Jan. 17, 1939. J. W. CONKLIN ET AL 2,143,864

WIDE RANGE BEAT FREQUENCY GENERATOR

Filed May 20, 1937 2 Sheets-Sheet 1

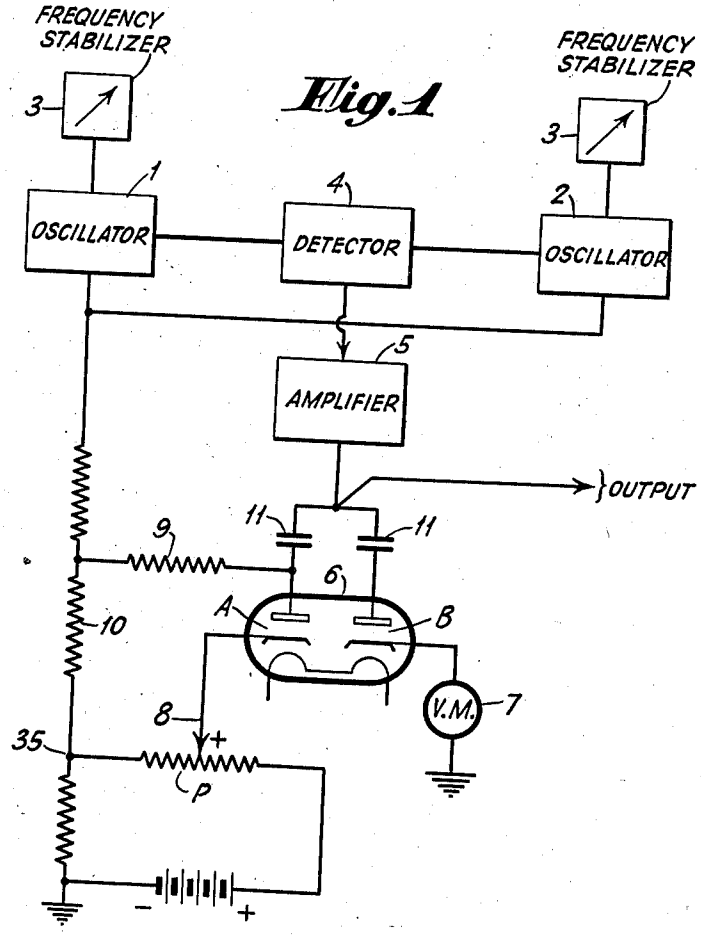


Fig. 1

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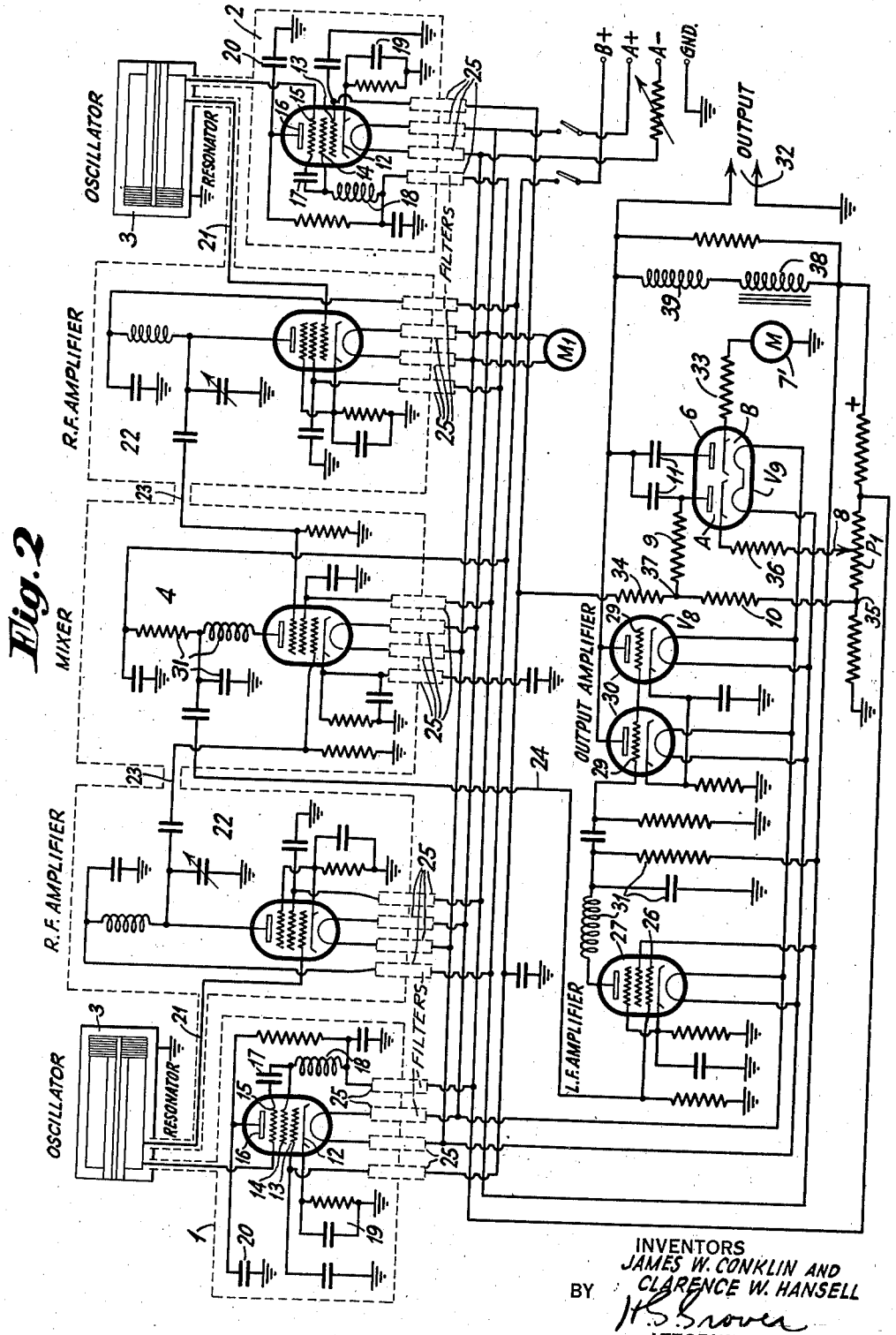


Fig. 2

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2,143,864

WIDE RANGE BEAT FREQUENCY GENERATOR

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Application May 20, 1937, Serial No. 143,666

8 Claims. (Cl. 250—36)

The present invention relates to a beat frequency generator for generating test frequencies over an unusually large frequency range, such as for use in testing television modulation equipment.

Beat frequency generators have long been known as a means for generating adjustable low frequency signals for various purposes. The designation "beat frequency generator" is obtained from the principle of operation in which two high frequency oscillators are caused to beat or modulate with each other for producing a low frequency beat note. This beat note may be varied over a wide percentage of frequencies by causing a small percentage variation of frequency of one or both of the beating oscillators. In such oscillators the resonant circuits are much smaller and more easily adjustable than are the oscillating circuits which are used to generate low frequencies directly, instead of by the beat method.

In applying the beat frequency generator principles to the generation of very high frequencies, such as are required for television test work, it is necessary to use very high oscillator frequencies in order that the frequency change involved be a small percentage of the oscillator frequency. One defect hitherto encountered is that high frequency oscillator circuits are, through various causes well known to the art, subject to conditions which would result in objectionable variations in the beat frequency. Another defect in known types of beat frequency generators, particularly where the output frequency covers an extremely wide range, lies in the variation in amplitude of the output signal coincident with the adjusted changes in frequency, an effect which arises from changes in the oscillation amplitude of the beating oscillators and changes in the efficiencies of the subsequent amplifying circuits.

One of the objects of the present invention is to provide a beat frequency generator capable of generating an extremely large range of frequencies, such as from 100 to 2,500,000 cycles per second, with satisfactory frequency stability.

Another object of the invention is to provide a beat frequency generator, the output voltage of which is substantially constant over the range of frequencies for which it is intended to be used.

In general, the invention comprises a pair of oscillation generators, each stabilized as to frequency by means of a resonant line circuit, the outputs of which are combined or intermodulated in a suitable frequency mixer or converter circuit. The resultant energy obtained from the frequency converter, which in reality is a beat note equal to the difference between the two oscillator frequencies, is passed on to a voltage amplifier from which, in turn, the amplified energy controls a suitable output amplifier. A portion of the energy from the output amplifier is in turn utilized to control the amplitude of the two individual oscillators.

A feature of the invention lies in the use of a double-diode electron discharge device, one-half of which is employed as a rectifier for indicating the output voltage, while the other half is employed to control the amplitude output of the individual oscillators.

A better understanding of the invention may be had by referring to the following description which is accompanied by drawings, wherein like parts are represented by like reference numerals.

In the drawings:

Fig. 1 illustrates diagrammatically, in box form, the essential features of the beat frequency generator of the invention; and

Fig. 2 illustrates in greater detail the preferred form of the beat frequency generator embodying the principles of the invention.

Referring to Fig. 1 in more detail, there are shown two beating oscillators of different frequencies, 1 and 2, each of which is stabilized as to frequency by a suitable stabilizer such as 3. Oscillators 1 and 2 may both or either of them be made variable as to frequency. The outputs of the oscillators 1 and 2 are passed into a frequency converter or mixer 4 where the energies intermodulate or beat to produce a suitable difference frequency in the output of the converter, which output frequency is in turn passed into an amplifier 5 from which the output energy is available for utilization purposes. A portion of the output energy, it will be noted, feeds into a double-diode rectifier 6, the right hand half of which, designated B, is in circuit with a direct current voltmeter 7 for indicating the output voltage, while the left hand half of the rectifier, designated A, is employed to maintain the output of the individual oscillators 1 and 2 substantially constant in amplitude despite non-linear characteristics present in the beat frequency generator and/or its load.

A constant output amplitude of the oscillators 1 and 2 is obtained in the following manner: The cathode of the A part of the rectifier 6 is maintained at a positive potential representing the desired beat output signal voltage, which potential is determined by the setting of the tap 8 of the potentiometer P. The presence of any voltage in the output of the amplifier 5 which exceeds the

positive potential applied to the cathode of A will produce a current flow in the resistances 9 and 10 of such value and in such sense as to bias the grids of the oscillators 1 and 2, in a manner shown in more detail in Fig. 2 to maintain constant the amplitude of output from the amplifier 5. At this time it should be noted that the cathode of part B of the rectifier 6 is in series with the direct current voltmeter 7 with respect to ground, and is unaffected by the adjustment of the potentiometer P, for which reason the voltmeter will continuously indicate the output from the amplifier 5 irrespective of the presence of voltages in excess of the positive voltage applied to the tap 8. Condensers 11, 11 are merely blocking condensers to prevent any direct connection between the output of the amplifier 5 and the anodes of the rectifier 6. A more detailed description of the operation of the system appears later.

The system of Fig. 2 illustrates a beat frequency generator comprising the two electron discharge device oscillators 1 and 2 each of which is stabilized as to frequency by means of a concentric conductor resonator 3 of the adjustable foreshortened type. Such a resonator is an adjustable tuned circuit constituting an inner conductor and an outer concentric conductor coupled together more closely at one of their adjacent ends than at the other. The inner conductor consists of two diameter sections, the smaller section of which acts in effect as an inductance while the larger section of inner conductor acts as a capacitance. Since this type of resonator does not form part of the present invention per se, and is adequately described in copending applications Serial No. 123,096 and Serial No. 133,614, filed January 30, 1937 and March 29, 1937, respectively, by James W. Conklin and Orville E. Dow, respectively, they will not be further described herein.

Oscillator circuits 1 and 2 are here shown as being negative transconductance electron discharge device pentodes, each having a cathode 12, a first grid 13, a second grid 14, a third grid 15, and an anode 16. Grid 13 is operated at zero or slightly negative potential while grid member 14 is at a high positive potential, the third grid 15 being at a negative potential, while the anode 16 is at a low positive potential. Under these conditions, the grid 14 functions as the primary anode, but since it is of mesh structure, part of the electrons pass through and are attracted to the slightly positive anode 16. If the grid 15 is given a sufficiently negative charge to overcome the velocity of the electrons, they will be caused to return to the grid 14, resulting in increased screen current. If we consider the grid 14 as the anode and the grid 15 as the control electrode, the resulting transconductance is negative, i. e., within a certain range of operation the current in grid 14 will decrease when the grid 15 is made more positive. A condenser 17 serves to tie grids 14 and 15 together for radio frequency potentials. Coil 18 is merely a shunt feed choke. A resistance and condenser combination 19 between the cathode 12 and ground is used to automatically bias the pentode for proper oscillation conditions. It will be noted that the concentric resonator is connected, in effect, between the grid 15 and the anode 16, there being a direct conductive connection from the inner conductor to the grid 15, and a connection through ground from the outer conductor of the resonator through a condenser 20 to the anode 16.

Output energy from each of the oscillators 1 and 2 is obtained from a suitable point on each of the concentric resonators 3 and passed through connections 21 to individual radio frequency amplifiers 22, 22 which, in turn, pass the amplified energy through suitable paths 23 to a pair of grids of a mixer or frequency converter tube of the pentode type, herein designated as a mixer 4. Suitable filters 25 in the direct current circuits of the individual oscillators, radio frequency amplifiers, and the detector circuit, serve to remove radio frequency currents from the direct current supply circuit, thereby preventing undesired intercoupling of the high frequency components of the beat frequency oscillator system. One type of filter which may be used, and given herein by way of example only, is described in copending application Serial No. 137,693, filed April 19, 1937, by J. W. Conklin. Since radio frequency amplifiers 22, 22 and mixer tube 4 are of a type well known in the art, further details thereof will not be given herein. To prevent intercoupling of the two oscillators 1, 2 with each other, there is provided suitable shielding for the electron discharge device circuits, for the amplifiers 22, 22, for the mixer 4, and for the interconnecting leads 21, 23, as shown. Otherwise there might be a tendency of one beating oscillator to pull the other oscillator into synchronism, particularly if the oscillators operate at frequencies very close to one another.

An advantage in the use of the resonant line over the conventional tuned circuit lies in its inherent shielding which makes it possible to reduce undesired coupling between the two beating oscillators 1, 2 to a minimum. Furthermore, the resonators 3, 3, by virtue of their inherent mechanical rigidity, due to the assembly of heavy metallic parts, enable greater freedom from mechanical vibration and mechanical changes in circuit connections than would normally be possible.

The radio frequency amplifiers 22, 22 serve not only to amplify the individual oscillator outputs of oscillators 1 and 2, but also act as buffer stages to minimize undesired intercoupling of the oscillators. These amplifiers are preferably class A radio frequency amplifiers. Mixer 4, it will be noted, is of the conventional electron-coupled type of bias frequency converter, which is used not only to produce intermodulation of the two amplified oscillator outputs but also to further reduce possible interaction of the two oscillators 1, 2.

The output of the mixer 4, comprising the beat note or difference frequency between the oscillators 1 and 2, is resistance coupled through connection 24 to the control grid 26 of a low frequency amplifier 27, the output of which is fed to the grids 29 of a pair of output amplifiers 30 arranged in parallel. A resistance-inductance-condenser combination 31 is used in the output coupling circuit of amplifier 27, and also in the output circuit of mixer 4, both to suppress any high frequency oscillator currents which may be present in these low frequency circuits and to obtain a substantially flat low frequency transmission characteristic over the desired range of output beat frequency. In other words, the circuit 31 is a coupling network, both between the mixer 4 and the low frequency amplifier 26, and between the amplifier 27 and the amplifier 30. The two electron discharge de-

vices of the output amplifier 30 are arranged in parallel to provide a lower effective internal resistance for the final output circuit 32, because circuit 32 is a lower impedance circuit.

For the purpose of maintaining the output amplitude of the beat frequency oscillator constant and for indicating the output voltage, there is provided a double-diode rectifier 6 which is capacitively coupled by means of condensers 11, 11 to the anode of the output amplifier 30. Rectifier 6 has two sets of elements A and B, one of which, namely B, cooperates with a resistance 33 and an ammeter 7' to indicate the voltage of the output. The other set of elements, namely A, includes resistance 9, one terminal of which is connected to its associated anode of the rectifier and the other terminal of which is connected through resistance 34 in common to the control grids 13, 13 of the two oscillators 1 and 2, and through resistance 10 to a point 35 on the potentiometer P. The cathode of the A set of elements of the rectifier 6 is maintained at a predetermined positive potential by means of tapping connection 8 through a resistance 36. When the output voltage appearing between the anode and the cathode of A exceeds a predetermined bias potential, the rectifier portion A becomes conductive on the positive peak, resulting in an equalizing current through resistors 9 and 10. The resulting current through resistors 9 and 10 produces a reduced potential at point 37, which point (being common to the oscillator grids 13, 13) results in a more negative control grid potential on these oscillator devices 1 and 2. Applying a more negative potential on the control grid 13, 13 of oscillators 1 and 2, reduces the amplitude of oscillation, resulting in a substantially proportionate reduction in amplitude of the final output of the beat frequency generator available at 32. Putting it another way, the function of this automatic control circuit is to maintain an amplitude of oscillations in oscillators 1 and 2 which will result in a final output peak voltage at 32 barely exceeding the predetermined positive bias potential applied to the cathode of portion A.

The function of resistor 34 is to produce a time delay in the operation of the control circuit in order that the speed of operation of the control circuit will be considerably lower than the lowest output frequency to be required. The purpose of resistor 36 is to prevent peak currents of excessive value in portion A of rectifier 6. If this resistor was not present, portion A of rectifier 6 would pass peak currents of sufficient magnitude to seriously distort the wave form of the output signals. A pair of choke coils 38 and 39 are employed in series with the positive lead with the potentiometer P for preventing the high frequency current from entering the current supply leads. Choke coil 38 is of the iron core type and prevents relatively low frequencies from entering the current supply while choke coil 39 is of the air core type and serves the same purpose for the higher frequencies.

An advantage of the present invention is that there is obtainable a beat frequency generator capable of generating an extremely large range of frequencies of from about 100 to 2,500,000 cycles per second. Such an extremely wide range is attributable in part to the use of frequency stabilizers of the concentric conductor type, which make practical the adaptation of ultra high frequency oscillators to beat frequency oscillator application. Ultra high frequency oscillators with conventional forms of tuned circuits do not possess sufficient stability to produce a satisfactory beat note at very low frequencies. It is an object of the beat frequency oscillator herein described to furnish very stable output frequencies over the entire range.

It is to be distinctly understood that the invention is not limited to the precise arrangements illustrated and described in the specification, since various modifications may be made in the various elements of the system without departing from the spirit and scope of the invention. For example, if desired, the electron discharge device oscillator circuits 1 and 2 may comprise other types of oscillation generators than the negative transconductance device described.

What is claimed is:

1. A beat frequency generator for generating alternating current energy of constant amplitude over a frequency range at least 2,000,000 cycles wide, comprising two electron discharge device sources of radio frequency oscillations, inherently shielded resonant line circuits, at least one of which is tunable over a range of frequencies, for stabilizing the oscillations of said sources, a radio frequency amplifier for amplifying the output of each of said sources, a mixer device for combining the outputs of said amplifiers to produce a beat frequency, shielding means for each of said sources of oscillations, for each of said amplifiers, for said mixer device, and for the connections between said elements, and means responsive to energy of said beat frequency exceeding a predetermined peak value for automatically controlling both of said electron discharge device sources of oscillations to produce substantial constancy of output.

2. A beat frequency generator for generating alternating current energy of constant amplitude over a large frequency range, comprising two electron discharge device sources of radio frequency oscillations, each including a control grid, inherently shielded low-loss resonant circuits for stabilizing the frequency of said sources, a mixer device for combining the outputs of said sources to produce a beat frequency, a low frequency amplifier for amplifying said beat frequency, a rectifier having its anode coupled to the output of said amplifier and its cathode maintained at a predetermined positive potential relative to ground, and a connection from the anode of said rectifier to the control grids of said sources of oscillations, whereby beat frequency energy whose peak amplitude exceeds the value of said predetermined potential automatically controls the bias of said control grids to produce substantial constancy of output.

3. A beat frequency generator comprising a pair of negative transconductance electron discharge device oscillators, at least one of which is tunable over a range of frequencies, each of said oscillators comprising a pentode having first, second, and third grids, and an anode, means for maintaining said first grid at a potential which is not positive with respect to said cathode, said second grid at a high positive potential, said third grid at a negative potential, and said anode at a low positive potential relative to said cathode, an inherently shielded low loss resonant circuit coupled to the anode and third grid of each of said oscillators for stabilizing the frequency of oscillations, a mixer device for combining the outputs of said oscillators to produce a beat frequency, shielding means for each of said oscillators and

for said mixer, a rectifier in the output of said mixer, and a connection from said rectifier to the first grid of each of said oscillators, whereby beat frequency energy whose peak value exceeds a predetermined amount controls the bias on said first grids to change the amount of negative transconductance exhibited by said oscillators in a direction to produce substantial constancy of output.

4. A beat frequency generator in accordance with claim 2, characterized in this that said rectifier is a twin diode, one portion of which is connected to a meter arrangement for indicating the voltage output of said generator, while the other portion is connected to the first grids of said oscillators.

5. A beat frequency generator for generating alternating current energy of constant amplitude over a large frequency range, comprising two electron discharge device sources of radio frequency oscillations, each including a control grid, inherently shielded low-loss resonant circuits for stabilizing the frequency of said sources, a mixer device for combining the outputs of said sources to produce a beat frequency, a low frequency amplifier for amplifying said beat frequency, a rectifier having its anode coupled to the output of said amplifier and its cathode maintained at a predetermined positive potential relative to ground, and a connection from the anode of said rectifier to the control grids of said sources of oscillations, whereby beat frequency energy whose peak amplitude exceeds the value of said predetermined potential automatically controls the bias of said control grids to produce substantial constancy of output, said connection including a time delay element in order to lower the speed of operation of the control circuit below the lowest output frequency of said generator.

6. A beat frequency generator for generating alternating current energy of constant amplitude over a frequency range at least 2,000,000 cycles wide, comprising two electron discharge device sources of radio frequency oscillations; inherently shielded resonant line circuits, at least one of which is tunable over a range of frequencies, for stabilizing the oscillations of said sources; a radio frequency amplifier for amplifying the output of each of said sources; a mixer device for combining the outputs of said amplifiers to produce a beat frequency; shielding means for each of said sources of oscillations, for each of said amplifiers, for said mixer device, and for the connections between said elements; and means responsive to energy of said beat frequency exceeding a predetermined peak value for automatically controlling both of said electron discharge device sources of oscillations to produce substantial constancy of output, said means including a rectifier having an anode coupled to the mixer device and an associated cathode connected to a source of potential at a point arranged to maintain said cathode at a predetermined positive potential relative to ground.

7. A beat frequency generator comprising a pair of negative transconductance electron discharge device oscillators, at least one of which is tunable over a range of frequencies, each of said oscillators comprising a pentode having first, second, and third grids, and an anode; means for maintaining said first grid at a potential which is not positive with respect to said cathode, said second grid at a high positive potential, said third grid at a negative potential, and said anode at a low positive potential relative to said cathode; an inherently shielded low-loss resonant circuit coupled to the anode and third grid of each of said oscillators for stabilizing the frequency of oscillations, each of said low-loss resonant circuits comprising an outer conductor and a coaxial inner conductor coupled together at one of their adjacent ends more closely than at their other ends, a connection from each of said inner conductors to the third grid of its associated oscillator, a connection from each of said outer conductors to the anode of its associated oscillator, an amplifier for each oscillator, a connection from the inner conductor of each low-loss resonant circuit to the amplifier associated with its oscillator, a mixer device for combining the outputs of said amplifiers to produce a beat frequency, shielding means for each of said oscillators and for said mixer, a rectifier in the output of said mixer, and a connection from said rectifier to the first grid of each of said oscillators, whereby beat frequency energy whose peak value exceeds a predetermined amount controls the bias on said first grids to change the amount of negative transconductance exhibited by said oscillators in a direction to produce substantial constancy of output.

8. A beat frequency generator for generating alternating current energy of constant amplitude over a frequency range at least 2,000,000 cycles wide, comprising two electron discharge device sources of radio frequency oscillations; inherently shielded resonant line circuits, at least one of which is tunable over a range of frequencies, for stabilizing the oscillations of said sources; a radio frequency amplifier for amplifying the output of each of said sources, each of said shielded resonant line circuits having an outer and a coaxial inner conductor, and a connection from a point on said inner conductor to its associated radio frequency amplifier; a mixer device for combining the outputs of said amplifiers to produce a beat frequency; shielding means for each of said sources of oscillations, for each of said amplifiers, for said mixer device, and for the connections between said elements; and means responsive to energy of said beat frequency exceeding a predetermined peak value for automatically controlling both of said electron discharge device sources of oscillations to produce substantial constancy of output.

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