Aug. 25, 1942. R. VON OTTENTHAL 2,294,103

KEYING DEVICE FOR PHASE REVERSAL

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FIG. 1.

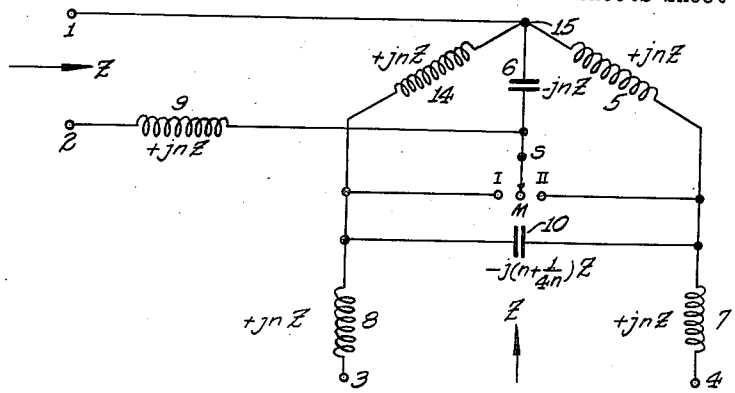


FIG. 2.

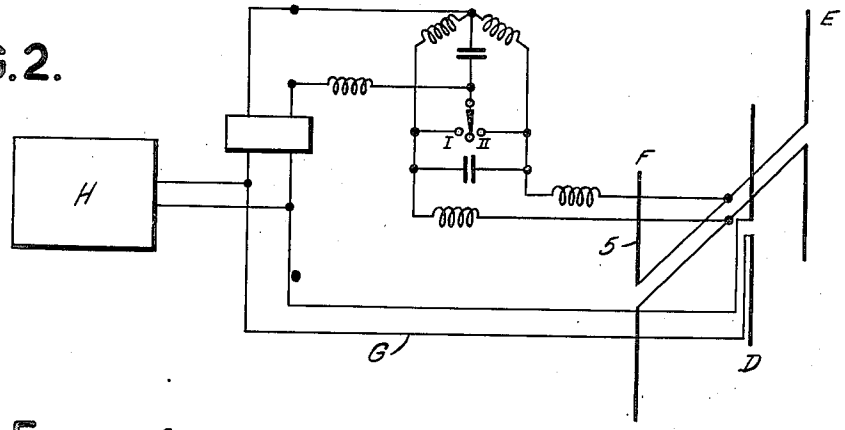
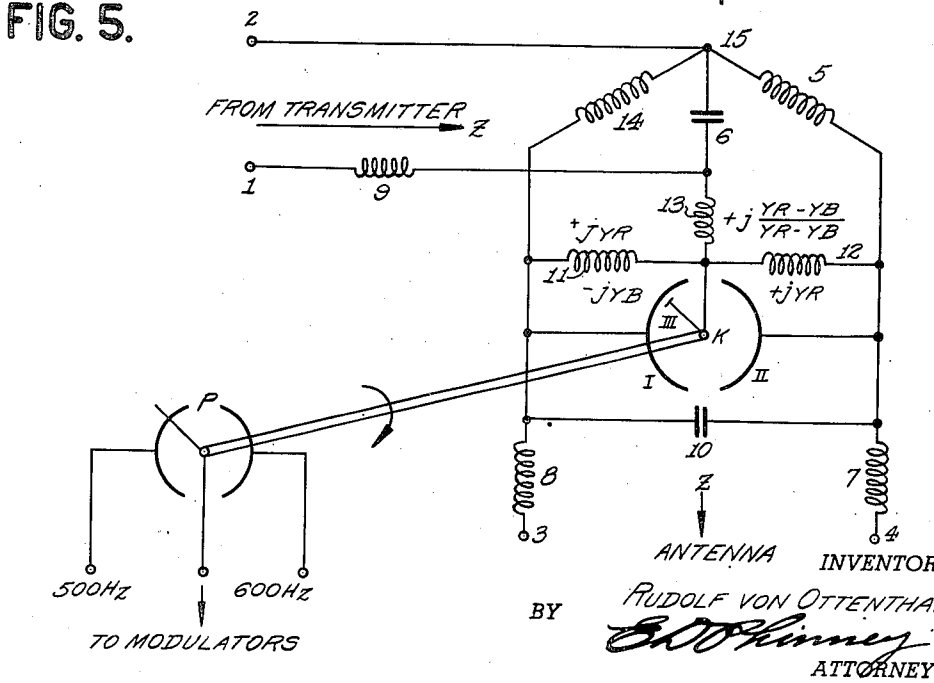


FIG. 5.



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FIG. 3a.

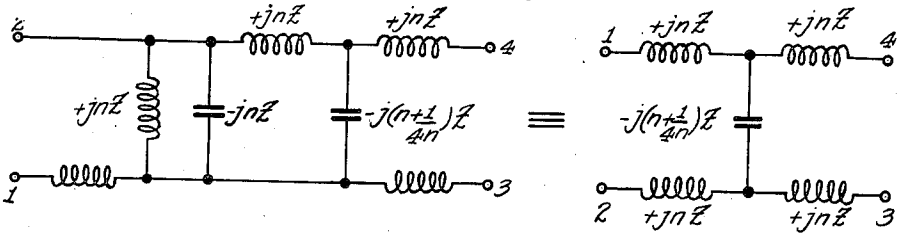


FIG. 3b.

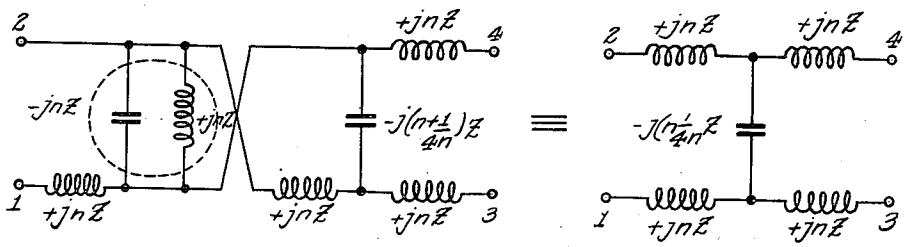


FIG. 3c.

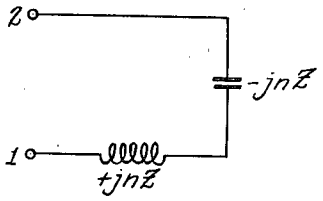
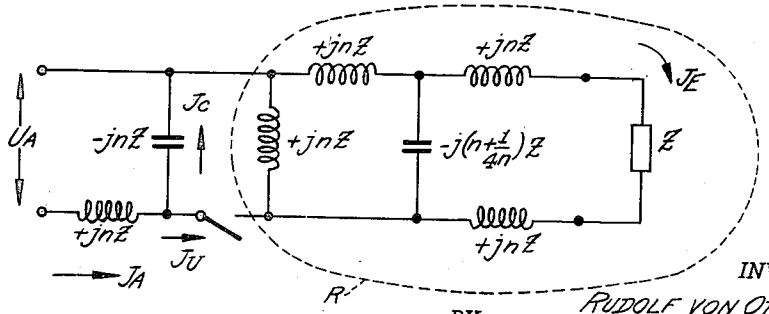


FIG. 4.



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KEYING DEVICE FOR PHASE REVERSAL

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Application March 1, 1941, Serial No. 381,333
In Germany February 16, 1940

11 Claims. (Cl. 250—17)

This invention relates to keying devices and has for its object to provide a symmetric reversing device which serves to reverse with the aid of a unipolar switch the phase of two energy conductors by 180°, the current to be controlled by the unipolar switch being much smaller than the consumer current flowing in the branch conductors. This is advantageous especially in the case of transmitting arrangements of the kind serving to produce course lines and in which two directional antenna systems, continually fed from a high frequency generator, are combined to cooperate at alternately opposite phase conditions.

According to the invention, the phase reversal is effected by network included in the energy line. Such network is under the control of a unipolar switch by which it can be so connected that the polarity of the energy line is reversed by 180°, and that further in each branch conductor always reactances of the same magnitude are located. The arrangement may be such that the current path of one branch conductor bifurcates in two reactances of the same magnitude and phase and that, depending upon the position of the switch, one reactance is released to be traversed by currents while the other is rendered ineffective by a resonant circuit arrangement and vice versa.

In the drawings, Fig. 1 is a diagram showing the novel network employed for phase reversal. Fig. 2 is a diagram illustrating the circuit arrangement of a transmitter in which the novel phase reversing device serves for reversing the phase conditions of the reflecting antennae of a directional antenna system. Figs. 3*a*, 3*b*, 3*c* represent substitute or equivalent circuits with the unipolar switch in different positions. Fig. 4 shows the substitute circuit that serves for calculating the operation of the switch. Fig. 5 is a diagrammatic view of an arrangement whose reversing switch is a rotating plate condenser.

In Fig. 1, 1 and 2 denote the branch conductors whose phase is reversed by network as provided by the invention. At 15, conductor 2 bifurcates in two reactances 14, 5 of the same magnitude and phase. As shown by way of example, such reactances may be coils or inductances.

The coils 14, 5 are alternately rendered ineffective with respect to conductor 2 by a switch S by which a reactance 6, such as a condenser, is connected in parallel with either coil 14 or coil 5. With the switch S in position I condenser 6 is connected in parallel with coil 14, the parallel resonant circuit so formed constituting a high resistance for conductor 2. The current of conductor 2 will therefore flow over coils 5, 7 while the current of conductor 1 passes over the switch S and coil 8. By turning the switch S into the position II the condenser 6 is connected in parallel with coil 5, whereby the current of conductor 2 flows over coils 14, 8 while the current of conductor 1 passes over switch S and coil 7.

Fig. 3*a* is the substitute diagram of the network with switch S in position I. Fig. 3*b* is the substitute diagram of the network with switch S in position II. Fig. 3*c* is the substitute diagram relating to the mid-position M of the switch.

In conductor 1, Fig. 1, a reactance or coil 9 is included which is to provide for an entirely symmetric construction of the phase reversing device, that is to say, a construction having resistances of the same magnitude located in each branch conductor, whether switch S be in position I or position II. The network as a whole has the surge impedance Z. Owing to the entirely symmetric construction of the network the casing may be at earth potential in order to obviate disturbances caused by the consuming apparatus joined to the phase reversing device. Connected in parallel with the contacts of S is a condenser 10 that acts to neutralize the capacity of switch S.

With switch S in its mid-position M the reactances 6, 9 are connected in series and thus constitute a series resonant circuit by which the conductors 1, 2 are short-circuited. Consequently, whenever the change-over switch S moves from one position to the other no energy arrives at the outgoing lines 3, 4.

The reactance 10, constituted by a condenser, for instance, is located behind switch S while the reactances 7, 8, which for example are coils or inductances and are in phase opposition, are included in the outgoing lines 3, 4. The entire network has the reactance Z.

Calculation of Surge Impedance and Phase Rate of the Phase Reversing Device

(1) *Short-circuiting resistance*

$$Z'K = j2nZ \parallel -j'\left(n+\frac{1}{4n}\right)Z + j'2nZ = \frac{j2n - j\left(n+\frac{1}{4n}\right)Z}{j\left(n-j\frac{1}{4n}\right)} + j'2nZ = \frac{j2nZ\left[-j\left(n+\frac{1}{4n}\right)+j\left(n-\frac{1}{4n}\right)\right]}{j'\left(n-\frac{1}{4n}\right)} = \frac{+Z}{j\left(n-\frac{1}{4n}\right)} = -j\frac{4n}{4n^2-1}Z$$

(2) *No-load resistance*

$$Z'L = +j2nZ - j\left(n+\frac{1}{4n}\right)Z = +j\left(n-\frac{1}{4n}\right)Z = +j\frac{4n^2-1}{4n}Z$$

(3) *Surge impedance*

$$Z'=+\sqrt{Z'K\cdot Z'L}$$

$$Z'=\sqrt{-j\frac{4n}{4n^2-1}\cdot Z+j\frac{4n^2-1}{4n}Z'};Z'=Z$$

(4) *Phase rate*

$$tg\ a=\pm\sqrt{-\frac{Z'K}{Z'L}}$$

$$tg\ a=-\sqrt{+j\frac{4n}{4n^2-1}\cdot\frac{4n}{j(4n^2-1)}}=-\frac{4n}{4n^2-1}$$

$$a=\pi-arc.tg\frac{4n}{4n^2-1}$$

The current controlled by switch S is the *n*th part of the current flowing through the consuming apparatus Z.

Fig. 4 represents the substitute diagram of the phase reversing device and consuming apparatus.

J_E denotes the current passing through consuming apparatus Z,

J_U indicates the current flowing through the switching relay.

(5) *Calculation of* J_E

With the reversing device terminating in Z its input resistance is equally Z, provided that there are no losses.

Input power:

$$N_A=\frac{U_A^2}{Z}$$

Output power: $N_E=J_E^2Z$

as

$$N_A=N_E\longrightarrow J_E^2=U_A^2/Z \qquad \underline{|J_E|=\frac{U_A}{Z}}$$

(6) *Calculation of* J_U

$$J_A=J_c+J_U, U_A=J_A, j\ nt+J_U,R, J_c,-j\ nt=J_UR$$

$$J_A=J_U\left(1+j\frac{R}{nt}\right) U_A=J_U(jnt-R)+$$

$$J_UR J_c=J_U\frac{R}{-jnZ}$$

$$J_U=\frac{U_A}{jnZ} \qquad \left|J_U\right|=\frac{U_A}{nZ} \qquad =\left|\frac{J_E}{n}\right|$$

Result:

$$\left|J_U\right|=\frac{1}{n}\left|J_E\right|$$

The advantages of the symmetric phase reversing device are as follows:

(1) This device may be constructed to be perfectly symmetric with respect to the casing.

(2) The current under the control of switch S is the *n*th part of the current passing through the consuming device. Thus, a comparatively small reversing device will be able to effect the phase reversal of high power currents. For instance, in the short wave range a reduction on the basis of $n=5$ may be employed without difficulty.

(3) The capacity due to the reversing device is harmless.

The novel phase reversing device is suitable especially for use with transmitters employed for obtaining course lines, namely, transmitters comprising two directional antenna systems continuously fed from a high frequency generator and combined to cooperate at alternately opposite phase conditions. An arrangement of this kind is represented in Fig. 2 by way of example.

A linear antenna D is continuously fed from a high frequency generator H over a line G. Superimposed upon the energy of antenna I is the energy effective in a directional antenna system which, for instance, is comprised of directional radiators E, F, such superposition being in phase coincidence and phase opposition alternately. The phase reversal in the antenna conductors E, F is effected by means of the phase reversing device according to the invention.

If it is desired not to key the antenna system in the rhythm of complementary signals but, for instance, to distinguish between the resultant directional characteristics with the aid of modulating frequencies, then according to another feature of the invention, the unipolar change-over switch is a rotating plate condenser arranged to cooperate with different modulators.

In Fig. 5, which shows an example of arrangements of the latter kind, the stator plates I, II of the rotating plate condenser K are connected to the lines 3, 4. The stator plates are designated I, II because they agree in position with the positions I, II, Figs. 1 and 2, the rotor III of condenser K having the office of the switch S. For instance, whenever the rotor is facing the plate I, the conditions are the same as in the case of switch S, Fig. 1, having the position I. Equally, position II of switch S agrees with the rotor facing the plate II.

This arrangement, however, is disadvantageous inasmuch as the residual capacities of the condenser K are still effective.

In order to overcome this drawback, inductances 11, 12 are arranged in advance of condenser K and between the lines 3, 4, while an inductance 13 is connected in series with rotor III. The inductances 11, 12, 13 are calculated to neutralize the residual capacity of condenser K. The residual capacity of this condenser is designated $-jYB$. With the rotor III facing plate I, as shown, this residual capacity and the inductance 13 constitute a short-circuit arrangement, while such residual capacity and the inductance 12 constitute a trap circuit for high frequency currents. Accordingly, with rotor III facing plate I, the current arriving from conductor 2 flows only over the coils 5, 7 while the current from conductor 1 passes only over condenser K and coil 8.

Whenever the rotor is facing the plate II, the conditions are the reverse of the former.

Mounted on the shaft of rotor III is a contact arm forming part of a switch P which thus depends in its action on the position of the rotor. Switch P acts to alternately connect two different modulators to the transmitter.

Condenser K may be employed also for keying in the rhythm of complementary signals. In such case, however, the stator plates must be of a special construction.

What is claimed is:

1. A circuit arrangement having an energy line that comprises two conductors, a network included in this line and comprising reactances, a unipolar change-over switch adapted to switch this network and thereby to reverse the polarity of said energy line by 180°, one of the said conductors being bifurcated into two of the said reactances so as to form two outgoing lines, these two reactances being of the same magnitude and phase, and means, under control of the said switch, for establishing resonant circuits adapted to neutralize either one or the other of the said two reactances.

2. An arrangement according to claim 1, wherein the means for establishing reasonant

circuits comprises a reactance in phase opposition to the said two reactances and arranged in bridge of the said conductors, this reactance being arranged to be connected in parallel with these two reactances by said switch.

3. An arrangement according to claim 1, having a reactance in bridge of the said outgoing lines, a reactance included in one of these lines, and a reactance included in the other outgoing line.

4. An arrangement according to claim 1, wherein the said two reactances are inductances of the same magnitude and wherein the means under control of the switch for establishing resonant circuits comprises a condenser.

5. An arrangement according to claim 1, wherein an inductance is included in the conductor of the energy line which is not bifurcated into said reactances.

6. An arrangement according to claim 1, having a condenser in bridge of said outgoing lines, an inductance included in one of these lines, and an inductance included in the other outgoing line.

7. An arrangement according to claim 1, wherein the unipolar switch is a rotating plate condenser comprised of a rotor and two stator plates, one of these plates being joined to one of said outgoing lines and the other stator plate being connected to the other outgoing line.

8. An arrangement according to claim 1, comprising a rotating plate condenser which constitutes the unipolar switch, this condenser being comprised of a rotor and two stator plates, one of these plates being joined to one of said outgoing lines and the other stator plate being connected to the other outgoing line. two inductances located in advance of this condenser and between said outgoing lines, and a third inductance, these three inductances being calculated to neutralize the residual capacity of said condenser.

9. An arrangement according to claim 1, wherein a radio transmitter is connected to said energy line, and wherein the unipolar switch is a rotating plate condenser comprised of a rotor and two stator plates, one of these plates being joined to one of said outgoing lines and the other stator plate being connected to the other outgoing line, means for modulating the energy from said transmitter, said means comprising two sources of current having different frequencies, means for connecting one of said sources to said rotor plate only during the part of its cycle in which it is operatively associated with a first one of said stator plates, and means to connect the other source to said rotor plate only while it is operatively associated with the other stator plate.

10. An arrangement according to claim 1, comprising a rotating plate condenser which constitutes the unipolar switch, this condenser being comprised of a rotor and two stator plates, one of these plates being joined to one of said outgoing lines and the other stator plate being connected to the other outgoing line, a switch having a rotary contact arm, a shaft common to this contact arm and said rotor, two modulators operating at different frequencies, a pair of stationary contact members each connected to one of said modulators, said contact members corresponding in length and position to said stator plates and being disposed so as to be contacted by said contact arm as it rotates, the arrangement being such that the current from said energy line is modulated alternately by two different frequencies.

11. An arrangement according to claim 1, wherein a reactance is connected in series with the conductor of the energy line which is not bifurcated into said reactances.

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