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METHOD OF AND MEANS FOR GENERATING LOW FREQUENCY ELECTRICAL OSCILLATIONS.

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1,357,657. Patented Nov. 2, 1920.

Fig. 1.

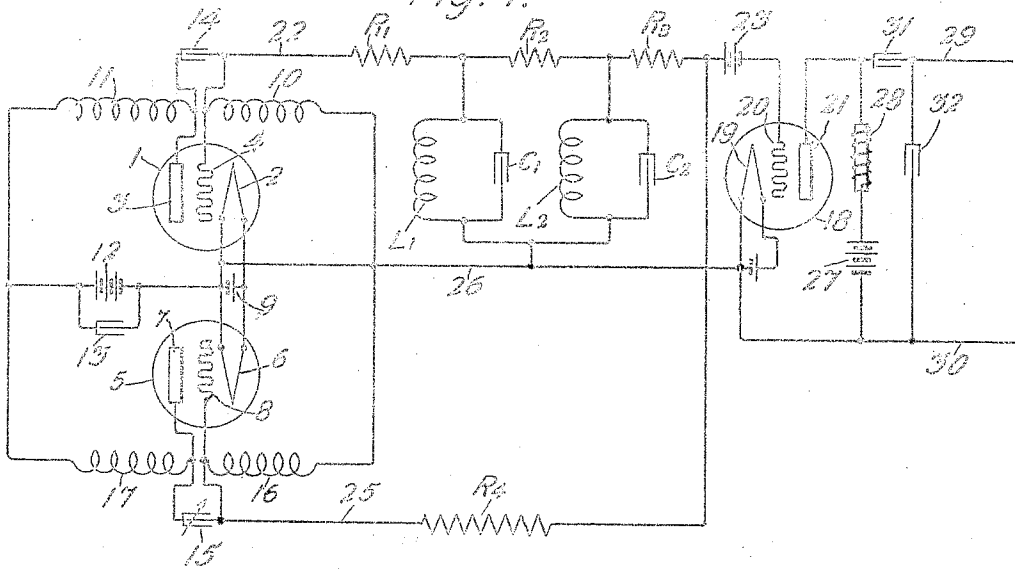
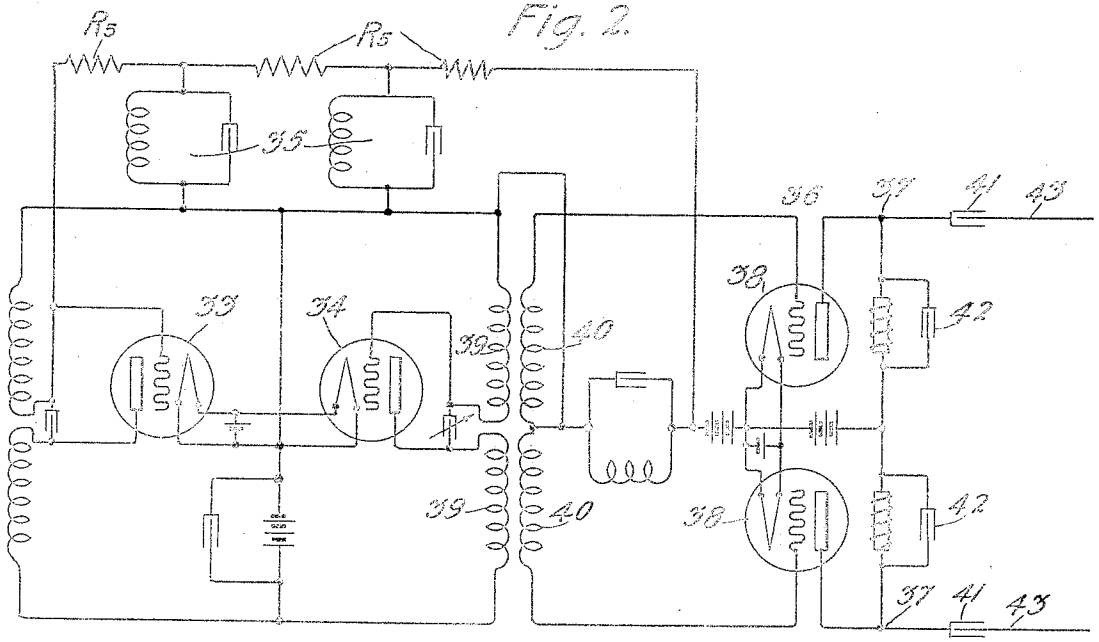


Fig. 2.



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UNITED STATES PATENT OFFICE.

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METHOD OF AND MEANS FOR GENERATING LOW-FREQUENCY ELECTRICAL OSCILLATIONS.

1,357,657. Specification of Letters Patent. Patented Nov. 2, 1920.

Application filed September 21, 1918. Serial No. 255,134.

To all whom it may concern:

Be it known that I, EDWARD O. SCRIVEN, a citizen of the United States, residing at New York, in the county of New York, State of New York, have invented certain new and useful Improvements in Methods of and Means for Generating Low-Frequency Electrical Oscillations, of which the following is a full, clear, concise and exact description.

This invention relates to methods of and means for generating low frequency electrical oscillations and more particularly to oscillation generators of the vacuum tube type.

An object of the invention is to provide means for generating low frequency oscillations, which permits the regulation of the frequency of the oscillations generated.

Another object of the invention is to provide a low frequency oscillation generator of the type having no moving parts, and which does not require associated inductances or capacity elements of excessive size.

A further feature of the invention relates to an arrangement whereby two oscillation generators supply oscillations of slightly different frequencies to a detecting or combining device from the output circuit of which oscillations of the low difference frequency may be derived.

An additional feature of the invention relates to an arrangement for keeping two oscillation generators out of step. As is well known, there is a tendency for two periodic driving forces of slightly different frequency, to get into step, if connected so as to react upon each other. According to the present invention, this tendency is overcome by coupling the oscillators non-reactively.

If the input and output circuits of an amplifying or repeating device are so related that energy is fed back from the output to the input circuit, it is possible to produce oscillations if the physical and electrical constants of the amplifier or repeater and the electrical constants of the associated circuits are properly proportioned. The feed back coupling may be either electromagnetic or electrostatic and in the case of vacuum tube amplifiers, the coupling effected through the internal capacity between elements or electrodes of the tube itself may be considerable. It is usually desirable to have a tuned circuit as a portion at least of either the input circuit, the output circuit, or both. Such a tuned circuit may be made to substantially determine the frequency of the oscillations generated. If a generator of this type were to be used for direct production of oscillations of low frequency, the tuned circuit would necessarily be of large natural period, thus involving either reactance elements of excessive size or magnetic core inductances. Where magnetic inductances are used, the wave generated is not in general, sinusoidal, and its form is variable under different conditions, for the reason that the magnetic characteristic of iron and other materials used in magnetic cores is not linear.

The present invention provides a method of and means for obtaining low frequency oscillations of practically sinusoidal wave form by the interaction of two sets of oscillations which differ in frequency by the low frequency desired. When two sets of different frequency oscillations are supplied to the input circuit of a repeater having a non-linear relation between input voltage and output current, the effect of the repeater is to combine the input frequencies in such a manner as to give their sum and difference frequencies as components of the output circuit current. The difference frequency component may be selected and applied to any work circuit.

In the drawing, Figure 1 illustrates diagrammatically one arrangement of circuits for producing low frequency oscillations and Fig. 2 illustrates a modification of the arrangement of Fig. 1.

Referring to Fig. 1, a highly evacuated tube 1 contains a hot filament 2 or other source of electrons, a plate electrode or anode 3 and a grid or impedance controlling element 4. A similar evacuated tube or bulb 5 contains a cathode 6, an anode 7 and a grid 8. Cathodes 2 and 6 may be heated by a common current source 9. The grid-filament circuit of tube 1 includes an inductance 10; the plate-filament circuit includes an inductance 11 inductively coupled to inductance 10, and a source 12 of space current may be common to the output circuits of both tubes. A large capacity element 13 is shunted around the

source 12 to furnish a low impedance path for high frequency currents. A capacity 14 connected between the grid and plate terminals completes a closed oscillatory circuit which includes elements 11, 13, 10 and 14. The circuits of tube 5 are similar in every respect to those of tube 1 with the exception that condenser 15 connected to terminals of elements 7 and 8 is preferably variable. The input circuit and output circuit inductances, 16 and 17, are inductively related. The closed oscillatory circuit of tube 5 includes elements 13, 17, 15 and 16. The reactance of capacity element 13, which is common to the two oscillatory circuits is very small and accordingly this element does not serve to couple the two circuits in such a manner as to cause reaction of the one upon the other.

A combining device 18 consists of a highly evacuated tube containing a hot cathode 19, a grid 20 and an anode 21. A conductor 22, which includes three high resistance elements R_1, R_2, R_3, and a polarizing electric current source 23 connects the grid 4 to grid 20, a conductor 25 including a high resistance R_4 connects the grid 8 to the terminal of source 23 electrically remote from grid 20, and a conductor 26 connects filaments 2 and 6 to filament 19. Bridged across the conductors 22 and 26 are two closed tuned circuits L_1C_1, L_2C_2, each tuned to the frequency of the oscillations produced by the oscillator comprising tube 1 and its associated circuits. The space current path of the output circuit of tube 18 includes a source 27 of space current in series with a choke coil 28. The low frequency oscillation output circuit 29, 30 to which the load or work circuit may be connected, is connected directly to the plate and filament respectively, a blocking condenser 31 of large capacity serving to prevent passage of direct current from source 27 to the load. A small capacity element 32 bridged across the output circuit offers low impedance to high frequency oscillations and high impedance to oscillations of the frequency which it is desired to produce and supply over the output circuit 29, 30.

The operation of the circuit arrangement illustrated in Fig. 1 is as follows: Tube 1 and its associated input and output circuits serves as a source of high frequency oscillations, the frequency of which is determined largely by the frequency of the circuit 11, 13, 10, 14 and oscillations of this fixed frequency are supplied over the conductors 22 and 26 to the input circuit of combining device 18. Tuned circuits L_1C_1, L_2C_2, each offer substantially infinite impedance to the fundamental frequency thus supplied but low impedence to harmonics which are therefore shunted out from the input circuit of tube 18 and largely dissipated by the particular resistance elements R_1 or R_2 through which they pass. This feature is important for if each oscillator delivers not only a fundamental frequency but harmonics as well, low frequency oscillations which are harmonics of the desired low frequency will be obtained in the output circuit of the combining device. The suppression of harmonics of one of the fundamental frequencies will prevent the production of harmonics of the desired low frequency beat oscillations. Although harmonics of one fundamental may produce with the other fundamental combination oscillations of other frequencies, these will all be of an entirely different order and may be easily suppressed or eliminated. It is therefore unnecessary to prevent the production of harmonics of both fundamentals. The resistance R_3 serves to keep the elements of the tuned circuits L_1C_1, L_2C_2, and those of oscillator 5 from affecting the period of the oscillatory circuit associated with generator tube 1. In practice each of the resistances R_1, R_2, R_3, may be of several thousand ohms so that they effectively separate the oscillatory circuits of the two generators. It follows that a substantially pure fundamental wave will be delivered from generator 1 to combiner 18. The oscillator tube 5 has an oscillatory circuit, the period of which may be varied by variation of capacity element 15, and the frequency of the oscillations generated thereby is made different from that of oscillations supplied by oscillator 1 by the value of the desired low frequency. If, for example, the frequency of oscillations desired is ten per second and source 1 produces thirty thousand oscillations per second, source 5 may be arranged to produce twenty-nine thousand nine hundred and ninety or thirty thousand and ten. If oscillations of some other low frequency are desired, capacity element 15 may be varied accordingly. Element 15 may be arranged to indicate difference frequencies directly. Oscillations are supplied by oscillator 5 over conductors 25 and 26 including a high resistance R_4 which serves in general the same purposes as resistances R_1, R_2, and R_3, and also to attenuate oscillations from source 5 to substantially the same degree that those from oscillator 1 are attenuated.

Oscillations of the two different high frequencies are thus supplied to combiner 18 which preferably has a non-linear relation between output current and input electromotive force. Oscillation current components of both the sum and difference frequencies of the two sets of impressed oscillations will appear in the output circuit. Choke coil 28 excludes both oscillation components from its path and capacity element 32 excludes low frequency components which are therefore impressed upon circuit 29, 30.

In Fig. 2, oscillator 33 is in every respect like oscillator 1, and oscillator 34 corre-

sponds to oscillator 5. Resistances R_5 and tuned circuits 35 serve respectively to perform the same functions as resistances R_1, R_2, R_3, and circuits L_1C_1, L_2C_2 of Fig. 1, circuits 35 each being tuned to the frequency of the oscillations produced by oscillator 33. A modulator or combiner 36 comprising two tubes 38 is used to produce oscillations of the difference frequency. The characteristic of the combiner 36 is such that the two tubes 38 amplify symmetrically impressed input electromotive forces to the same degree, and balance these amplified variations against each other in their common output circuit, so that between the points 37 there will be no difference of potential of the frequency of the symmetrically impressed variations. Under these circumstances no resulting current of this frequency will flow between points 37. If, however, another electromotive force is applied unsymmetrically to the combiner device, that is in such manner as to tend to make one grid positive and the other negative with respect to their common cathode connection, the amplifying power of one tube is increased and that of the other decreased so that the amplified variations of the symmetrically impressed input electromotive force variations no longer balance in the output circuit of the modulator and a resultant oscillation component of the frequency of the symmetrically impressed electromotive force, varying in amplitude in accordance with the unsymmetrically impressed electromotive force appears, and oscillations of this character will be transmitted thereby. As is well known, such a varying amplitude current may be resolved into two components one of which has the frequency sum, and the other, the frequency difference of the two impressed electromotive forces.

Oscillations are symmetrically impressed from source 33 across a circuit which is tuned to their frequency and serves as a high impedance to this frequency in the common portion of the input circuits of tubes 38. Oscillations are impressed from source 34 by output windings 39 upon input windings 40 inductively related thereto. Source 34 accordingly impresses oscillations unsymmetrically upon the tubes 38 since it tends to make the grid of one tube positive and at the same time to make the grid of the other negative with respect to their cathodes. As in the case of the single tube combining device of Fig. 1, blocking condensers 41 of large capacity are provided to prevent flow of unidirectional current to the load, and small capacity elements 42 are provided to furnish a path of low impedance to the frequency sum component. The load or work circuit may be connected across the output circuit 43 and oscillations of the difference frequency of those supplied by sources 33 and 34 will be supplied thereto. The operation of this arrangement will be clear from the explanation given in connection with Fig. 1.

Although two specific circuit arrangements have been illustrated and described, it is to be understood that the invention is not to be limited to these particular arrangements as a whole or to their specific features, but covers all such modifications and rearrangements as fall within the scope of the appended claims.

What is claimed is:

1. A system for the production of oscillations of low frequency comprising means for generating oscillations of two different frequencies, means for preventing reaction between said generating means, and means for combining said oscillations to produce oscillations of their difference frequency.

2. A generator of low frequency oscillations comprising means for generating high frequency oscillations of two different frequencies, means for preventing reaction between said generating means, and means for combining said high frequency oscillations to produce oscillations of their difference frequency.

3. A system for the production of oscillations of low frequency comprising means for generating oscillations of two different frequencies and for combining said oscillations to produce oscillations of their difference frequency, said means including two vacuum tubes having their output circuits connected oppositely, the characteristic of each of said tubes being such that the relation between current in the output circuit and the electromotive force impressed upon the input circuit is non-linear.

4. A generator of low frequency oscillations comprising two sources of high frequency oscillations, a common circuit connected to said sources, and a high resistance in said circuit.

5. The combination of two oscillators, a circuit connecting each of said oscillators to a common oscillation supply circuit, and a high resistance of constant value permanently connected in one of said connecting circuits.

6. The combination of two oscillators, a circuit connecting each of said oscillators to a common oscillation supply circuit, and an oscillation circuit tuned to the frequency of the oscillations produced by one of said oscillators, bridged across its respective connecting circuit.

7. The combination of two oscillators, a circuit connecting each of said oscillators to a common oscillation supply circuit, and means for preventing harmonics of the oscillations produced by one of said oscillators from being transmitted to said oscillation supply circuit.

8. The combination of means for producing oscillations of two different frequencies,

means for suppressing harmonic oscillations of one of said frequencies, and means for combining said oscillations of different frequencies to obtain oscillations of their difference frequency.

9. In a system for producing low frequency oscillations a combining device comprising two electron discharge tubes, each having an input circuit including a transformer winding, a common portion of said input circuits including a closed tuned circuit, means for inducing oscillations of one frequency in said transformer winding, and means for impressing oscillations of another frequency across said tuned circuit.

10 The method of producing low frequency oscillations which comprises generating oscillations of one frequency, suppressing harmonics of said oscillations, generating oscillations of a second frequency and combining said oscillations to produce new oscillations of their difference frequency.

11. The method of producing low frequency oscillations which comprises generating oscillations of one frequency, suppressing harmonics thereof, generating oscillations of a different frequency, combining said oscillations of different frequencies to produce oscillation components of their sum frequency and of their difference frequency and selecting from the combined oscillations said difference frequency component.

In witness whereof, I hereunto subscribe my name this 11th day of September, A. D. 1918.

EDWARD O. SCRIVEN.