

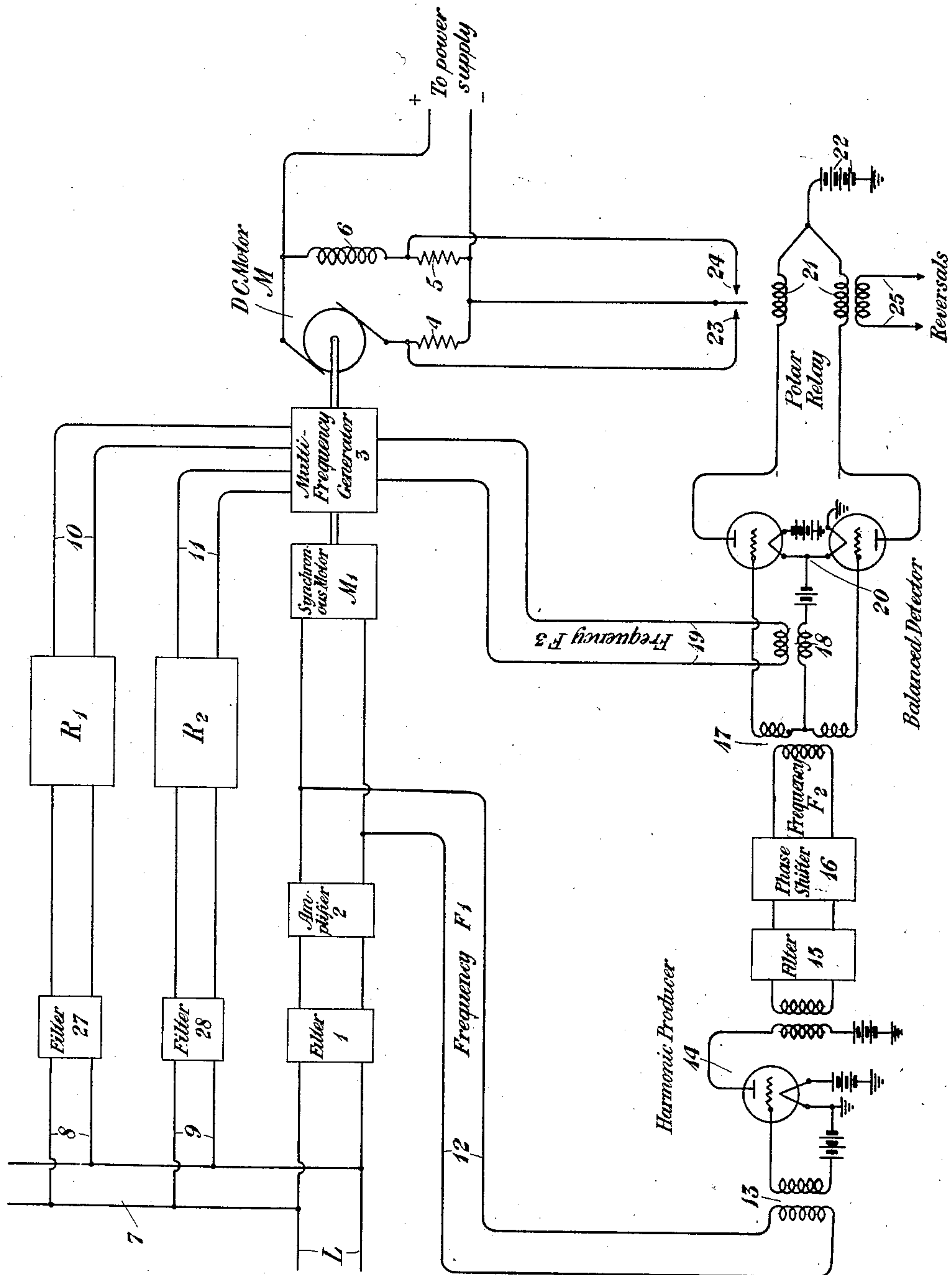
July 28, 1925.

1,547,217

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PHASE REGULATOR FOR MULTIFREQUENCY GENERATORS

Filed July 11, 1924



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Patented July 28, 1925.

1,547,217

UNITED STATES PATENT OFFICE.

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PHASE REGULATOR FOR MULTIFREQUENCY GENERATORS.

Application filed July 11, 1924. Serial No. 725,504.

To all whom it may concern:

Be it known that I, JOSEPH HERMAN, a citizen of the Republic of Austria, residing at New York, in the county of New York and State of New York, have invented certain Improvements in Phase Regulators for Multifrequency Generators, of which the following is a specification.

This invention relates to arrangements for maintaining synchronism in the phase relationship between two or more alternating current generators.

A particular application of the invention, for purposes of illustration, might be found in certain types of carrier telegraph systems which provide for multiplex telegraphy with discrimination by difference of phase between messages in the same frequency range. At the receiving end of such systems reception is by the homodyne method and a local generator generates currents corresponding to the various carrier channels utilized. It is essential in such systems that these local currents be in the proper phase relationship with the carrier currents transmitted from the sending station and for accomplishing this purpose the arrangements of the invention are particularly useful and, accordingly, the invention will be illustrated in connection with a telegraph system of this type. Such a system is illustrated in a copending application, Serial No. 696,048, filed February 29, 1924, in the name of H. Nyquist, and reference is had thereto for a more detailed description thereof. It is understood, however, that its application is not limited thereto but that it may be utilized in many other ways. A particular feature of the arrangements of the invention consists in the provision of a multiplying device by means of which differences in phase between the two generators may be multiplied a number of times. This magnification of error is then utilized to give very accurate and automatic adjustment of one of the generators to secure and maintain the desired phase relationship. Other features and details of the arrangements of the invention will appear more fully from the detailed description hereinafter given.

In the drawing is shown a circuit diagram embodying a preferred form of the invention. The drawing illustrates a multiplex telegraph line L terminating at a receiving station. At the sending station, which is

not shown, a plurality of carrier frequencies may be superimposed on the line. Each of these carrier frequencies may carry a plurality of telegraph messages by means of discrimination by difference of phase between messages on the same carrier frequency. These carrier frequencies will be transmitted over line L to the receiving station, where they will be transmitted over circuit 7 and thence the separate carrier frequencies will be selected by the filters 27 and 28 and transmitted over circuits 8 and 9 to the receiving apparatus R_1 and R_2 . The reception at this apparatus is accomplished by the well known homodyne method and hence it is necessary to supply to the receiving arrangements R_1 and R_2 frequencies similar to and with a proper phase relationship to the carrier frequencies generated at the sending station. For this purpose the circuits 10 and 11 and the multi-frequency generator 3 are provided. In order to control and regulate the phase of the currents generated by the multi-frequency generator 3 a certain synchronizing frequency, which may be termed F_1 , is sent out from the sending station. This synchronizing frequency is transmitted through the filter 1 and the amplifier 2 and then connected to a synchronous motor M_1 . The synchronous motor M_1 is operated by this current and is geared to the shaft of the multi-frequency generator 3 and serves as a speed regulator to maintain it in approximate synchronism with the generator at the sending station. However, other mechanism than the motor M_1 might be used for this purpose, such for example, as a centrifugal governor on the driving motor M. The main driving power for the generator is obtained from a direct current motor M, which is geared to the shaft of the generator. The motor M includes a shunt field 6, a field resistance 5, and an armature resistance 4 by means of which the phase regulator maintains the proper phase relationship between the multi-frequency generator 3 and the generator at the distant station.

The operation of regulation is as follows: Part of the synchronizing frequency F_1 is transmitted over circuit 12 to the transformer 13 and thence to the grid of a detector tube 14, which is designed to function as an harmonic producer. The output of this detector contains a number of harmonics

of the input frequency F_1 and any one of these harmonics may be used for the phase regulation. It is desirable to use a fairly high harmonic if very close phase regulation or synchronism is required. This is true because any change in phase of the fundamental frequency will be multiplied by the harmonic ratio in the various harmonic frequencies. It is evident, therefore, that the higher the harmonic the greater will be the effect upon the phase regulator of a given phase change in the fundamental. The various harmonics in the plate circuit of the harmonic producer 14 are connected through a transformer to a filter 15. This filter is designed so that only the desired harmonic, which may be termed F_2 , passes through it. After passing through the filter this harmonic F_2 is made to pass through a variable phase shifter device 16, which is well known in the art, which permits of any desired phase adjustment of this frequency. From the output of the phase shifter 16 the frequency F_2 is connected differentially to a duplex vacuum tube detector 20 of the balanced type through the transformer 17. A frequency F_3 similar to the frequency F_2 will be supplied from the multi-frequency generator 3 to the circuit 19 from when it will be applied in parallel aiding to the grids of the balanced detector 20 by the transformer 18. Connected to the output of the balanced detector 20 is a polar relay 21. By now adjusting the phase of the frequency F_2 by means of the phase shifter device 16 so that the frequency F_2 will be 90° out of phase with the frequency F_3 , the detector current through the two windings of the polar relay 21 will be equal and have no effect upon the relay. Under this condition the polar relay will vibrate unbiased under the influence of reversals applied to circuit 25 and the third winding of the relay. The armature resistance 4 and the field resistance 5 of the direct current motor M, which are connected as shown to the contacts of this relay, will therefore be short-circuited for one half of the time and the motor will tend to run at a predetermined desired speed. Should either of the generators at the different stations tend to change their speed the phase relationship between the frequencies F_2 and F_3 will change very rapidly because of the multiplying effect of these high frequencies. This will destroy the condition of balance in the detector 20 and produce unbalanced currents in the windings of polar relay 21 which will bias the vibrating armature of the relay to one contact or the other. A bias to the contact 23 tends to increase the speed of the motor by short-circuiting the armature resistance 4 for a longer period of time than the field resistance 5 and a bias to contact 24 will tend to decrease the speed for the opposite reason.

It is evident that this tendency of the relay to change the speed of the local generator is so related to the causes which produced the unbalanced current that the phase relationship between F_2 and F_3 will tend to be restored. By utilizing very high harmonics of the synchronizing frequency F_1 it is evident that a small change of phase can be made to produce a very large restoring force.

While the invention has been disclosed as embodied in certain specific arrangements and illustrated in connection with telegraphic circuits, it is understood that it is capable of embodiment in many and widely varied forms without departing from the spirit of the invention as defined by the appended claims.

What is claimed is:

1. A transmission line interconnecting two stations, generators at each of said stations, means at one of said stations for applying to said line from the generator thereat current of a certain frequency, means at the other station for producing harmonics of said frequency, and means at said last mentioned station controlled by variations in the phase of one of said harmonics for controlling the generator thereat.

2. Arrangements for controlling the phase relations between generators at different stations comprising a generator at each of said stations and a transmission line interconnecting said stations, means at one of said stations for selecting one of the frequencies applied to said line by the generator at the other station, means for producing harmonics of said frequency, means for selecting one of said harmonics, and means controlled by variations in the phase of said harmonic for controlling the generator at said station.

3. Arrangements for controlling the phase relations between generators at distant stations comprising generators at each of said stations, a transmission line interconnecting said stations, and arrangements at one of said stations comprising means for selecting one of the frequencies applied to the line from the generator at the distant station, means for producing harmonics of said frequency, means for selecting one of said harmonics, a balanced detector, a polar relay in the output circuit thereof, means controlled by said polar relay for controlling the generator at said station, means for applying from said generator to said detector a beating current similar in frequency to said selected harmonic, and means for adjusting the phase of said selected harmonic so that it will be 90° out of phase with said beating current and for applying said harmonic to said detector.

4. Arrangements for controlling the phase relations between generators at distant stations comprising generators at each of said

stations, a transmission line interconnecting said stations, and arrangements at one of said stations comprising means for selecting one of the frequencies applied to the line from the generator at the distant station, means for producing harmonics of said frequency, means for selecting one of said harmonics, a balanced detector, a vibrating polar relay in the output circuit thereof and controlled thereby, driving mechanism for the generator at said station, control circuits for said driving mechanism controlled by said vibrating polar relay, means for applying from said generator to said detector a beating current similar in frequency to said selected harmonic, and means for adjusting the phase of said selected harmonic so that it will be 90° out of phase with said beating current and for applying said harmonic to said detector.

In testimony whereof, I have signed my name to this specification this 8th day of July 1924.

JOSEPH HERMAN.