three-phase wire. Let W represent the weight of each three-phase wire, then the total weight of the three wires will be 3 W. The weight of each single-phase wire will be 2 W and the weight of the two single-phase wires will be 4 W. This shows that the three-phase line will require 75 per cent of the copper that will be required for the single-phase line. This copper saving is worth considering on long lines where station lighting and other loads increase the line current, but with a short line where the signal load only is carried, calculations often indicate a wire that is too small for mechanical strength.

The three-phase system gives better voltage regulation and permits the use of polyphase motors, which are more economical and have better starting characteristics than the single-phase induction motors. Repulsion or series single-phase motors may be used on the single-phase lines for operating the signals, but these motors require more attention than the polyphase motors and are not as dependable.

Three-phase transmission with single-phase current at signal locations may be obtained by rotation of phases between signal locations; that is, by taking the load for one location from one phase, for the next location, from the second phase, etc. Where track circuits with double-element relays are used, it is necessary to feed the local element of the relay and the track transformer for each track circuit from the same phase; therefore, if three-phase transmission, with single-phase operation, is to be used in territory of this sort, the line should be divided into three sections, feeding one section from each phase. Care should be taken to arrange the sections so that the load will be as nearly balanced as possible.

The above has reference principally to color-light signal installations. Where a.-c. semaphore signals are installed, using induction motors, it would be desirable to have a three-phase system, on account of the better starting characteristics of a three-phase induction motor.

Favors Single-Phase Circuits Wherever Power and Communication Wires Are Carried on Same Pole Line

By W. F. Follett

Assistant Signal Engineer, New York, New Haven & Hartford, New Haven, Conn.

IN considering the comparative merit of a three-phase and a single-phase, 440 or 550-volt signal power supply line, it is assumed that the location of the supply line is to be on the signal cross arm beneath communication circuits, in which case the National Safety Code limits the amount of power to 1,600 watts per circuit. The best authorities upon this subject, interpret the term "circuit" as used in the Code, to mean all three wires of a three-phase system. This being the case, if a three-phase circuit is used, the total amount of energy transmitted must not exceed 1,600 watts for the three phases.

In practically all instances, it is more economical to use single-phase. We are, therefore, limited to the same amount of power whether we use two wires or three wires and will be until another revision of the Code is made. Such a revision, I believe, could be made to the great advantage of the railroads without undue hazard to communication circuits.

If the signal supply circuit is to be located on a pole line by itself, or under other power wires (not communication wires), undoubtedly, the three-phase system would have considerable merit, as there would be no legal limit to the load and transmission could be extended beyond the limits of single-phase.

In reference to the advantages, both from a voltage standpoint and an economic standpoint: With a fixed value for the voltage between lines, transmission distance, power transmitted and power lost and assuming unity power factor, the copper efficiency of the two systems is a follows:

	Single-phase	Three-phase
Relative current per wire	100	57.7
Total relative conductor weight	100	75.0

Color-Light, Train-Order Signals Are Effective

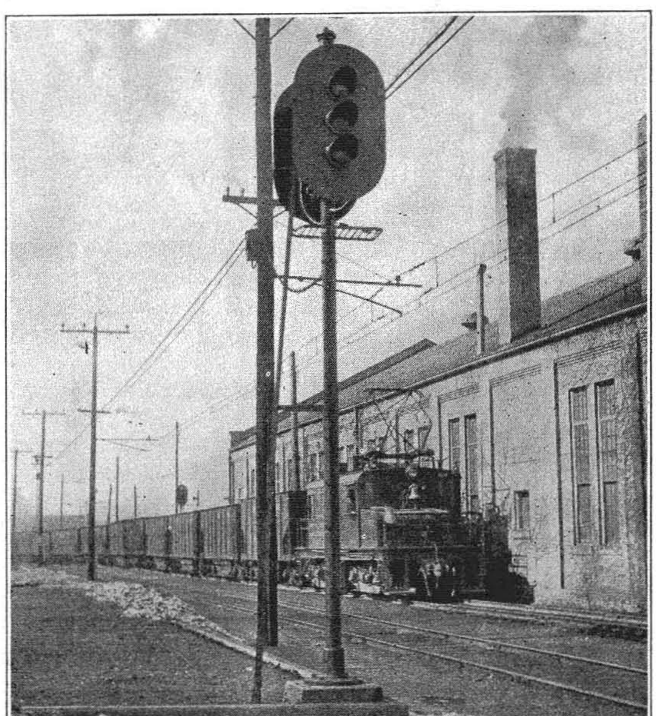
"Do you use color-light signals for train order purposes? If so, how is the signal controlled and what check is made to determine whether the proper indication is being displayed?"

South Shore Adopts Color-Light Train-Order Signal as Standard

By B. L. Smith

Signal Supervisor, Chicago, South Shore & South Bend, Michigan City, Ind.

THE South Shore is using a color-light train-order signal, the details of which were worked out by the supervisor in charge of signal work. Two Union Type-M light signal heads are mounted on a 20-ft. pole opposite each other. The color-light train-order signal is distinguished from an automatic signal by a lunar white marker light. The signal lights are controlled by two switches in the dispatcher's office at Michigan City. The switch for eastbound trains is mounted on the east side of the call board and the one for the westbound trains on the west side. These switches are of the tumbler type in which the handle moves up and down. When



Typical color-light train-order signal on the South Shore in the up or clear position, a green plaque is visible in the lower part of the switch. In the red, or down position, this plaque is red, the green disappearing. In addition to this, a red and green light is mounted above the call board. These lights are wired in series with the lights in the signal and give the dispatcher immediate information as to the indication of the train-order signal. Also, should a lamp burn out in the signal, this fact would be evident immediately in the dispatcher's office.

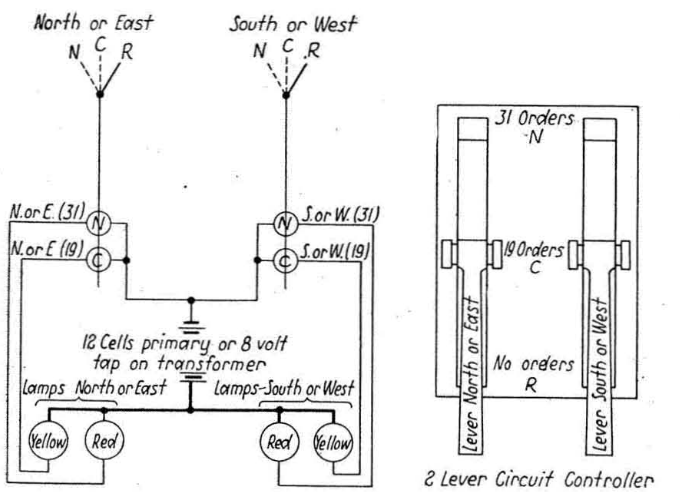
A track diagram furnished by the Railroad Supply Company is mounted above the call board. This covers automatic territory extending two blocks in either direction and gives the dispatcher advance information as to the approach of trains. This arrangement has proved satisfactory due to the frequency of trains at this point. This color-light train-order signal has been in service for a year and has proved superior to the old mechanical type of semaphore signal. The color-light type has been adopted as standard and has been placed in operation at three other points on the road.

Color-Light Train Order Signals Are Used at Interlocking Plants on the A. C. L.

By C. J. Kelloway
Superintendent of Signals, Atlantic Coast Line, Wilmington, N. C.

The Atlantic Coast Line uses color-light signals for train order purposes at interlocking plants, under the following rule:

"221 (d) At interlocking stations a red light or a yellow light displayed from the office, in view of the approaching train, in addition to the interlocking home signal at stop, will indicate that orders are held for the approaching train. The red light will indicate that trains are to be *stopped* for train orders;



Control circuit for color-light train order signal

the yellow light will indicate that trains are to receive "19" orders *without* stopping.

"Enginemen finding light signal displayed at the office and home signals indicating "stop" will acknowledge signal displayed by two short blasts of the whistle. The operator then, if other conditions permit, will clear home signal authorizing the train to pull up to the office for orders. Trains will not leave when such signals are displayed without clearance card."

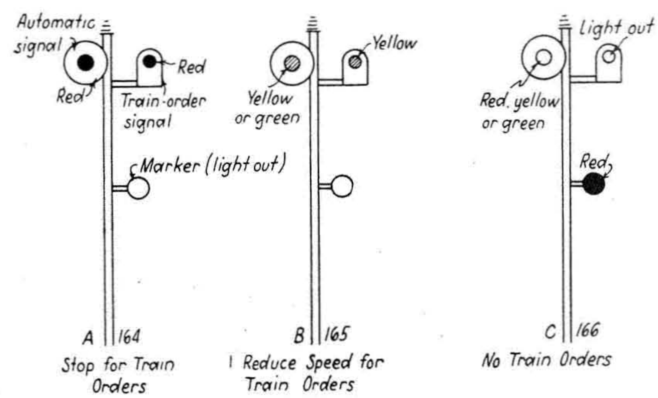
A specially designed small lever-type circuit controller controls the signals. Its lever positions correspond to those of an interlocking machine lever, and enameled plates, reading "31 ORDERS," "19 ORDERS" and "NO ORDERS," are fastened opposite the corresponding positions of the lever. The circuits are in accordance with the drawing.

It has not been considered necessary to supply a check to determine whether the proper indication is being displayed, as the trains are controlled by indications of the interlocking signals, the train order signal being secondary. It is intended, however, to supply a "light out" indication, but we have not decided whether to use an indicator or an auxiliary light.

Color-Light Train-Order Signals on N. Y. C. Are Mounted on Automatic Signal Masts

By B. J. Schwendt
Assistant Signal Engineer, New York Central, Lines West, Cleveland, Ohio

We have in use what might be called color-light train-order signals. Two separate applications are involved, one for color-light automatic signal territory, and the other for interlocking territory. The chart shows the application in automatic signal territory. Normally, our automatic color-light signals have the red marker light diagonally arranged with the main light. At stations where train orders are to be handled,



Color-light train-order signal in automatic territory

the train-order light (shown in the upper right-hand corner) is applied to an adjacent automatic signal mast. Circuiting is so arranged that whenever the train-order light is displayed, the marker light is extinguished, thus there are always two lights displayed under normal conditions.

The application to an interlocking plant is explained by the following rule:

"Where train-order signals are not provided at an interlocking plant, a yellow flag by day and a yellow light by night displayed, to an approaching train, in addition to the stop indication of the fixed signal, indicates there are train orders and will be acknowledged by two short sounds of the whistle. If after acknowledging signal by two short sounds of the whistle, stop signal is not changed to proceed, it will indicate there are '31' orders and conductor must promptly report at signal station. If stop signal is changed to proceed it will indicate that '19' orders are to be delivered and train may advance to signal station but must not leave until orders have been received."

In order to take care of conditions of poor visibility due either to weather or local conditions, the use of a color-light signal (yellow) fits in nicely with the following code rule:

"Day signals must be displayed from sunrise to sunset, but when day signals cannot be plainly seen, night signals must be used in addition. Night signals must be displayed from sunset to sunrise."

Chesapeake & Ohio Uses 2.5-Volt, 0.3-Amp. Pilot Light in Shunt with 1.5-Ohm Resistance

By George A. Washburn

General Signal Inspector, Chesapeake & Ohio, Richmond, Va.

We have two installations of color-light signals for train-order purposes, using two-unit, color-light type signals with 10-volt, 18-watt lamps in the signal unit and a 2.5-volt, 0.3-amp. lamp cut around a 1.5-ohm resistance unit in series with the lamp in the signal unit. The 2.5-volt lamp is located on the desk in front of the operator so that he will know that the lamp in the signal unit is burning. If the 2.5-volt lamp is not burning it indicates one of two things that can be readily checked by the operator; that is, the lamp itself is burned out, or the lamp in the signal unit is burned out, either of which he can replace, having a renewal for each lamp available at all times.

The lamp for the signal unit is a rebased lamp with a medium bayonet base, while the pilot light has a candelabra bayonet base, thus making it impossible to get the wrong lamp in the receptacle. The light circuits for the signal are cut through a revamped locomotive headlight switch, the cover of which indicates the position of the switch, reading "R" and "G" instead of the customary "On" and "Off." So far these installations have given satisfactory service. We would probably make more installations of this type were it not for the high first cost of the installation as compared with the cost of an installation of our present standard train-order signal electrically lighted.

Believes That Color-Light Signals Can Be Used Satisfactorily for This Purpose

By D. W. Fuller

Assistant Signal Engineer, Atchison, Topeka & Santa Fe, Topeka, Kan.

On the Eastern lines of the Atchison, Topeka & Santa Fe we do not have any color-light signals which are being used as train-order signals, therefore, I am unable to give our experience with regard to their use for this purpose. I have made a study of the use of color-light signals for train-order signals, and I see no reason why they cannot be used satisfactorily.

It is an easy matter to provide lever locking or lights for indication purposes. A relay can be connected in series with the lamp filament for checking the indications. If a color-light signal is to be employed as a train-order signal, its location must be studied carefully on the ground. The same considerations apply in the case of a semaphore-type, train-order signal.

It seems to me that the interference brought about by having too many signals in close proximity, indicates that there is an advantage to be gained by the use of a single-arm interlocking home signal, where more than one route is involved. It would also appear that there is an additional advantage to be gained by using the home interlocked signal for a train-order signal, wherever possible to do so.

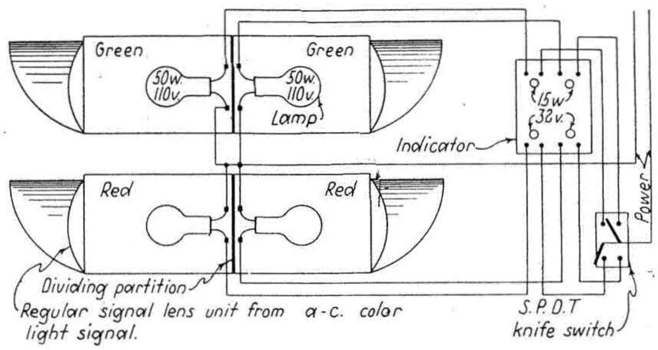
Whenever the matter of one signal interfering with another is brought to our attention, it is obvious that the fewer signals we can get along with, the better off we are.

Color-Light Train Order Signal Made From 110-Volt, 50-Watt Lamp

By W. A. Ramsey

Signal Maintainer, Mobile & Ohio, Corinth, Miss.

At TUPELO, Miss., we have just completed the installation of a color-light train-order signal, constructed as shown in the sketch, using 50-watt, 110-volt lamps in the signal and 15-watt, 32-volt lamps in the indicator box. The two green color-light units (one for northbound trains and the other for southbound trains) are mounted end to end in a common barrel-shaped housing. Similarly, the two red lights for northbound and south-bound trains are mounted below the green units. Both signal units are fastened to a square pole with a piece of angle iron. Two single-pole, double-throw knife switches



Color-light train order signal used on the M. & O.

control the color-light signals, one being for northbound trains and the other for southbound trains. A 32-volt, 15-watt indicating lamp is connected in series with each color-light signal. When a green train order signal is displayed, the indicator in the office displays a miniature green light. Similarly, a minature red light indicates the operation of the red color-light signal. Being in series with the color-light unit, the miniature lamp functions as a repeater of the train-order signal aspect.

The lenses for the color-light, train-order signal units were obtained from regulation color-light signals. The indicator lamps employ a glass slide, using green paper or red paper between the two glasses of the slide for the two colored indications.

[When the above scheme was referred to a representative of one of the lamp manufacturers, the following suggestions were offered as being more suitable under the conditions described by Mr. Ramsey: When the 50-watt, 110-volt lamp is thus burned at a 22 per cent reduction in voltage (at the lamp terminals) the candlepower output is only 46 per cent of normal, and hence the lamp is not even the equivalent of a 25-watt lamp burned at normal voltage. It is doubtful if a satisfactory daylight indication can be received with a 25-watt lamp used without a scientifically designed optical system to utilize the light output of the lamp. If, however, experience proves the 25-watt lamp to be satisfactory when used in the manner described, it is more economical of current to employ a 3-volt, Style-P3, 0.214-amp. indicating lamp in series with the 25-watt lamp in the train-order signal. The indicating lamp has a miniature screw base. If a 50-watt, 110-volt lamp is used in the train-order signal, the indicating lamp in the station should be the 3-volt, Style P-3, 0.519-amp. size. These miniature indicating lamps have a burning life of over 1,500 hr.]

E. P. Weatherby, signal engineer, Texas & Pacific, replied that: "We use color-light signals for train order signals in several places where it is impracticable to use the semaphore type of signal. Lights are controlled by three-position table levers. No check is made to determine whether the proper indication is displayed. We do not consider this essential in automatic block-signal territory. If check were considered necessary, we would put an indicator lamp in the office in series with the signal lamp, using the same color as displayed in the signal."

Series and Multiple A-C. Circuits

In the a-c. relay circuit shown below, a reader desires to know what the instantaneous polarities would be at the transformers and relays and along the common wire.

Explains Essential Differences Between Series and Multiple Connections of Transformers and Relays

By J. S. Gensheimer
Engineer of Telegraph and Signals, Pennsylvania, Pittsburgh, Pa.

The instantaneous polarities of the 110-volt primaries of the various transformers were not shown on the circuit diagrams accompanying the question. Therefore, a new sketch has been prepared with the primary polarities indicated, Figs. 1a and 1b being the circuit shown with the question as Fig. 1, and Figs. 2a and 2b being the circuit shown as Fig. 2.

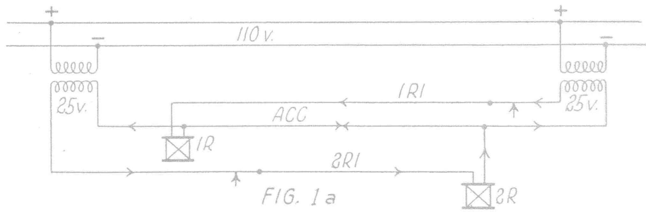
Figure 1a, with controlling circuits made through the controls shown, has the two relays, *1R* and *2R*, in series with practically no current flowing in wire *ACC*. Assume the current from the transformer at the left flows through wire *2R1*, through relay *2R* to the junction with wire *ACC*, to the transformer on the right, through transformer to wire *1R1*, through relay *1R* to junction with wire *ACC*, to transformer on the left. Thus it is seen the two relays are in series and no current flowing in wire *ACC* unless there is some unbalancing.

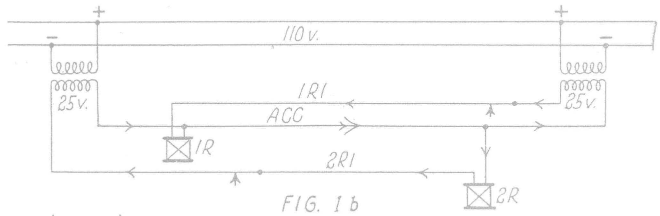
Should the control for either of the relays be open while the other is closed, then current will flow through wire *ACC*. For instance, assume the circuit for *1R* is open at the back contact shown in wire *1R1* in Fig. 1a, then current will flow from the transformer on the left through wire *2R1*, to relay *2R*, then to wire *ACC*, back to the same transformer. Should the contact be open in *2R1* and closed in *1R1* the current will then flow similarly in the circuit for *1R* from the transformer on the right.

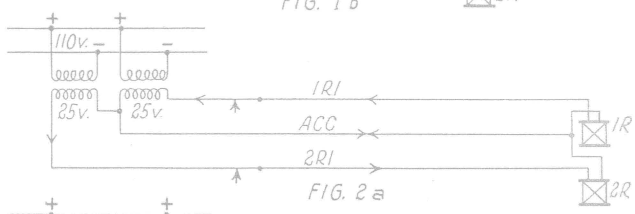
In Fig. 1b with both circuits complete, current will flow from the transformer on the left to *ACC*, to relay *2R*, then return to transformer on the left via wire *2R1*; at the same time, current will flow from the transformer on the right to wire *1R1*, to relay *1R*, to wire *ACC* and back to the same transformer. It can be seen that double current flows in wire *ACC* between relays *1R* and *2R* when both relays are energized. The current for the relays flows through the same path for its relay regardless of whether one or both circuits are complete. In Fig. 1a, the voltage at the relays is somewhat higher when both relays are energized than when only one relay is energized as the transformer secondaries and relays are then in series, while in Fig. 1b the reverse is true.

Figure 2a has the transformer secondaries and the relays in series and practically no current flows in wire *ACC*. Current leaves the transformers as indicated by the arrow, and flows through wire *2R1* to relay *2R*, to relay *1R*, to wire *1R1* and back to transformer.

With either circuit open, the current flows through wire *ACC*. An open contact in *1R1* will cause current to flow from the left-hand transformer.







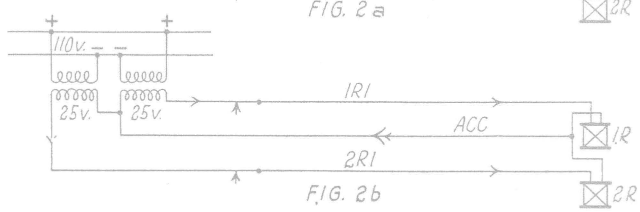


Fig. 1a—Series connection of transformers and relays with zero current in common wire
Fig. 1b—Multiple connection of same units with double current in common wire
Fig. 2a—Series hook-up of end-fed, three-wire circuit with zero current in common wire
Fig. 2b—Similar circuit, but with multiple connection of transformers and relays—Double current in common wire

Figure 2b has the relays in multiple and the current flows for either or both relay circuits as indicated by the arrows. With both relays energized, the voltage at the relays is less than when only one relay is energized, as twice the current is flowing in wire *ACC*, thereby causing a greater IR drop. Circuits shown in Fig. 1a and 2a are preferable.

Direction of Current at Any Instant Depends Upon How Transformer Primaries Are Connected to the Supply Line

By R. Y. McCullough
Commercial Engineer, Railway Department, General Electric Company, Schenectady, N. Y.

The instantaneous polarities and directions of current flow in the circuits of Fig. 1 and Fig. 2 will be different for three different primary connections, namely: (1) Primaries connected in the same direction to the same source of power. (2) Primaries connected in opposite directions to the same source of power. (3) Primaries connected to different sources of power.

Consider first the connections of Fig. 2. With equal load impedances and two identical additive-polarity