

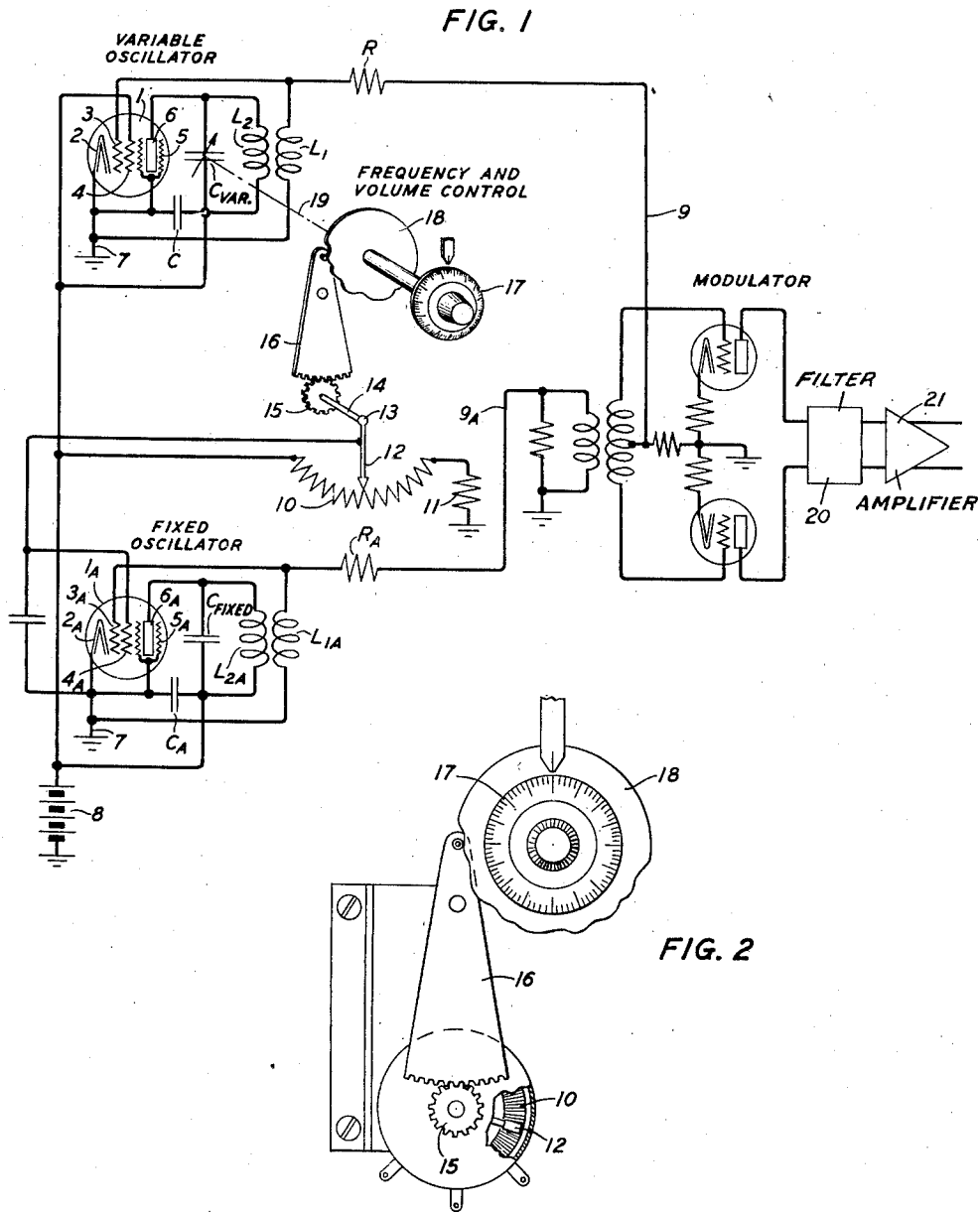
Nov. 11, 1941.

T. SLONCZEWSKI

2,262,149

VOLUME CONTROL CIRCUIT FOR OSCILLATORS

Filed July 3, 1940



INVENTOR
T. SLONCZEWSKI
BY *Guy T. Morris*
ATTORNEY

UNITED STATES PATENT OFFICE

2,262,149

VOLUME CONTROL CIRCUIT FOR
OSCILLATORS

Thaddeus Slonczewski, Glen Head, N. Y., assignor
to Bell Telephone Laboratories, Incorporated,
New York, N. Y., a corporation of New York

Application July 3, 1940, Serial No. 343,737

5 Claims. (Cl. 250—36)

This invention relates to a mechanical volume equalizer circuit as applied to a variable frequency oscillator, and more particularly as applied to an oscillator of the heterodyne type, whereby the variation of frequency attending the normal use of the oscillator is unattended by a substantial change of volume output.

The object broadly of the invention is as above indicated namely, to vary the frequency of an oscillator over a substantial range without substantial effect on the amplitude of the output wave.

A more specific object of the invention is to so mechanically relate elements concerned in the frequency varying and volume varying functions of an oscillator as to insure automatic preservation of an initial volume of output wave while the frequency is caused to vary from the initial frequency over a substantial range.

Still another object of the invention is to operate a heterodyne oscillator over a range from near-zero to well within the megacycle range while automatically maintaining the volume output of the resultant heterodyne frequency wave substantially constant.

A feature of the invention is a mechanical linkage between the operating member of a variable frequency determining element and the operating member of a variable impedance strategically positioned so as to affect the volume of the output wave, the linkage containing an element carefully designed so as to quantitatively relate the movements of the two linked members so that when the frequency is varied as by manual manipulation of the operating member, said impedance will be caused to vary compensatorily and therefore so as to maintain the volume of the output wave substantially constant in the face of a tendency otherwise for it to vary with the frequency.

In an embodiment of the invention in a heterodyne oscillator which has been found effective in practice, the impedance is related to a screen grid element of the relatively fixed frequency unit oscillator which is of the electron discharge type and the mechanical coupling or linkage comprises a cam, the profile of which is empirically designed with relation to the law governing the change of volume as affected by the corresponding change in the potential of said screen grid as affected by the amount of the impedance in circuit with it, all with proper regard to the tendency of the volume, less otherwise compensated for, to change with change in the frequency. In the practical case the coupling is

between a tuning condenser of a frequency determining circuit of the variable frequency unit oscillator, the volume changing impedance being related to a screen grid of the fixed frequency unit oscillator, although the principle of the invention could be exemplified were the elements of the invention confined to a single unit oscillator of the heterodyne oscillator.

For a further description of the invention, reference will be made to the accompanying drawing, in which:

Fig. 1 illustrates a preferred embodiment of the circuit of the invention; and

Fig. 2 illustrates the mechanical coupling means of the invention in a more realistic aspect than in the semi-diagrammatic showing of it in Fig. 1, the structure being shown partially broken away in one detail in order to better disclose the volume controlling impedance in its relationship to contiguous circuit elements and structure.

Referring to Fig. 1, the heterodyne oscillator disclosed comprises generally the two component or unit oscillators indicated as the "variable oscillator" and the "fixed oscillator," the combining device or "modulator" on which are impressed the output waves of the component oscillators and from which is derived the difference or heterodyne frequency, that is, the characteristic frequency of the over-all oscillator, and the filter 20 and amplifier 21, both shown at the extreme right of the drawing, for conditioning and amplifying the resultant wave for utilization. Of these elements of course only the component oscillator and modulator elements are essential to make up the heterodyne oscillator circuit although the other elements are of practical utility.

The component oscillators may be of similar type or of different type with complete impartiality so far as concerns the ultimate result achieved, although, for practical convenience, they are preferably, as in the present showing, of like type and differ only within the requirements that one oscillator is fixed and the other is variable in frequency away from and toward the frequency of the fixed oscillator so as to develop the desired range of difference or heterodyne frequency in the output circuit of the modulator. In the description of the component oscillators herein, specific attention will be directed only to one said component oscillator to the extent that the other one has duplicate elements. (Where the elements are so duplicated, duplication has, of course, to do only with the continuity of circuit and not with the electrical values.) The rela-

tionship between the duplicate elements are indicated by the use of literal subscripts in the labeling of the elements of fixed frequency component oscillator.

In a particular heterodyne oscillator of the invention which was found very successful in practice, the fixed frequency oscillator generated a wave of 17 megacycles frequency, while the variable frequency oscillator generated a wave of a frequency made variable by manipulation of a single variable condenser, between the frequency of 13 megacycles and a frequency very close to that which is characteristic of the fixed oscillator. As a matter of fact the range was from 50 kilocycles to 4,000 kilocycles, a range notable not only for the very great absolute frequency range, but also for the smallness of the lower boundary frequency. Of course the heterodyne principle was used in the generation of this range of frequencies because of these special frequency requirements which would be exceedingly difficult to secure by a single unit oscillator. By the use of the heterodyne principle this very great frequency range, in its dual aspect, may be achieved by a relatively slight variation of frequency of a given prime oscillator, namely, the variable frequency oscillator. Of course this very condition, that is, the necessary condition that the beat frequency variation should be relatively slight presupposes that the oscillator experiencing this variation of frequency should be capable of generating a wave of the extremely great frequency here illustrated.

In all oscillators there is a strong tendency for the output volume to vary as the frequency is varied. Perhaps this problem is accentuated where the frequency variation occurs between limits differing as enormously on a percentage basis as in the present instance, and still more because of the necessity for using extremely great unit frequencies where this range is achieved by use of the heterodyne oscillator, also as in the present case. By refinement of detail of the conventional elements making up a heterodyne oscillator, especially as related to the filter circuit and the usual attenuation network forming parts thereof, this volume variation may be greatly reduced. However, in the instant case it was found necessary by the inherent difficulty of the situation to resort to the particular means of the invention to achieve the requisite uniformity of volume. This means is not approximated in any conventional oscillation generating circuit either of the single unit type or of the heterodyne type, although it could be incorporated in principle in any oscillator to enhance the effect of the use of other expedients in the nature of refinements of conventional circuit elements.

Considering first the variable frequency unit or component oscillator, and again remembering that except where especially noted otherwise, the description applies equally well to the fixed frequency oscillator, this oscillator comprises the electron tube 1 together with associated circuits made up of resistance, inductance, and capacitance so as to constitute the whole a quite conventional reversed feedback vacuum tube oscillator with plate tuning. The tube comprises the usual cathode 2, control grid or electrode 3, screen grid 4, suppressor grid 5 and plate or anode 6. Of course, other types of tubes, for instance employing three electrodes, may be substantially equally well used with like associated circuits to achieve the same result, and the cathode may be indirectly heated if desired. The anode-cath-

ode circuit is energized from source 8 which may be a direct current prime source or a direct current source comprising an alternating current prime source with regulator and rectifier. The energizing circuit goes from the positive terminus of this source through the frequency determining circuit made up of inductance L_2 and variable capacitance $C_{VAR.}$, thence through the internal anode-cathode path to ground 7 and to the negative terminal of the source 8 which, also, is grounded. The cathodes of all of the tubes are shown diagrammatically but it is obvious that they may be connected, as in accordance with conventional practice, so as to receive energy from the anode battery 8 or they may be separately excited. The alternating current output circuit comprises the above-identified frequency determining circuit and the by-pass condenser C connected between the frequency determining circuit and the cathode.

The alternating current input circuit comprises coupling coil L_1 connected between the control electrode 3 and the grounded cathode. The showing of the tube circuits is devoid of the details which would be comprised in a practical circuit, this in the interest of a more teachable disclosure; for instance, the grid or control electrode 3 may well have some means associated with it for determining a steady biasing potential as in accordance with a choice of several conventional practices in that regard. The coupling between the coil L_2 and the coupling coil L_1 provides the requisite feedback with phase reversal, whereby there may be a perpetuation of continuous oscillations at a frequency determined by the resonant frequency of the circuit made up of elements L_2 and $C_{VAR.}$. The capacitance $C_{VAR.}$ is the sole element determining the variation of the characteristic frequency of the heterodyne oscillator as a whole although there might well be other variable capacitances and variable inductances for scale adjustment and the like. Alternatively, the frequency variation could be achieved by a variable inductance instead of by a variable capacitance. The variable capacitance here assumed could well take the form of any one of a choice of conventional variable air condensers with manual operating means. The suppressor grid 5 is shown conventionally directly connected to the cathode and the screen grid 4 of the variable frequency oscillator is shown conventionally directly connected to the anode source.

The screen grid of the fixed oscillator is, like the corresponding element of the variable oscillator, connected to the common anode source 8 but, instead of being directly connected to the positive terminus thereof, it is connected through contactor 12 to the potentiometer resistance 10 intermediate its ends, said resistance being connected, as shown, effectively directly across the source 8 and preferably in series with an impedance, like resistance 11, for conditioning the resistance 10 with reference to the function of varying the potential of the screen grid of the fixed frequency oscillator by movement of the contactor 12 along said resistance. This resistance 10, or at least the portion of it included in the circuit of the screen grid is the impedance referred to in the statement of invention as determining the potential thereof and therefore the output volume of the fixed oscillator and, likewise, by derivation, the output volume of the oscillator as a whole. In satisfaction of this function, it could be varied considerably from

the specific form disclosed. In the circuit shown, the alternating current path to ground from this grid is exclusive of this impedance which, since it carries only direct current, comprises resistance only. Obviously there could be a common impedance or network for the alternating and direct currents and this might result in a considerable change in the character of the screen grid potential determining impedance. As will be presently described, this variation of the screen grid potential of the fixed frequency oscillator is made use of in accordance with the invention to maintain the output substantially constant with variation of frequency.

The output energy of the component oscillators is impressed on the modulator by the connections shown from the input circuits thereof to the respective control electrodes. A resistance, like resistance R, is used in the connection of each said component oscillator to limit and determine the potentials impressed on the input electrodes of the modulator. Such connections may be made to the component oscillator circuits in other ways than as shown, as in accordance with conventional practice. Likewise, the connections may be made to the modulator in other ways than as shown. The modulator shown and the connection thereto whereby the circuits from the effective component oscillators are conjugately related, conform closely to the circuit of the patent to Carson 1,343,307, June 15, 1920. The showing here is fragmentary as to detail. The filter and amplifier following the modulator may be of conventional character and are conventionally used. A further description seems to be unnecessary.

The invention principally inheres in the relationship between the frequency varying means, here disclosed as the variable condenser C_{VAR}, and the variable impedance represented by that portion of resistance 10 included in the circuit with the screen grid of the fixed frequency oscillator. The movable elements of these means are mechanically coupled so as to operate integrally except that the variation of the impedance must be such, as determined by the proper design of the mechanical coupling means, that the law of variation of the screen grid potential as determined by the impedance is such as to maintain the volume of the waves in the output of the circuit as a whole and therefore in the output of the modulator, and preferable at the output of the amplifier, substantially constant as the frequency is varied. By proper design of the cam the volume could be maintained constant at other points alternatively.

Since the showing in Fig. 2 relates only to a slightly different aspect of the mechanical movement and necessarily related circuits as disclosed in Fig. 1, and since the figure discloses the same elements similarly labeled, it is unnecessary to separately describe this structure with reference to the two figures individually. The description which follows is equally applicable to the two figures.

The linkage, that is mechanical coupling, between said resistance and the operating member of variable capacitance C_{VAR}, comprises the following elements in the order of their occurrence beginning with resistance 10. The contactor element 12 whereby a variable portion of resistance 10 is placed in circuit with the grid of the fixed frequency oscillator is driven by gear 15 pivoted at 13, and is actuated by rack 16 through shaft 14. The rack 16 is in turn actuated by the cam

18, the profile of which determines the law of variation of the screen grid potential and therefore is the principal ingredient in the achievement of the resultant constancy of volume. This cam, the variable condenser C_{VAR}, and the manual operating member therefor and the dial 17 for indicating the frequency are integrally connected through shaft or spindle 19.

It is apparent that by an adequate design of the mechanical movement constituting the coupling between the frequency varying means and the volume controlling means, especially as relating to the cam 18, substantial constancy of volume may be maintained while the frequency is varied through any desired range. Furthermore, the design of this mechanical movement is not at all exceptional except as applied to this particular function and, as depending mostly on the profile of the cam, the design to achieve the desired result may be achieved empirically with little difficulty. It is also apparent that the principle of the invention, as relating to the linkage of the two variable elements may be applied to a single unit oscillator as distinguished from the heterodyne oscillator disclosed, although it has special significance when used in a heterodyne oscillator.

Although only one specific circuit arrangement of the invention has been illustrated with certain suggestions as to variances therefrom, it is to be understood that the invention is not to be limited to the particular arrangement so illustrated or as otherwise disclosed, but covers all such modifications and rearrangements as fall within the scope of the appended claims.

What is claimed is:

1. In an oscillation generating circuit, an electron tube amplifying device having input and output electrodes including an electrode common thereto, and an additional electrode the potential on which determines the amplitude of the generated wave, input and output circuits therefor together with means coupled therewith for determining the frequency of the generated wave, a fixed potential source for energizing said output electrodes, an impedance connected across said source, movable means to connect a variable portion of said impedance between said additional electrode and said common electrode for determining the potential on said additional electrode, and a single operative means to vary the frequency and actuate said movable means whereby a variation of frequency is attended by a substantial constancy of the amplitude of the generated wave.

2. An oscillation generator comprising an electron discharge device, input and output electrodes therein including an electrode common thereto, circuits coupling said output electrodes with said input electrodes to produce oscillations and including a movable frequency determining element, an electrode separate from said input and output electrodes, the potential on which relative to the potential on said other electrodes is a determinant of the volume of the generated wave, a fixed potential source for energizing said output electrodes, an impedance connected across said source, movable means to connect a variable portion of said impedance between said separate electrode and said common electrode for determining the potential of said separate electrode, and a mechanical linkage between said movable frequency determining element and said movable potential varying means whereby the volume

of the generated oscillations is maintained substantially constant with variation in frequency.

3. The combination specified in claim 2 in which the mechanical linkage comprises a rack, a gear engaged therewith for driving the impedance varying means, together with a cam which is integral with the movable frequency determining element and adapted to drive the rack, the profile of said cam being adapted to drive the rack, gear and impedance varying means according to such a law as to insure a substantially constant volume of generated oscillations as the frequency is varied.

4. A heterodyne oscillator comprising a variable frequency oscillator unit, a relatively fixed frequency electron discharge oscillator unit comprising oscillation generating cathode, anode and control electrodes, and a means for combining the waves from said unit oscillators, a movable frequency varying means associated with the variable frequency unit oscillator, an electrode in said fixed frequency oscillator additional to the said above electrodes, the potential on which relatively to said cathode determines the volume of the output wave of the oscillator as a whole, a

fixed potential source connected between said anode and cathode electrodes, an impedance connected across said source, movable means to connect a variable portion of said impedance between said additional electrode and said cathode for determining the relative potential on said additional electrode, and a coupling between said movable frequency determining means and said movable potential determining means, said coupling means being so constituted as to determine a law of relative movement of said respective movable means such that the volume of the output wave of the oscillator as a whole is maintained substantially constant as the frequency is varied.

5. The organization specified in claim 4, in which said coupling comprises a rack operatively connected to said potential varying means and a cam operatively connected to said frequency varying means, said cam having a profile predetermined by the necessary law of relation between said movable means to enable the achievement of volume constancy with frequency variation.

THADDEUS SLONCZEWSKI.