Nov. 17, 1942. G. HEPP ET AL 2,302,123

ARRANGEMENT FOR SYNCHRONISING OSCILLATIONS

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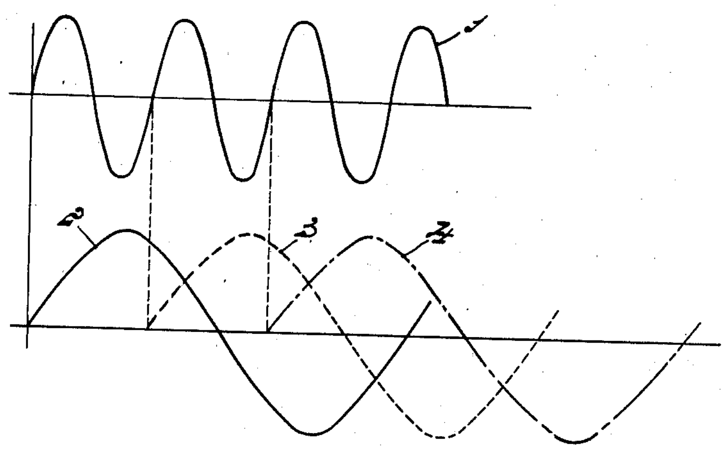

Fig. 1

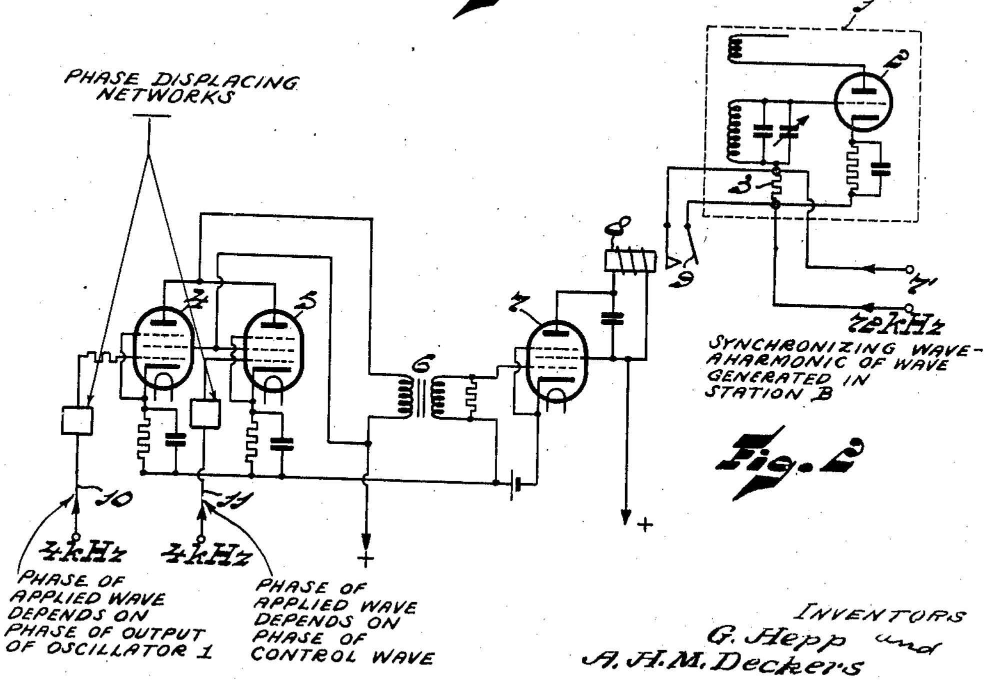

Fig. 2

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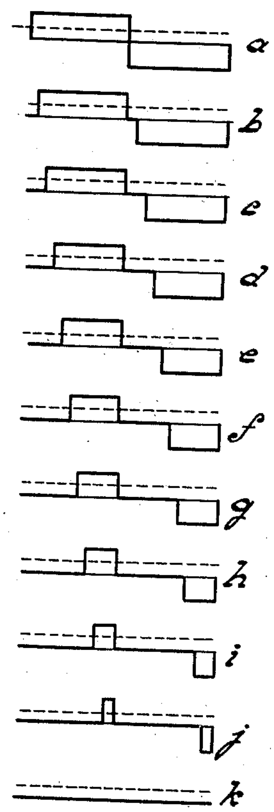

Fig. 3

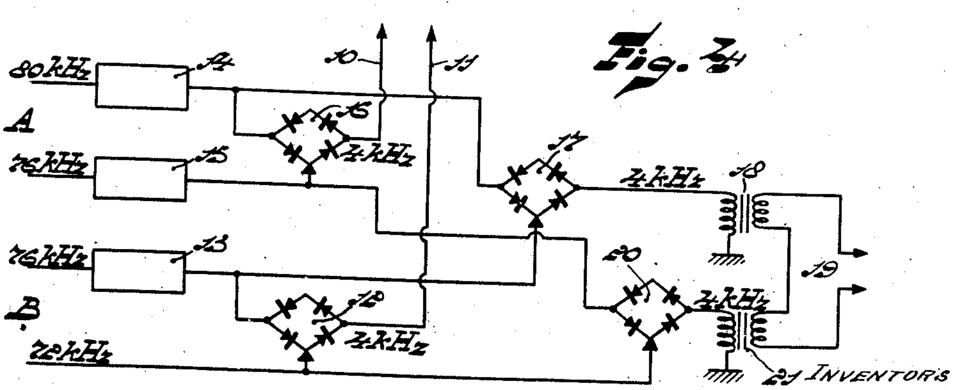

Fig. 4

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ARRANGEMENT FOR SYNCHRONIZING OSCILLATIONS

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9 Claims. (Cl. 250—36)

This invention relates to circuit arrangements for synchronizing an oscillation generated by a generator in the correct phase with the aid of a control oscillation of the same frequency, the control oscillation not acting directly upon the generator to be synchronized. The frequency of the generator to be synchronized is, for example, directly influenced either by a harmonic of the control oscillation or by an oscillation derived either from two harmonics of the control oscillation or from a harmonic of the control oscillation and a harmonic of the generator to be synchronized.

The invention will be described with reference to the appended drawings forming part of the specification and in which:

Figure 1 shows the phase relationship existing between a generated oscillation and a harmonic synchronizing oscillation.

Figure 2 illustrates a circuit arrangement in accordance with the invention for obtaining synchronization in the correct phase by means of two auxiliary oscillations.

Figure 3 illustrates the variations in the control action with changes in the phase relationship between the auxiliary oscillations.

Figure 4 schematically illustrates a method for providing the auxiliary oscillations for the correct phasing of the oscillating generator.

During synchronization by means of a synchronizing oscillation which directly acts upon the frequency of the generator to be synchronized and is equal to the harmonic of the control oscillation, the phase of the generated oscillations may take different values depending on the moment of starting of the synchronization. If, for example, the synchronizing oscillation, which is represented by a curve **1** in Fig. 1 of the accompanying drawings, has a frequency of 12 kilocycles per second, being the third harmonic of an oscillation of 4 kilocycles to be generated, the phase of the generated oscillation may take three different values, depending on whether the synchronization takes place during the first, the second or the third period of the synchronizing oscillation. Accordingly, the generated oscillation will vary in accordance with one of the curves **2**, **3** or **4** of Fig. 1 which exhibit a phase difference of respectively 120° and 240°.

The same disadvantage occurs during synchronization with the aid of a synchronizing oscillation whose frequency is equal to that of the oscillation to be generated and is derived either from two harmonics of the control oscillation or from a harmonic of the control oscillation and a harmonic of the oscillation to be generated.

The invention has for its purpose to make one definite choice from these different possibilities and to exclude the other ones.

According to the invention this object is achieved by providing means making the influence of the control oscillation upon the generator inactive, if the phase of the generated oscillations does not exhibit the correct value. The said means are controlled by the phase displacement between two auxiliary oscillations at the frequency to be generated, the phase of one of these auxiliary oscillations being at least dependent on the phase of the control oscillation and the phase of the other being at least dependent on the phase of the oscillation generated by the generator.

Fig. 2 shows one example of an arrangement according to the invention as applied to a carrier-wave telephony system, in which in each of the stations the carrier-waves for the various channels are derived from a common generator, the latter being synchronized in the correct phase in at least one of these stations by the generator in the other station and the generator to be synchronized being directly influenced by a synchronizing oscillation, whose frequency is a higher harmonic of the frequency of the control oscillation. In the example, the generator to be synchronized is designated **1** in one station, hereinafter referred to as the station A, and is constituted by a discharge tube **2** with positive feed back in known manner which does not require a detailed description. For synchronizing this generator, the grid circuit includes an impedance **3** which has supplied to it the synchronizing oscillation which is a harmonic of the oscillation generated by the generator in the other station, referred to hereinafter as the station B, and which acts as a control oscillation. It is assumed that the frequency to be generated by the generator **1** amounts to 4 kilocycles/sec., whereas the synchronizing oscillation has a frequency of, say, 72 kilocycles/sec., being the 18th harmonic of the frequency of the generators in the stations A and B.

In the generator **1** is synchronized in this way by the 18th harmonic, the phase of the generated 4 kilocycles oscillation may take 18 different values, as is set out above.

In order to ensure that the phase of the generated oscillation is always adjusted at one and the same value, according to the invention use is made of that part of the arrangement shown in Fig. 2 which will be described hereinafter. This arrangement comprises devices each constituted by a discharge tube 4 or 5, said devices having supplied to them an auxiliary oscillation, whose phase is at least dependent on the phase of the oscillation generated by the generator 1 and having the frequency to be generated and a second auxiliary oscillation. The phase of the second auxiliary oscillation which is supplied, for example, to the discharge tube 5 and, whose frequency is equal to the frequency to be generated by the generator 1 is at least dependent on the phase of the control oscillation. The way of obtaining the two auxiliary oscillations will be set out by reference to the arrangement of Fig. 4 which will be described later in greater detail.

The discharge tubes 4 and 5 are connected in known manner so as to convert the auxiliary oscillations supplied to the grids into an oscillation having a substantially rectangular wave. To this end, resistances may be interposed, for example, in the connecting leads to the control grids, which prevent the voltage at the grids from becoming greatly positive. The tubes 4 and 5 have a common output circuit in which the primary winding of a transformer 6 is included through which a resulting voltage occurs depending on the phase displacement between the auxiliary oscillations fed to the two tubes 4 and 5.

Fig. 3 indicates the resulting voltage through the transformer 6 for various phase displacements between the auxiliary oscillations. In this figure it has been assumed that the amplitudes of the oscillations of rectangular wave supplied by the tubes 4 and 5 so that, if the auxiliary oscillations at the grids of the tubes 4 and 5 are in phase with one another, a resulting voltage is obtained, as is shown in Fig. 3*a*, whose amplitude is equal to twice the amplitude of each of the rectangular oscillations supplied by the tubes. An increase in the phase displacement between the two auxiliary oscillations results in a voltage which may be represented respectively by Figs. 3*b* to 3*k*. In the case of a phase displacement of 180° between the two auxiliary oscillations the resulting voltage is zero, as is shown in Fig. 3*k*.

The resulting voltage produced across the transformer 6 is fed to a discharge tube 7 serving for making the influence exercised by the synchronizing oscillation upon the generator 1 inactive. To this end, a relay 8 is included in the anode circuit which upon the occurrence of a resulting voltage across the transformer 6 short-circuits the impedance 3 by means of a switch 9. The discharge tube 7 exhibits a threshold value obtained, for example, by a negative grid bias which is greater than half the amplitude of the resulting voltage supplied through the transformer to the grid 7 and indicated in Figs. 3*a* and 3*k* by a dotted line. This threshold value results in the anode circuit of the tube 7 being traversed by an anode current and the switch 9 short-circuiting the impedance 3 only in the case that the phase displacement between the auxiliary oscillations at the grids of the tubes 4 and 5 differs from 180°.

Since the phase of the auxiliary oscillation supplied to the grid of the tube 5 is dependent on the phase of the control oscillation and moreover the phase of the oscillation supplied to the grid of the tube 4 is dependent on the phase of the oscillation generated by the generator 1, this auxiliary oscillation being derived from the generator, the phase displacement between the two auxiliary oscillations will vary with the moment at which the generator 1 is synchronized by the synchronizing oscillation. In the described arrangement in which the synchronizing oscillation is the 18th harmonic of the oscillation to be generated, 18 different phase displacements between the auxiliary oscillations may occur in the case of synchronism. However, only with one of these 18 possibilities there is no phase displacement between the two auxiliary oscillations and only in this condition the impedance 3 is not short-circuited by the switch 9. In each of the remaining 17 conditions the relay 8 is energized and consequently the influence of the synchronizing oscillation upon the generator 1 made inactive. The generator 1 is then subjected to frequency variations, resulting in a displacement of the phase of the auxiliary oscillation fed to the tube 4. This phase displacement continues until a moment is obtained at which the phase displacement between the auxiliary oscillations is 180° and the short-circuit of the impedance 3 is eliminated. At this moment the synchronizing oscillation becomes active and the frequency of the oscillation generated by the generator is maintained at a correct value.

Only a single condition of the generator is possible in which it is synchronized in the correct phase. By adjusting the phase relation between the auxiliary oscillation at the grid of the tube 5 and the synchronizing oscillation and by adjusting the phase relation between the auxiliary oscillation at the grid of the tube 4 and the oscillation generated by the generator 1, which is effected by using phase displacing networks in the conductors 10 and 11 through which the auxiliary oscillations are supplied to the tubes 4 and 5, the moment of synchronization of the generator may be adjusted at will.

Due to the tube 7 being given a threshold value which is greater than half the amplitude of the resulting voltage supplied through the transformer 6 to the grid of the tube 7 and consequently greater than the amplitude of the rectangular oscillations supplied by each of the tubes 4 and 5, it is ensured that if during operation, after the generator 1 has been brought into the desired condition, one of the auxiliary oscillations is suppressed by interference, the remaining auxiliary oscillation has no amplitude sufficiently large to overcome the threshold and to energize the relay 8; consequently the synchronism is maintained in spite of the occurring interference.

Consequently it is not necessary that the auxiliary oscillation whose phase is at least dependent on the control oscillation of 4 kilocycles generated in the station B is always present. This auxiliary oscillation may be, for example either the 4 kilocycles carrier-wave of the station B and consequently the control oscillation itself or, as will be set out in detail hereinafter by reference to Fig. 4, it may be obtained either by generating a difference-frequency from two carrier-waves generated in the station B, which differ by 4 kilocycles per sec., or by mixing a harmonic of the control-oscillation and a harmonic of the oscillation generated by the generator to be synchronized. Each of these harmonics serve as carrier waves for a conversation to be transmitted and are suppressed during the normal speech transmission and are only transmitted from B to A for signalling purposes. Consequently, auxiliary oscillation is supplied to the tube 5 only during the times of the signalling.

During signalling the phase of the oscillations generated by the generator 1 is adjusted at the value desired. After that, the auxiliary oscillation is suppressed but the synchronism of the generator is maintained.

It is not necessary for the amplitudes of the rectangular oscillations supplied by the tubes 4 and 5 to be equal. In the case of unequal amplitudes only the threshold value of the tube 7 must be chosen so as to be greater than the largest of the amplitudes of the two rectangular oscillations active at the grid of the tube 7.

Although the illustrated example indicates a relay 8 which short-circuits the impedance 3, use may also be made of an electric relay, for example a discharge tube.

Fig. 4 shows in what manner the auxiliary oscillations can be generated in a carrier-wave system, as has been described by reference to Fig. 2. The auxiliary oscillation whose phase is at least dependent on the control oscillation is formed by two carrier-waves generated in the station B. These carrier oscillations of, say, 72 and 76 kilocycles per sec. are received in the station A and supplied to a mixing arrangement 12 constituted by a bridge connection of dry rectifiers. A frequency of 4 kilocycles per sec. is obtained in the output circuit of this mixing arangement and supplied as an auxiliary oscillation through the conductor 11 to the grid of the tube 5 in Fig. 2. The phase of this auxiliary oscillation may be adjusted with the aid of a phase control device 13, through which the carrier oscillation of 76 kilocycles is supplied to the mixing arrangement. The other auxiliary oscillation is formed in a similar way in the station A by the difference frequency of two higher harmonics of, say, 76 and 80 kilocycles per sec. of the generator 1. These two higher harmonics are supplied through phase-control devices 14 and 15 to a mixing arrangement 16 constituted by a bridge connection of dry rectifiers and in the output circuit of which an oscillation of 4 kilocycles occurs which is supplied through the conductor 10 to the discharge tube 4.

In this arrangement the synchronizing oscillation has the same frequency as the oscillation to be generated by the generator 1 in Fig. 2. In this arrangement, however, the synchronizing oscillation is derived from two oscillations having frequencies which are higher harmonics of the oscillation to be generated by the generator 1. To this end, the harmonic of 76 kilocycles per sec. originating from the station B, together with the harmonic of 80 kilocycles per sec. originating from the station A, is supplied to a mixing arrangement 17 constituted by a bridge connection of dry rectifiers. An oscillation of 4 kilocycles per sec. is obtained in the output circuit of this mixing arrangement which is supplied through a transformer 18 to a circuit 19, in which the impedance 3 of Fig. 2 is included.

In order to increase the reliability of service, the circuit 19 has supplied to it, in addition, a 4 kilocycles oscillation derived from the 76 kilocycles oscillation originating from the station A and the 72 kilocycles oscillation originating from the station B. These oscillations are fed to a mixing arrangement 20, in whose output circuit the 4 kilocycles oscillation occurs which is supplied through a transformer 21 to the circuit 19. If one of the oscillations generated by the station B, for example that of 76 kilocycles, is suppressed by interference, the synchronization is not disturbed, since the carrier-wave of 72 kilocycles which still exists together with the oscillation of 76 kilocycles of the station A, continue to supply the 4 kilocycles required for synchronization.

In the example represented in Fig. 2, the auxiliary oscillations fed to the tubes 4 and 5 are converted into oscillations having approximately a rectangular wave. Though this is advantageous in view of an exact comparison of the phases of the two auxiliary oscillations, this conversion is not necessary under any conditions. These tubes 4 and 5 may also be connected as an amplifier so that the anode currents of these tubes are sinusoidal and the tube 7 is put into operation in dependence on the phase displacement existing between these currents.

What we claim is:

1. A circuit arrangement comprising an oscillation generator, a source of control oscillations for directly influencing the frequency of said generator, and a circuit rendering inactive the influence of said control source, said circuit including a first source of auxiliary oscillations whose phase is dependent upon the phase of the oscillations of said generator, a second source of auxiliary oscillations whose phase is dependent upon the phase of said control oscillations, and means combining the oscillations of said sources in phase relationship.

2. A circuit arrangement comprising an oscillation generator, a source of control oscillations for directly influencing the frequency of said generator, and a circuit rendering inactive the influence of said control source, said circuit including a first source of auxiliary oscillations derived from said generator and having a phase dependent upon the phase of the oscillations of said generator, a second source of auxiliary oscillations whose phase is dependent upon the phase of said control oscillations, and means combining the oscillations of said sources in phase relationship.

3. A circuit arrangement comprising an oscillation generator, a source of control oscillations for directly influencing the frequency of said generator, and a circuit rendering inactive the influence of said control source, said circuit including a first source of auxiliary oscillations derived from said generator and having a phase depending upon the phase of the oscillations of said generator, a second source of auxiliary oscillations derived from the source of the control oscillations and having a phase depending upon the phase of control oscillation, and means combining the oscillations of said sources in phase relationship.

4. In a circuit arrangement in combination, an oscillation generator, a source of control oscillations directly influencing the frequency of said generator, a first source of auxiliary oscillations whose phase is dependent on the phase of the oscillations of said generator, a second source of auxiliary oscillations whose phase is dependent on the phase of said control oscillations, means combining said first and second auxiliary oscillations to provide resulting oscillations and means controlled by said resulting oscillations to render inactive said source of control oscillations upon the departure from a predetermined phase difference between said first and second auxiliary oscillations.

5. A circuit arrangement comprising an oscillation generator, a source of control oscillations for directly influencing the frequency of said generator, a first source of auxiliary oscillations

whose phase is dependent upon the phase of the oscillations of said generator, a second source of auxiliary oscillations whose phase is dependent upon the phase of said control oscillations, means combining the oscillations of said sources in phase relationship and producing resulting oscillations having a substantially rectangular wave form, and means controlled by the resulting oscillations to render inactive said source of control oscillations upon the departure from a predetermined difference of the phases of said first and second auxiliary oscillations.

6. A circuit arrangement comprising an oscillation generator, a source of control oscillations for directly influencing the frequency of said generator, a first source of auxiliary oscillations whose phase is dependent upon the phase of the oscillations of said generator, a second source of auxiliary oscillations whose phase is dependent upon the phase of said control oscillations, means combining the oscillations of said auxiliary sources in phase relationship to provide resulting oscillations and a relay member controlled by the resulting oscillation to render inactive said source of control oscillations upon the departure from a predetermined difference of the phases of said first and second auxiliary oscillations.

7. A circuit arrangement comprising an oscillation generator, a source of control oscillations for directly influencing the frequency of said generator, an impedance common to said generator and to the control oscillations, a first source of auxiliary oscillations whose phase is dependent upon the phase of the oscillations of said generator, a second source of auxiliary oscillations whose phase is dependent upon the phase of said control oscillations, means combining the oscillations of said auxiliary sources in phase relationship to provide resulting oscillations and a relay member controlled by the resulting oscillations short-circuit said impedance upon the departure from a predetermined difference of the phase of said first and second auxiliary oscillations.

8. In a circuit arrangement in combination, an oscillation generator, a source of control oscillations directly influencing the frequency of said generator, a first source of auxiliary oscillations whose phase is dependent on the phase of the oscillations of said generator, a second source of auxiliary oscillations whose phase is dependent on the phase of said control oscillations, means combining said first and second auxiliary oscillations to provide resulting oscillations and means controlled by said resulting oscillations to render inactive said source of control oscillations upon the departure from a predetermined difference of the phases of said first and second auxiliary oscillations, said means having a threshhold value equal to the amplitude of the largest of said resulting oscillations.

9. A multi-channel carrier wave telephony system comprising a plurality of stations, carrier waves for the various channels derived from a common generator, a source of synchronizing oscillations for the generator of a first station derived from the generator of a second station, said first station comprising a circuit rendering inactive the influence of said synchronizing oscillations, said circuit including a first source of auxiliary oscillations whose phase is dependent upon the phase of the oscillations of the generator of the first said station, a second source of auxiliary oscillations whose phase is dependent upon the phase of said synchronizing oscillations and means combining the oscillations of said auxiliary sources in phase relationship.

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