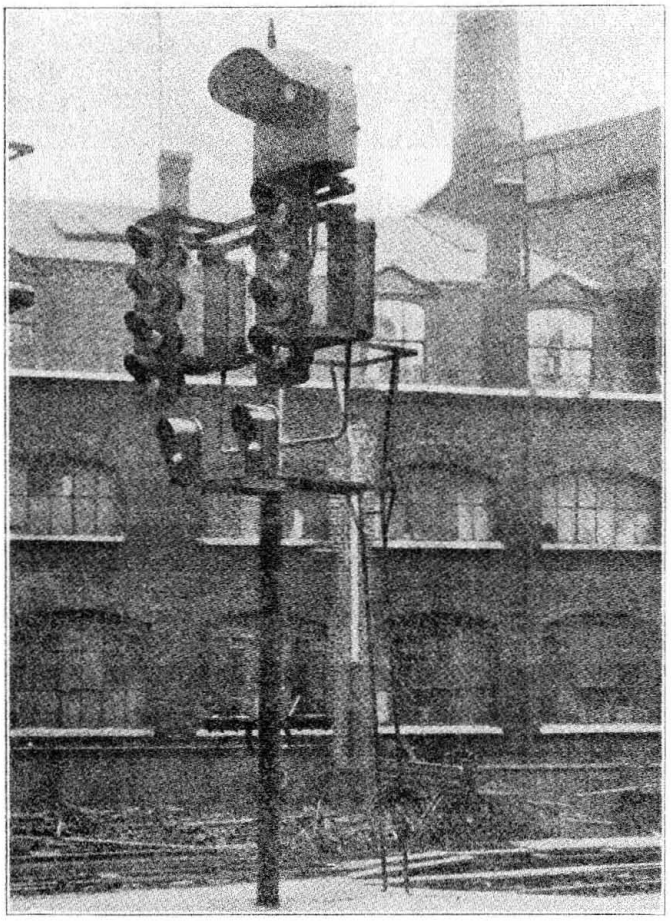
Generally, the aspect will be arranged in a vertical line, but in many places there is not sufficient head room to allow of this, and in such cases the four-aspect lights have been arranged in the form of a cross in a cluster, the green being on the left-hand side, the red on the right and nearest to the driver, and one yellow on the top and the other at the bottom, so that the two yellows appear in the same vertical line and separated sufficiently to prevent them combining or running into each other at a distance. Thus the general form of the aspects is maintained as far as the driver is concerned. In some cases where signals have had to be placed under stations roofs, there has not been sufficient headway to allow of the route indicator and colored aspects to be in a vertical line. In those cases it has been arranged to place the route indicator, on the left-hand side of the colored aspects.

Owing to the fact that the light given out from the front of the lens of the color light signal lamps is in the form of a beam, it can only be seen while the driver is in a straight line, or very nearly so, with the front of the lens. Consequently, if the lamp is fixed high up he cannot see the beam when he arrives within about 15 to 40 ft., in fact, he is below the beam. With these signals it is arranged that the lamps shall be as near to the engineman's line of sight as possible—11 ft. 6 in. above rail level is the height aimed at. The lamps have to be placed at least 4 ft. 6 in. to the left of the running rail, so that even then, when he comes up to the signal, he is out of the main beam of light and cannot see it. To overcome this, a side light has to be provided.

Junction Signals.

The signal aspects for the straight running track present no difficulty as the aspects are in one vertical line, but at diverging junctions two separate sets of light signals are placed side by side vertically. The aspects for the straight road are similarly arranged to those on a single straight road, but when the route is set for the diverging road, such as in the case of a

crossover from, say, the up main through track to the up main local track it is arranged that the engineman shall pass a single yellow aspect in the signal next before the junction signal and that the junction signal shall remain at "on" or red irrespective of the state of the road ahead, until the engineman has passed the single yellow aspect. It is thought that although the engineman should receive a "caution" signal on approaching the junction and pass a single yellow aspect, a green or double yellow or single yellow aspect should not be exhibited in the junction signal at the same time. It is undesirable than an eigineman should be given a single yellow aspect as a "caution," on account of the location he is approaching, and at the same time see a green, single or double yellow showing the road ahead of the junction is "clear." It would not be in conformity with the squence adopted with the four-aspect color signal scheme. This modification should not, provided the junctions are not numerous, delay traffic unduly, but at terminal stations and other similar places it is considered that the speed of trains is slow and the principle of this modification is not applied within the station limits.



Platform Starting Signals at Holborn

The question as to what should be done as regards signals at the junction of the existing semaphore arm and the new four-aspect light signal system, has been solved by arranging that the starting signal at Elephant and Castle, where the semaphore system ends, shall be of the semaphore arm pattern, but the equivalent of the distant signal for Blackfriars signal tower shall be a two-aspect light signal with a green and yellow aspect, so that if the Elephant and Castle starting signal is "clear" and Blackfriars distant is at caution a yellow light will be exhibited, but if, the Elephant and Castle signal and the Blackfriars distant signals are both "clear," a green light will be given for the latter.

Route Indicating Signals.

The route indicator consists of a clear lens with movable discs and the figures or the letters stencilled out of the disc, so that the light passes through the stenciled places only and the letters or figures appear brilliantly on the surface of the lens. This figure can be distinctly seen and read by the enginemen at from 450 to 600 ft. away in bright sunlight with an electric lamp of 20 to 25 c.p. in the focus, but at night-time, when it is dark, the letter, or figure, would appear extraordinarily brilliant and, from peculiar characteristisc of the lens and the source of light, the letters or figures may run into one another, so that the definition is bad. It may at a distance even look like an ordinary brilliant light, without any shaped figure being seen. To overcome this the voltage on the lamps is reduced from 12 to 8 volts, resulting in the candle power of the lamps being lowered, but the brilliancy of the letters or figures remains bright enough to be seen during the dark hours with equal ease as in the daytime.

In an ordinary light signal lamp a source of light is placed at the principal focus of the lens and a single beam of light passes out of the lens in a straight parallel beam. The distance between the principal focus and the principal point of the lens is the focal length of the lens. Now, if a second source of light is placed on the right-hand side of the first source of light, at, say, an angle of 45 deg., so arranged as to be the focal length from the principal point of the lens, and that the angle between the lines from the first source and the second source of light and the principal point shall be, 45 deg., then a second and distinct beam of light will pass from the second source of light through the principal point of the lens and emerge from the front of the lens as a parallel beam on the right-hand side of the main beam and in a direction making an angle of 45 deg., with it. Similarly, if a third source of light is placed on the right-hand side of the first source, a beam of light will pass from the third source through the principal point of the lens at an angle of 45 deg. from the main beam but on the left-hand side of it. Thus there are three beams of brilliant light given out from the same lens, all at the same time.

Multiple Beam Lights.

Such a three-beam lamp has been tried in tunnels full of black smoke, and in all conditions found in long tunnels, and the light given out by it has been distinctly seen by the engineman where an ordinary white, or green, or yellow, or red signal aspect is exhibited, at least from 30 to 40 yards away. In the case of a red three-beam light aspect the black smoke around the signal is illuminated brightly so that, in addition to the red light aspect, the smoky atmosphere is distinctly colored, and assists the enginemen to locate the signal. Similarly with yellow and green aspects.

The principle involved in the three-beam lamp is applied to provide the side light for the light signal aspect as mentioned before. It can be arranged by placing the second lamp on any particular point on the spherical focus so that the beam of the side light will emerge from the lens in any direction required,

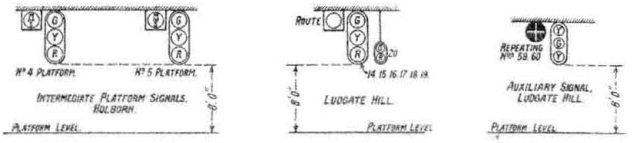
and give the driver a good view of it, either to the right, or left, or above, or on a level, or lower than the main beam.

Under the mechanical signaling system which has been displaced on the section of the Southern Railway between Holborn Viaduct and Elephant and Castle there were seven signal towers. The work has now been concentrated into two signal towers. Holborn Viaduct and Blackfriars Jct. The new electric power signal machine and illuminated diagram have been erected in the old signal tower at Holborn Viaduct, but a new relay house has been added.

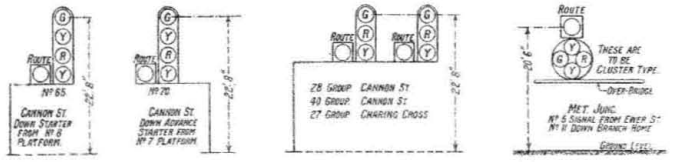
At Blackfriars Jct. an entirely new and imposing building has been erected, combining the signal (with ample window space), the storage battery room, and power switchboard and motor-generator compartment on the top floor. On the ground floor, immediately under the signal tower is the relay and fuse board room.

Electric Power Distribution

The whole of the running lines in the area from Holborn to Elephant and Castle are completely track circuited. No facing point lock-bars are used, but all the facing switches are track locked and the switch



Intermediate Platform Signals Specially Designed Owing to Insufficient Clearance



Signal Arrangement at Cannon St., Charing Cross and Metropolitan Jct.

levers electrically locked. The points are worked by direct current taken from a central battery at Blackfriars Jct.; a direct current main being run from Blackfriars Jct. to Holborn Viaduct.

A five-wire cable is run from the signal machine to each switch. The central accumulator battery consists of two sets of 72 cells, the voltage varying from 135 to 148 volts. When fully charged, one set will supply current to operate the switches for three days. The energy for charging the accumulators is taken from the traction 650-volt conductors to the power switchboard and thence to the motor-generator sets, giving current at 150 volts.

Electric energy for working the track-circuit relays, the control apparatus, and supplying current to the lamps of the four-aspects signals is taken from 220-volt 75 cycle signal mains. Energy is transmitted from the main electric sub-station at Lewisham Jct. at a pressure of 3,300 volts to the main switch and transformer at Holborn, where it is transformed from 3,300 volts to 220 volts and transmitted by means of a cable to the switch-fuse to the main signal transformer and again transformed to 110 volts for use with the track-circuit relays, control locks, etc. The energy is again transformed to 7 to 12 volts for the track-circuit leads, also on each of the light signal lamps to 12 to 16 volts, small transformers being used for each lamp. Twenty-four candle-power Osram special lamps are used in the light signals, the current being nearly 2 amp.

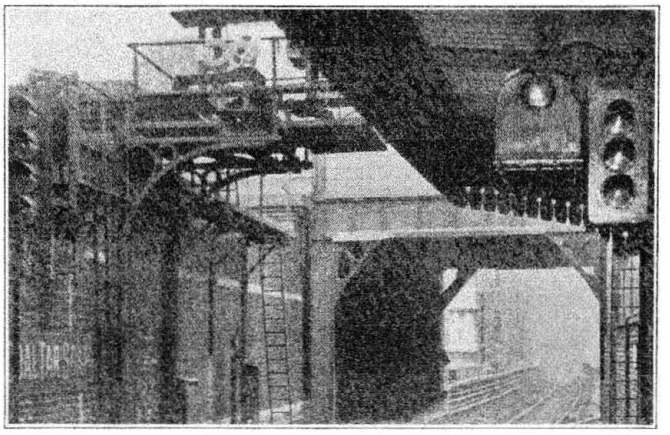
Relays and Wiring.

The track-circuit relays are of the double element a.c type while the line relays are a.c. single element type. The interlocking switch detector relays are of the Siemens type. There are a total of 186 relays in the Blackfriars tower.

To provide against stray currents, every wire, as it comes in the tower, is led to a fuse on the fuseboard. Practically the whole of the track-circuit relays are in one or other of the two signal towers, consequently the wiring of the control circuits is simple and economical.

Four-Aspect Signals.

The four-aspect color-light signals have been fixed as low as possible so as to be in the engineman's line of vision, though in places where the construction



Three-Aspect Color-Light Signal with Route Indicator at Ludgate Hill

gage prevents this the aspects are arranged in cluster form. In some cases, as a temporary measure, the new four-aspect signals have been fixed to the existing signal posts. In such cases the difference in height of the semaphore arms and the new light signals illustrates remarkably one of the advantages of the new light signals, which can be brought much lower down the post.

Most of the four-aspect light signals are erected on tubular posts, and the others will be thus arranged in the near future. The tubular posts are fixed on solid concrete bases and made as rigid as possible to prevent vibration and so avoid the beams of light being removed from their normal position.

There are 112 multi-aspect color light signals in the area and a total of 329 main lights and 217 side lights of the Southern Railway standard pattern in the running signal lamps. Side lights are not provided in the shunt signals.

Power Switch Mechanisms.

The electric point movements are of the Siemens type. The mechanism is simple and works with a voltage of from 85 to 125 volts. It must be understood in regard to this comparatively large difference in voltage that the current is on only for approximately 25 sec. The heating effect is therefore not great even at the higher voltage. The starting current is about 5 amp. but this quickly drops to 2 amp. until the movement of the switch has been completed, which is 25 sec.

Owing to the electric traction currents, it is not

practical to use lead-covered wire. Consequently insulated wire of various gages, has been used throughout the whole area.

Generally it has been run in trunking, but where it passes underground bituminized fibre conduit surrounded with 4 to 6 in. of concrete has been put in; also, in shallow places, with suitably-shaped wooden trunking.

Insulation and Track Circuits.

The insulated fish plates are of the Southern Railway standard pattern, consisting of the fish plate proper cut down ⅛ in. top and bottom, four narrow strips of hard fibre—one strip between the fish plate and top of rail on both sides—similarly at the bottom, with insulated fibre collects through the bolt-holes in the web of the rails. The arrangement is economical and efficient, as only one pattern fibre strip is required, as it fits between fish plate and rail at the top and bottom.

The majority of the track circuits are single-rail type, fitted with the usual transformer case containing transformer, regulating coil and fuses.

Impedance bonds of the non-resonating type are used in all cases of double-rail track circuits. Their resistance is 55 ohm, and 20 per cent. out-of-balance current has been provided for.

The electric power signal machines at Holborn Viaduct and Blackfriars are of the Siemens type, with levers 4½ in. long with 5½-in. stroke. The length of the latter machine is 258 ft., and it contains 120 levers. The height of the signal machine is 4 ft. above floor level, and the width 2 ft. 3 in.

The signal aspects are repeated immediately behind each signal lever. Four small lights are provided for the purpose, so that a single or double yellow, green, or red repeating signal is given, to correspond with the aspect exhibited in the signal itself.

The front and back electric locks are arranged in the front of the machine as are the contact strips for changing the controls as the levers are moved. The mechanical locking is situated at the back of the machine in two tiers, which go the whole length of the frame, and are as wide as the space will permit. The whole is enclosed in a dust-proof metal case made up of metal panels, which can easily be removed in case of need. The locking is of the usual small size used in power signaling machines. Illuminated signal diagrams with spot lights are provided and fitted vertically behind each of the interlocking machines.

Protection of Low-Voltage Lines*

A Discussion of the Problem of Preventing Serious Over-Voltages on Signal Circuits, Whether Due to Lightning or Line Conditions

By Edward Beck

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LIGHTNING conveys the idea of any kind of a hazardous potential appearing on a circuit to ground or between wires, whether this is due to actual lightning, that is, discharges between clouds or clouds and earth, or to some other cause. It is more to the point to use the term over-voltage as this is a more general one. The designation of protective devices as lightning arresters is ill chosen. It is necessary for them to drain off not only voltages due to lightning, but also voltages occurring from other causes and our object in protection is anything but what the word arrester implies. We want to divert the voltage to get rid of it as quickly as possible. In this discussion over-voltage will be used in preference to lightning, except when actual lightning is meant.

The term low-voltage applied to circuits is somewhat indefinite in meaning. Some of us may think of a 15-volt line as low and a 110-volt line high, while others may consider the 550-volt line low and the 2,300-volt line high. Considering the matter from the standpoint of lightning protection, it will be very advantageous to divide the lines into three general classes: (1) Those operating at higher than 500 volts, (2) Those carrying between 110 and 550 volts, and (3) Those carrying less that 110 volts.

We can dismiss the first class without much comment. The protection of this type of line should in general be handled in the same way as that of any transmission line of the corresponding voltage. Lines over 550 volts, applied to signal practice are in fact transmission lines.

The second class presents a somewhat different problem. In power company practice such lines are generally distribution circuits, usually short. In signal practice they may be feeders and long, perhaps miles in extent. The division between long and short lines is rather sharply drawn at 1,000 ft., as determined by statistical survey. Lines shorter than this need no protection, as they are not in general subjected to over-voltage unless due to a direct lightning stroke. Unfortunately there are probably few signal lines to which this applies as there are but few 110-volt lines shorter than 1,000 ft. However, it is interesting to note that where such lines exist it is probably not economical to protect them against over-voltage. The 110 and 550-volt lines will nearly always be feeders extending for several miles except in the case of certain 110-volt actual signal circuits. The 110-volt signal circuit would be classified in the third group. The feeders, as far as protection is concerned, fall into that class into which the matter of so-called "power follow" must be reckoned with. The term "power follow" defines the tendency of a spark discharge across a gap or over or through insulation to establish an arc which will be maintained by the power in the circuit. An exception to this will again be the 110-volt signal line in which the power is too small to permit the establishment of an arc. This would be true of circuits fed by primary or storage batteries

*Abstract of paper presented at annual meeting of Signal section, A. R. A., March 9, 1926, at Chicago.