

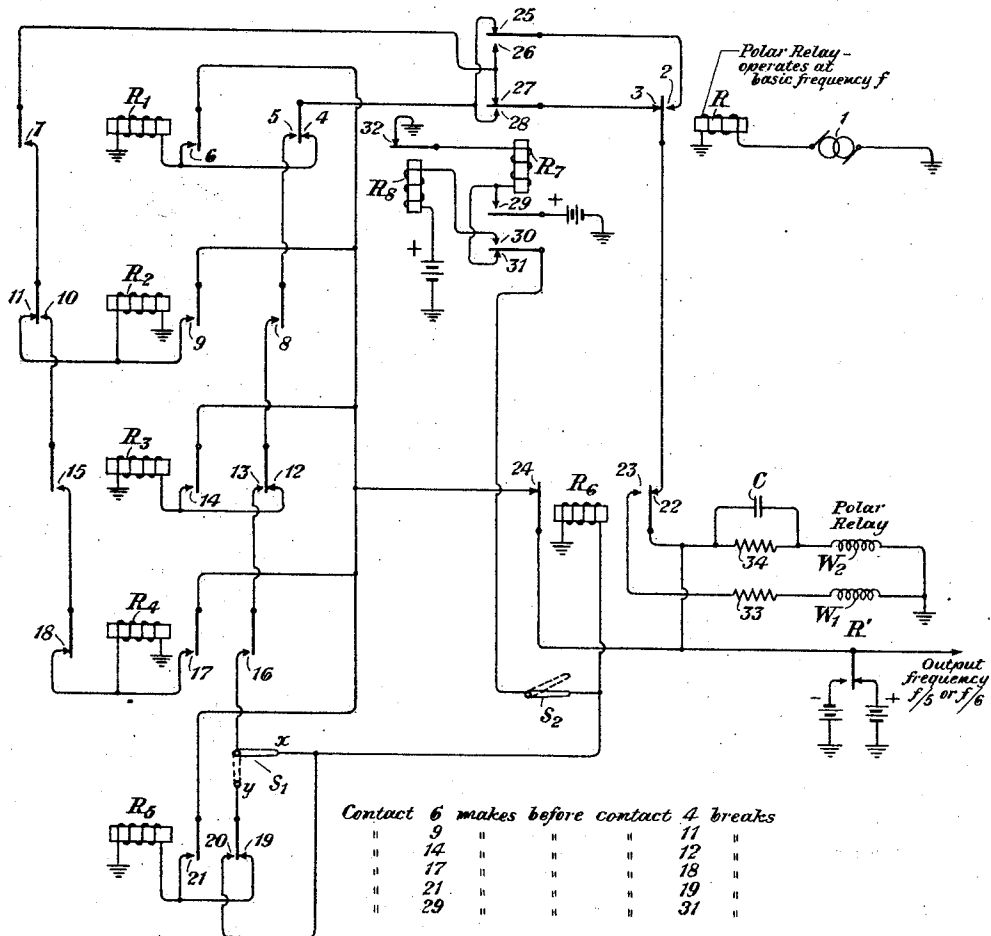
Dec. 22, 1931.

L. C. ROBERTS

1,837,337

MEANS FOR PRODUCING CURRENT OF REDUCED FREQUENCY

Filed June 2, 1928



INVENTOR
L. C. Roberts
BY
J. E. Forde
ATTORNEY

UNITED STATES PATENT OFFICE

LELAND C. ROBERTS, OF TOWACO, NEW JERSEY, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK

MEANS FOR PRODUCING CURRENT OF REDUCED FREQUENCY

Application filed June 2, 1928. Serial No. 282,470.

This application is a continuation in part of my co-pending application filed August 6, 1927, and given Serial Number 211,248.

This invention relates to means for producing a reduced frequency, that is, a current alternating at a lower frequency than a basic current and more particularly to electrical circuit arrangements for dividing any basic frequency by any integer.

It would be desirable, especially in extensive systems of electrical circuits involving electrical apparatus to great numbers, to make use of a standard frequency. This standard frequency would be available for controlling the speeds of machines and calibrating oscillators, for instance.

With a standard frequency in use, a requirement for many purposes is a suitable device for reducing the standard or basic frequency to a lower frequency or any one of a number of lower frequencies—that is, for producing a current alternating at a lower frequency than the current of the standard frequency.

The principal object of my invention is the provision of simple circuit means for reducing a basic frequency (in the sense indicated above) by dividing it by any integer.

The accompanying drawing shows in a diagrammatic form a suitable circuit arrangement embodying my invention. The basic frequency is divided by five to illustrate the production of an odd sub-multiple and by six to illustrate the production of an even sub-multiple.

The system specifically disclosed in the drawing consists essentially, in association with an alternating current generator, of a relay R actuated by current of the basic frequency and vibrating its armature in synchronism with this frequency, a polar relay R' having an armature associated with a source of direct current and designed to reverse the polarity thereof, a relay R₆ controlling the operation and in part the timing of the polar relay, and a chain of relays R₁, R₂, R₃, R₄ . . . together with certain other features pertaining to the production of either a sub-multiple of the basic frequency which is an odd sub-multiple, or a

sub-multiple of the basic frequency which is even, and switching means for including in the circuit the element or elements contributing to the particular result desired. Certain minor features and numerous advantages of the circuit arrangement of the invention will be disclosed and discussed below in connection with the detailed description of the operation of the system. The number of relays in the chain R₁, R₂, R₃, R₄ . . . may be varied to produce a different division of the basic frequency, as will appear more clearly hereinafter.

It is deemed desirable to present first a discussion of the operation of the system when an odd sub-multiple of the basic frequency is desired, and then to follow this discussion with a discussion of the operation of the system when an even sub-multiple of the basic frequency is desired. For the purpose of clarity of description the basic frequency may be termed f . The first operation to be described is that which will produce the sub-multiple

$$\frac{f}{5};$$

the second operation to be discussed will produce the sub-multiple

$$\frac{f}{6}.$$

If the circuit is to be used to produce the odd sub-multiple of the basic frequency f , the switch S₁ is operated to close the circuit between the contact 16 and x , the circuit being opened between contact 16 and y , and the switch S₂ is closed to complete the circuit between contact 31 and x ; thus the relays R₇ and R₈ contribute to the operation of the system. If, on the other hand, the even sub-multiple of the basic frequency f is to be produced, the switch S₁ is operated to break the circuit between contact 16 and x and to close it between that contact and y , and the switch S₂ between contact 31 and x is opened; thus the relays R₇ and R₈ are eliminated from the active circuit.

It being understood that an odd sub-mul-

multiple of the basic frequency f , specifically the frequency

$$\frac{f}{5}$$

is to be produced, the series of relay operations may be described in some detail as follows:

The relay R operates in synchronism with the current produced by the alternating current generator 1, and the armature of this relay is thrown between contacts 2 and 3 once every half-cycle. Let it be assumed that the armature rests on contact 3 and during the first half cycle is thrown to contact 2. When the armature touches contact 2, a circuit is closed from the battery connected to the armature of the polar relay R' through contact 22, contact 2, contact 25, contact 4, and the winding of relay R₁, and relay R₁ is operated. Relay R₁ locks in its operated position through contact 6 and contact 24 over the left-hand armature of relay R₆. Likewise when relay R₁ operates, the closing of contact 7 prepares a circuit including the winding of relay R₂, and contact 5 closes, preparing in part a path to relay R₃. One half-cycle later, with reference to the basic frequency f which is produced by the generator 1 and which controls the operation of relay R, the armature of relay R goes to its back contact 3 and the circuit is closed from battery over the armature of the polar relay R', contacts 22, 3, 27, 7, and 11, and the winding of relay R₂. Upon the operation of relay R₂, contact 8 is closed, completing the preparation of a path to relay R₃; the closing of contact 9 completes a locking circuit for relay R₂ similar to the locking circuit of relay R₁, described above, and the closing of contact 10 prepares in part a path to relay R₄. During the third half-cycle of the alternating current of the basic frequency, the armature of relay R again touches contact 2, and battery over the armature of relay R' is connected in circuit with the winding of relay R₃, the path being similar to those described above and readily traced. It should be borne in mind that when relay R₁ operated, the lead from contact 25 was disconnected from contact 4 and connected to contact 5. Similarly, the operation of relay R₃ throws the armature at the extreme right from contact 12 to contact 13 and prepares in part a path through α to relay R₆. Also the relay R₃ is locked through contact 14, and contact 15 is closed to complete a circuit to relay R₄. During the fourth half-cycle of the current of frequency f , the armature of relay R is thrown for the second time to contact 3, battery is connected in circuit with the winding of relay R₄ over contact 18 associated with that relay, and contacts 16 and 17 are closed. The relay R₄ is locked over contact 17, and the closing of contact 16 completes the circuit path to relay R₆. With ref-

erence to relays R₁, R₂, R₃, and R₄ in order, it should be noted that contact 6 must make before contact 4 breaks, contact 9 must make before contact 11 breaks, contact 14 must make before contact 12 breaks, and contact 17 must make before contact 18 breaks.

When the armature of relay R goes to contact 2 during the fifth half-cycle, a circuit is completed from battery over the armature of the polar relay R' and contacts 22, 2, 25, 5, 8, 13, and 16 to the winding of relay R₆, and this relay is operated. Likewise, a circuit, as just described, is closed from battery over contact 31 to the winding of relay R₇.

The operation of relay R₆, in response to the fifth operation of relay R, opens contact 24 and thus breaks the locking circuit for the relays of the chain R₁, R₂, R₃, and R₄. Likewise, this relay operation closes contact 23 and opens contact 22.

The polar relay R' has two windings W₁ and W₂ and an armature which, as indicated above, makes alternating contacts to reverse the polarity of the battery, this armature being shown in the drawing in contact with the plus pole of the battery. The relay winding W₁ is so connected that current through it will cause the armature of the relay to go to the contact opposite that on which it is resting; with the condition as indicated in the drawing, current through this winding will cause the armature to go from the right-hand contact to the left-hand contact this operation, of course, reversing the polarity of the battery. The winding W₂ is so connected that current through it will have an effect opposing the effect of current through the winding W₁.

When relay R₆ is operated as a result of the fifth operation of relay R, the battery is removed from the armature of relay R and is connected through a resistance 33 and the winding W₁ of polar relay R', upon the opening of contact 22 and the closing of contact 23. The current through winding W₁ throws the armature of relay R' from the right-hand contact (as shown in the drawing) to the left-hand contact. When this latter contact is made, a charging current flows through the condenser C and the winding W₂, this momentary charging current serving to hold the armature of relay R' firmly on the left-hand contact until relay R₃ releases. In order that this operation may be effected, the resistance 33 must be of such value that the effect of the momentary current through condenser C and the winding W₂ will be greater than the effect of the operating current through resistance 33 and the winding W₁. The resistance 34 serves as a leak to discharge the condenser C during the interval when the armature of relay R' is between its two contacts. Resistance 34 is of such value that steady static current will hold the armature of relay

R' on its contact; when relay R₆ operates, current through the winding W₁, large enough to overcome the effect of the current in winding W₂, will move the armature to the opposite contact.

As has been stated above, the fifth operation of relay R causes not only the operation of relay R₆ but also the operation of relay R₇. Since the completion of the first cycle of operations of relays R₁, R₂, R₃, R₄, and R₆ finds the armature of relay R touching contact 2, and since, of course, the production of the reduced frequency is based on repeated cycles of operations of these relays, it now becomes necessary, in the case of the production of an odd sub-multiple of the frequency f , to provide for the repeated operation of the relays of the chain in the proper sequence; this may be done by an interchange of the connections from the contacts 2 and 3. This interchanging of connections is the function of the relay R₇. As will appear hereinafter, the release at the proper time of relay R₇ is the function of relay R₈.

When relay R₇ operates, in response to the fifth operation of relay R, contact 25 is opened and contact 26 closed, and likewise, contact 27 is opened and contact 28 closed; there is thus produced the desired interchange of connections from contacts 2 and 3. Also, upon the operation of relay R₇, the contact 29 is closed (before contact 31 opens), and a locking circuit is completed through battery, contact 29, winding of relay R₇, and contact 32. In addition, the relay operation breaks contact at 31 in the original operating circuit of relay R₇, and by the closing of contact 30 completes a circuit from battery through the winding of relay R₈ over contact 30 and switch S₂ to the point x associated with switch S₁. If this circuit is traced beyond x it appears of course, that it is the same circuit which controls the operation of relays R₆ and R₇. Relay R₈ does not operate when relay R₇ operates because positive battery is connected to both ends of its windings, as an examination of the drawing will show.

The interchange of connections 25 to 26 and 27 to 28 having been made by the operation of relay R₇, it will now readily be understood that the sixth, seventh, eighth, and ninth half-cycles of the alternating current of frequency f will, through the corresponding operations of relay R, cause the relays R₁, R₂, R₃, and R₄ to operate in the proper sequence. More specifically, the first time in the second cycle of operations that the armature of relay R touches contact 3, relay R₁ will operate, the first time contact 2 is touched relay R₂ will operate, and so on. After the second operation of relay R₄, relay R₆ is again operated and the polar relay R' operates to throw its armature from the negative contact at the left back to the positive contact at the right. As will readily be under-

stood, the operation of relay R' is maintained by repeated cycles of operations of the relay chain R₁ to R₄, the relays of the chain being put in condition for each new cycle of operations by the operation of relay R₆, which breaks the locking circuits at contact 24, and by the operation of relay R₇, as described above.

It is necessary, of course, that relay R₇ be released after the tenth half-cycle and the tenth operation of relay R. This tenth operation of relay R not only operates relay R₆ but also completes an operating circuit for relay R₈. This circuit is traced as follows: from battery over the armature of relay R'—which battery is now negative—over contacts 22, 3, 28, 5, 8, 13 and 16, switches S₁ and S₂, and contact 30 through the winding of relay R₈ to positive battery. Since the battery at the two ends of the relay winding is no longer positive in both cases but is negative at one end and positive at the other, relay R₈ will now operate and break the locking circuit of relay R₇ at contact 32. As a result, the relay R₇ releases, and the original connections from contacts 2 and 3 are restored. Thus the system is placed in condition for the third cycle of operations of relays R₁ to R₄.

It remains to discuss the operation of the system when the desired result is the production of an even sub-multiple of the basic frequency f . The system is placed in condition for suitable operation by the throwing of the switch S₁ from x to y and the opening of switch S₂. These switching operations add the circuits associated with relay R₅ to the system—that is, they add one relay to the chain R₁ to R₄—and they also remove the relays R₇ and R₈ from the active circuit.

During the first, second, third, and fourth half-cycles of the alternating current of basic frequency f , relays R₁, R₂, R₃, and R₄ operate in order, as has been described above in connection with the production of the odd sub-multiple. The operation of relay R₄ through the closing of contact 16 now completes a circuit from battery over the armature of relay R' to relay R₅ through contact 19 associated with the last named relay. Relay R₅ then, upon the fifth operation of relay R, is actuated, locks up through contact 21 and closes contact 20 to prepare the necessary path from battery over the armature of relay R' to relay R₆. In response to the operation of relay R₆, as was shown to be the case in the above discussion, the polar relay R' operates to throw its armature from the positive battery contact at the right to the negative battery contact at the left. Since there are now five relays in the chain R₁, R₂, R₃, R₄, and R₅, (it being remembered that relay R₆ operates on the next half-cycle, that is, the sixth), we now find that at the completion of the first cycle of operations the armature of

relay R is touching the back contact 3 where it was originally. Accordingly, the system is placed in condition for the next cycle of operations by the mere breaking of the chain relay locking circuits at 24 in response to the operation of relay R₅, and no interchange of the connections from contacts 2 and 3 is required. It should be noted, in connection with relay R₅, that contact 21 must make before contact 19 breaks.

It will now be clearly understood that in the specific case discussed above, of the operation of the system to produce an odd sub-multiple of the basic frequency f , the armature of the polar relay R' will reverse the battery polarity so as to produce an output frequency of

$$\frac{f}{5},$$

that is, the basic frequency has been divided by 5. Likewise, it will readily be understood that when the specific circuit shown is altered to include relay R₅ in the chain of relays, to give an odd number of relays in the chain, the output frequency produced by the operation of relay R' will be

$$\frac{f}{6},$$

It is readily understood, of course, that the basic frequency f may be divided by any other integer, odd or even, if the number of relays in the chain R₁, R₂, R₃, R₄ . . . is changed, the output frequency being

$$\frac{f}{n+1},$$

where f represents the basic frequency and n the number of relays in the chain indicated. In other words, the frequency f may be reduced to the frequency

$$\frac{f}{n}$$

by connecting in the relay chain relays which are $n-1$ in number.

Looking exclusively at the operation of the system as it affects the timing of relay R', it is seen that relay R₅ may be considered as one relay of the chain, in which case the total number of relays in the chain equals the integer by which the basic frequency is divided.

While the applicant's invention has been disclosed in a specific embodiment which is deemed desirable, for the purpose of clear illustration, it will be understood that the scope of the invention is not limited thereby but is determined by the appended claim.

What is claimed is:

In association with a source of alternating current of a basic frequency of F cycles, an

electrical system or producing a current alternating at a frequency of

$$\frac{F}{N}$$

cycles, said system comprising a first switching means responsive to the reversals of the current of the basic frequency, a source of output current, a second switching means for alternating the polarity of said source of output current, a relay for controlling the operation of said second switching means, and a chain of relays numbering N-1 interposed between said first switching means and said controlling relay, the relays of said chain and the controlling relay operating successively in response to the successive operations of said first switching means.

In testimony whereof, I have signed my name to this specification this 1st day of June, 1928.

LELAND C. ROBERTS.