Sept. 10, 1935. K. MEYER 2,014,049

LIGHT SIGNALING CIRCUIT

Filed Jan. 29, 1932

Fig. 1.

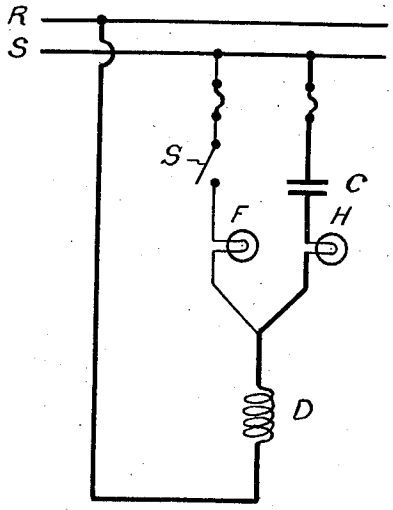


Fig. 2.

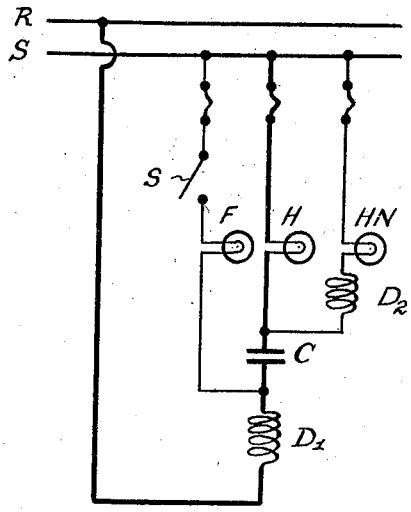


Fig. 3.

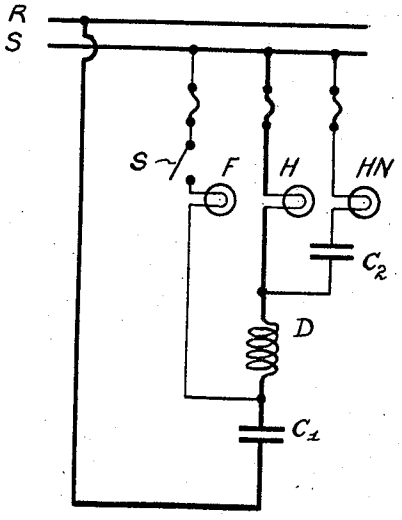
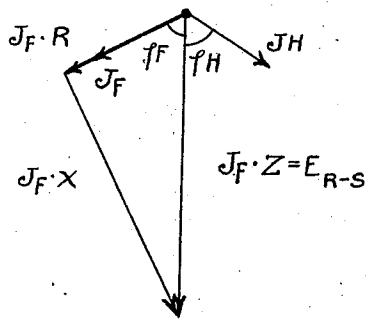


Fig. 4.



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LIGHT SIGNALING CIRCUIT

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Application January 29, 1932, Serial No. 589,695
In Germany May 12, 1931

3 Claims. (Cl. 177—329)

My former U. S. application filed April 13, 1931, Serial No. 529,770 describes a light signaling system wherein the change of signals takes place semi-automatically by using a polyphase network. During the flow of the "clear" current, the "stop" lamp is extinguished by an electromotive force which is induced in a reactance and is practically equal to and practically oppositely directed to the "stop" light phase voltage in the phase position. Consequently, in the case of a closed clear current branch, only a small fraction of the clear current flows in the stop current branch so that the stop lamp is absolutely dark when the clear lamp lights up. If, however, the clear circuit is broken by a switch in the clear lamp circuit or by a defect such as the burning out of the clear lamp, the electromotive force, which hitherto acted against the stop lamp current, is eliminated and, therefore, the stop lamp will light up with full strength as soon as the clear lamp is extinguished.

According to the present invention, the same effect is obtained by using a single phase alternating current. It is also possible in these systems to devise the arrangement in such a manner that in the closed clear lamp circuit, the stop lamp receives a weakened current so that the lamp does not light up while after the clear lamp circuit is broken, the stop lamp receives its full current and, therefore, lights up with normal strength.

According to the same principle, an emergency stop lamp connected in parallel to the stop lamp can be brought into reciprocal action with the main stop lamp so that when the main stop lamp is extinguished, in consequence of a disturbance, as for instance, when it burns out, the emergency stop lamp lights up, and vice versa.

Three constructional forms of the invention are shown in the accompanying drawing by way of example:

Figure 1 shows the system with a clear lamp F and a stop lamp H;

Figure 2 shows the system according to Figure 1 but with an emergency stop lamp HN connected in parallel to the stop lamp H;

Figure 3 shows a system similar to Figure 2 but with a different arrangement of the condensers and choke coils;

Figure 4 is a vector diagram for representing the voltages of the currents.

Referring to the drawing in detail, a circuit extends from a pole R of a single phase network R—S to a choke coil D, Figure 1, and branches behind the latter into two parallel conductors which are connected to the other pole S of the network. One of these branches which may be called the clear lamp branch, contains in series connection the clear lamp F, a switch s and a fuse, while the other branch contains the stop lamp H, condenser C and a fuse.

In Figures 1 and 4

X_C is the capacity reactance of the condenser C;

X_D the inductive reactance of the choke coil D;

R_H the ohmic resistance of the stop lamp;

R_F the ohmic resistance of the clear lamp;

J the total current in the circuit extending from the pole R;

Z the so-called impedance of the whole circuit, i. e. that ohmic resistance which per se would give the same current J with the network voltage E_{R-S}.

The capacity reactance X_C is a multiple higher than the ohmic resistance R_H of the stop lamp, i. e.,

$$X_C \geqq 4R_H \text{ ohms}$$

Furthermore, one selects:

$$-X_C \geqq 2X_D \text{ ohms}$$

For the stop lamp branch, there results an impedance

$$Z_H = \sqrt{R_H^2 + X_C^2}$$

while the impedance of the clear lamp branch consists only of the ohmic resistance R_H. However, Z_H is great relative to R_H or R_F and consequently, in the case of the closed clear lamp branch, the current flowing through the stop lamp branch is only a small fraction of the current flowing through the clear lamp branch and is, therefore, practically negligible.

Consequently, when making the equation for the network voltage E_{R-S} and neglecting the current in the stop lamp branch, the result is:

$$E_{R-S} = J.z = J.\sqrt{R_F^2 + X_D^2}$$

Since it is assumed that

$$X_C = 4R_H = 4R_F = 2X_D$$

one may also write

$$E_{R-S} = J.\sqrt{R_F^2.(1+4)} = J.R_F.\sqrt{5}$$

$J.R_F$ indicates the effective voltage E_F on the clear lamp. It is to be noted that, as already stated, the total current J is practically equal to the current J_F flowing through the clear lamp branch. The constitution of the network voltage is shown in the vector diagram of Figure 4; the

vectors $E_F=J_F.R_F$ and $J_F.X_D$ which are joined at right angles yield the total voltage $J_F.Z=E_{R-S}$; in the vector diagram the index H at R is omitted and the index D at X is omitted so that the diagram also applies to further cases.

It will be seen that in the case of an illuminated clear lamp, a voltage of self induction is produced by the clear lamp current J_F which voltage is composed of the effective voltage components $J_F.R$ so that a practically appreciable voltage and current component for the branch of the stop lamp does not remain.

The phase angle ϕ_F between the network voltage E_{R-S} and the effective voltage $J_F.R$ is determined according to Figure 4 from

$$\cos \phi_F=\frac{R}{Z}=\frac{R_F}{X_D}$$

because the total impedance Z is practically equal to X_D.

Furthermore, when selecting the electric values of the choke coil D and the condenser C so that in the case of the closed clear lamp circuit the impedance Z is equal according to its absolute value to the impedance X_D+X_C when the clear lamp circuit is open, the phase angle ϕ_H between the current J_H and the network voltage E_{R-S} is determined from the equation

$$\cos \varphi_H=\frac{R}{X_D+X_C}$$

Since according to the above assumption

$$X_C=-2X_D$$

the denominator of the fraction will be

$$X_D+X_C=-X_D$$

and therefore

$$\cos \varphi_H=-\frac{R}{X_D}$$

that is to say, according to the above assumption

$$\cos \phi_F=-\cos \phi_H$$

in other words, the angles ϕ_F and ϕ_H are equal as shown in Figure 4.

It may be desirable to give a numerical example for the selection of all electrical values as follows:

The clear lamp F and the stop lamp H have each a power of 60 watts with a voltage of 120 volts, the current being 0.5 ampere and the resistance 240 ohms.

The reactance of the choke coil D in the common branch circuit amounts to

$$X_D=2R_H=2R_F=2.240=480 \text{ ohms}$$

This corresponds to an inductivity of

$$L_D=\frac{480}{2\pi.50}=1.5 \text{ henry at 50 Hertz}$$

The condenser C in the stop lamp circuit has a reactance

$$X_C=4.R_H=4R_F=960 \text{ ohms}$$

and a capacity of

$$C=\frac{10^6}{2.\pi f.X_C}=3.3 \text{ micro-farads}$$

Consequently, the voltage of the network must amount to

$$E_{R-S}=J.\sqrt{R_F^2+X_D^2}=0.5.\sqrt{240^2+480^2}=265 \text{ volts}$$

The residual current over the stop lamp H with closed clear lamp branch circuit therefore results in

$$J_H \text{ residual}=\frac{120}{\sqrt{240^2+960^2}}=0.122 \text{ amp.}$$

This is about 24% of the rate current, that is to say the stop lamp remains dark.

However, when the clear lamp branch circuit is open, a current

$$J_H=\frac{265}{\sqrt{240^2+(960-480)^2}}=0.5 \text{ amp.}$$

flows over the stop lamp, which current is as high as, in the former case the current J for the clear lamp, so that now the stop lamp will fully light up.

The invention may also be realized by using a condenser instead of the choke coil and a choke coil instead of the condenser. Such an exchange is obvious when comparing Fig. 2 and Fig. 3 with one another.

The use of an emergency stop lamp HN is also obvious from these two figures, which lamp, with regard to arrangement and effect, bears the same relationship to the main stop lamp H as the latter to the clear lamp F.

According to Figure 2, a choke coil D_1 is located in the circuit coming from the network conductor R; behind the said coil, the circuit is branched into two conductors, the first one, namely, the clear lamp branch corresponding with the clear lamp branch of Figure 1. The second branch contains a condenser C behind which extends the branch of the main stop lamp H over a fuse to the network conductor S. The emergency lamp branch containing a choke coil D_2, the emergency stop lamp HN and a fuse extends parallel to the main stop lamp H from behind the condenser C to the network conductor S.

The operation is as follows:

When the switch *s* is closed, the clear lamp F lights up and produces in the choke coil D_1 such a voltage of self-induction directed against the network voltage that the voltage for the main lamp branch and especially the voltage for the emergency lamp branch is not sufficient for producing a current sufficient for lighting up the main stop lamp H or even the emergency stop lamp HN, these two lamps being extinguished.

If the switch *s* is now opened or the clear lamp branch interrupted, the counter-voltage in the choke coil D_1 coming from the clear lamp current according to Figure 1 will disappear again.

The capacity resistance of the condenser C is again greater than the inductive resistance of the choke coil D_1; a counter-voltage directed against the network voltage will be produced in the choke coil D_1 and in the condenser C by the current passing over the main stop lamp H against the network voltage and the voltage for the emergency stop lamp HN behind the choke coil D_2 is not sufficient for lighting up the emergency stop lamp. The emergency stop lamp HN receives a current sufficient for the lighting up only when in the case of an interruption of the clear current branch, the branch of the stop lamp H (by burning out) is also interrupted; the sum of the resistances in the choke coils D_1 and D_2 and also in the condenser C may be such that the absolute value of the apparent resistance is the same as in the case of the lighted clear lamp F or lighted main stop lamp H.

A numerical example will also be given for Fig. 2. It is assumed that all three lamps F, H and HN are adapted for the same rated current

and the same rated voltage; this is not absolutely necessary; more favorable values are obtainable by feeding each lamp over a transformer in which case the same voltage values are not necessary. It must be borne in mind that the assumed numerical values as well as the assumed proportional values of the reactances are nothing more than mere examples.

The calculation is based on the following symbols one part of which is defined above:

E_{R-S}=network voltage of the single phase network R—S;

E'=rated voltage of the individual lamps F, H or HN;

E_F=voltage for the clear lamp;

E_H=voltage for the stop lamp;

E_{HN}=voltage for the emergency stop lamp;

J'=rated current of each of the three lamps F, H or HN;

J_F=actual clear lamp current;

J_H=actual stop lamp current;

J_{HN}=emergency stop lamp current;

X_{D1}=reactance of the choke coil D_1;

X_{D2}=reactance of the choke coil D_2;

X_C=reactance of the condenser C;

R_F=effective resistance of the clear lamp F;

R_H=effective resistance of the stop lamp H;

R_{HN}=effective resistance of the emergency stop lamp HN;

Z=impedance of the current branch viewed momentarily;

N'=power rating for each of the three lamps F, H, and HN.

N_F=power actually available for the clear lamp.

N_H=power actually available for the stop lamp.

N_{HN}=power actually available for the emergency stop lamp.

If

$$R_H=R_F=R_{HN}$$

$$E_H=E_F=E_{HN}$$

$$-X_C=2X_{D1}=X_{D2}=4R_H$$

there will be for

(1) Closed clear current branch

$$E_{R-S}=J.Z=J.\sqrt{X_{D1}^2+R_F^2}=J.R_F.\sqrt{5}=E_F.\sqrt{5}$$

(a) In the clear current branch:

$$E_F=E' \text{ volts}$$

$$J_F=J' \text{ amp.}$$

$$N_F=N' \text{ watts}$$

(b) In the stop current branch:

$$J_H=\frac{E_F}{Z}=\frac{E_F}{\sqrt{X_C^2+R_H^2}}=\frac{J'.R_F}{R_H.\sqrt{17}}=0.242\ J'$$

$$E_H=0.242\ J'.R_H$$

$$N_H=0.058\ J'^2.R_H$$

(c) In the emergency current branch:

$$J_{HN}=\frac{E_H}{Z}=\frac{J_H.R_H}{\sqrt{R_{HN}^2+X_{D2}^2}}=\frac{J_H.R_H}{R_{HN}.\sqrt{17}}=0.242J_H.=0.058J' \text{amp.}$$

$$E_{HN}=0.058\ J'.R_{HN} \text{ volts}$$

$$N_{HN}=0.0033\ J'^2.R_{HN} \text{ watts}$$

(2) Clear current branch open, main stop lamp intact

$$E_{R-S}=J.Z=J.\sqrt{(X_{D1}-X_C)^2+R_H^2}=J.R_H.\sqrt{5}=E_H.\sqrt{5}$$

(a) In the clear current branch:

$$E_F=0$$
$$J_F=0$$
$$N_F=0$$

(b) In the stop current branch:

$$E_H=E' \text{ volts}$$
$$J_H=J' \text{ amps.}$$
$$N_H=N' \text{ watts}$$

(c) In the emergency stop current branch:

$$J_{HN}=\frac{E_H}{Z}=\frac{J'.R_H}{\sqrt{X_{D2}^2+R_{HN}^2}}=\frac{J'.R_H}{R_{HN}.\sqrt{17}}=0.242J' \text{amps.}$$

$$E_{HN}=0.242\ J'.R_{HN} \text{ volts}$$
$$N_{HN}=0.058\ J'^2.R_{HN} \text{ watts}$$

(3) Clear current branch and stop current branch interrupted

$$E_{R-S}=J.Z=J\sqrt{(X_{D1}-X_C+X_{D2})^2+R_{HN}^2}=J.R_{HN}.\sqrt{5}=E_{HN}.\sqrt{5}$$

(a) $E_F=0$, $J_F=0$, $N_F=0$

(b) $E_H=0$, $J_H=0$, $N_H=0$

(c) $E_H=E'$ volts, $J_H=J'$ amp., $N_H=N'$ watts

Assuming

$$N'=60 \text{ watts}$$
$$E'=120 \text{ volts}$$
$$J'=0.5 \text{ amp.}$$
$$R_H=R_F=R_{HN}=240 \text{ ohms}$$

there results for the choke coil D_1

$$X_{D1}=2R_H=2.240=480 \text{ ohms}$$

or the inductance

$$L_{D1}=\frac{480}{2.\pi.50}=1.51 \text{ henries with 50 Hertz}$$

For the condenser C:

$$X_C=4R_H=4.240=960 \text{ ohms}$$

or the capacity

$$C=\frac{10^6}{2\pi.50.960}=3.3 \text{ microfarads}$$

For the network voltage:

$$E_{R-S}=E_F.\sqrt{5}=120.\sqrt{5}=265 \text{ volts}$$

The individual value for the cases (1), (2) and (3) are:

(1) a. $E_F=120$ volts, $J_F=0.5$ amp., $N_F=60$ watts

b. $J_H=0.121$ amp., $E_H=29$ volts, $N_H=3.5$ watts

c. $J_{HN}=0.029$ amp., $E_{HN}=6.95$ volts, $N_{HN}=0.2$ watts

(2) a. $E_F=0$, $J_F=0$, $N_F=0$

b. $J_H=0.5$ amp., $E_H=120$ volts, $N_H=60$ watts

c. $J_{HN}=0.121$ amp., $E_{HN}=29$ volts, $N_{HN}=3.5$ watts

(3) a. $J_F=0$ amp.
b. $J_H=0$ amp.
c. $J_{HN}=0.5$ amp.
$E_{HN}=120$ volts
$N_{HN}=60$ watts

The arrangement according to Figure 3 has been derived from that according to Figure 2 by replacing the condenser C by a choke coil D and replacing the choke coils D_1 and D_2 by condensers C_1 and C_2.

It has been proved by means of Figure 2 that the condenser C which is connected in front of the branches for the stop lamp H and for the emergency stop lamp HN is adapted to act together with the choke coil D_2 of the emergency stop lamp branch in the same manner as was proved in connection with the clear lamp branch for a case where vice versa the means connected in front was a choke coil D_1 and the means located in one branch was a condenser C. It follows therefrom that the exchange made in Figure 3 also constitutes an effective arrangement in accordance with the invention.

What I claim is:

1. A light signaling system for single phase alternating current with successive illumination of lamps of different character comprising a current supply circuit, lamps connected in parallel branches of said circuit, a switch in the branch of one lamp, a condenser or a choke coil in the branch of the other lamp, and a choke coil or a condenser, respectively, common to both branches, having at most half the value of the condenser or choke coil, respectively, in the one of the said two parallel branches, so that the lamp in the parallel branch not containing the said switch will light up automatically, when the switch is opened.

2. A light signaling system comprising a stop lamp and a clear lamp inserted in separate circuits connected in parallel and together in series with a choking coil across the supply circuit, a condenser in one of said parallel circuits, having at least double the value of the said choking coil, a switch in the other parallel circuit for disconnecting the clear lamp circuit and thereby rendering operative the stop lamp, and vice-versa, and a substitute stop lamp and a choking coil in series with one another connected in parallel with the main stop lamp, this choking coil having at least half the value of the said condenser, so that the substitute stop lamp will light up automatically when neither the clear lamp nor the main stop lamp is in operation.

3. A light signaling system as per claim 2, the said condenser being substituted by a choke coil, and the said choke coils being substituted by condensers.

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