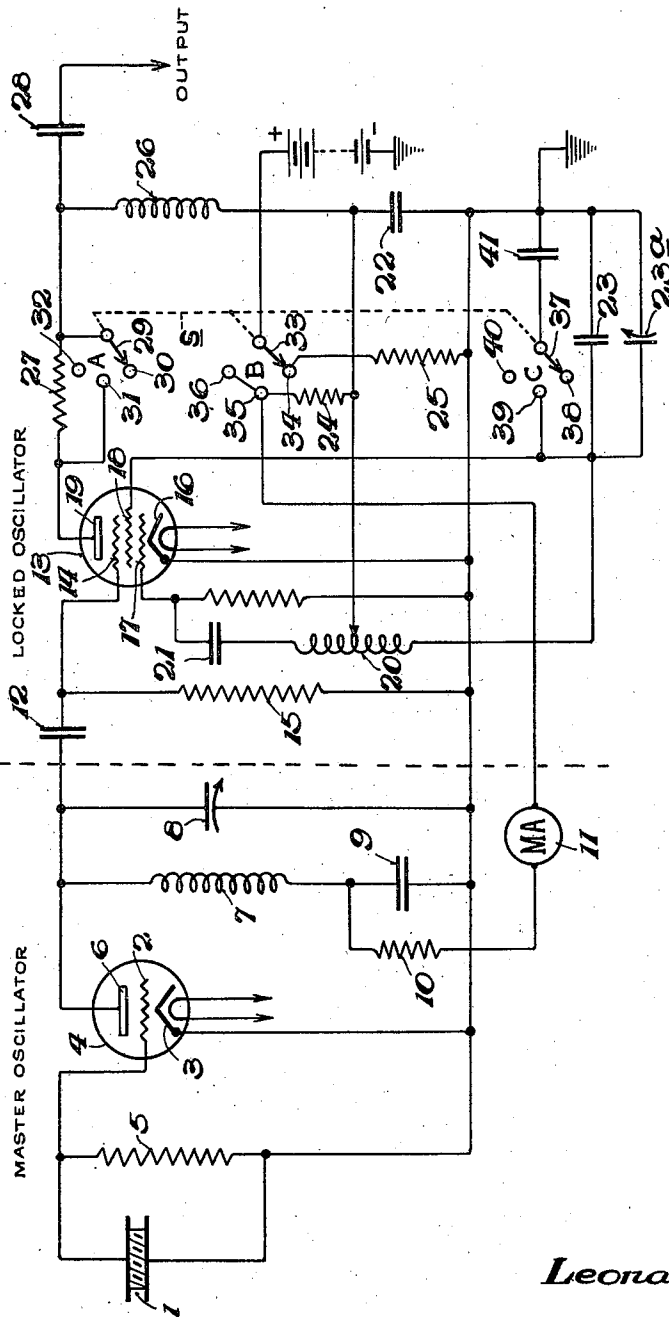


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OSCILLATING SYSTEM

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1 Claim. (Cl. 250—36)

This invention relates to oscillation generators for producing harmonic or subharmonic frequencies, and more particularly to a system incorporating a locked oscillator, in which the output frequencies are maintained against shifting by an applied reference frequency of high accuracy.

It is known in prior art practice to stabilize the frequency of an oscillator by feeding into the circuit the output of a crystal oscillator or other form of closely regulated reference frequency. A stabilized subharmonic of the reference frequency is obtained by utilizing an oscillator to produce a complex wave whose fundamental frequency is normally approximately that of the desired subharmonic frequency and which has a harmonic approximately equal to the reference frequency. The current of the reference frequency is caused to coast with the current of the designated harmonic frequency in the oscillating circuit of the oscillator. The effect of such coaction on the oscillator is to pull it into step with the impressed reference frequency, that is, to cause the reference frequency and the designated harmonic frequency to coincide. The fundamental frequency is thus correspondingly automatically adjusted to exact subharmonic relationship with the reference frequency.

Locked oscillator systems of this type are customarily employed in critical applications demanding close frequency regulation. In instances where the source of reference frequency fails or where the oscillator falls out of step with the reference frequency, there is usually no warning of such a condition. The output of the normally controlled oscillator continues without control in fact, and the component frequencies may drift appreciably. If the oscillator has been employed as a calibration standard or in a frequency meter, the error may have serious consequences.

The invention to be disclosed will illustrate a system in which a crystal controlled master oscillator excites a locked oscillator operating at a fundamental frequency which is a subharmonic of the master oscillator frequency. Where the system is to be employed in frequency measuring devices, it is desirable to have harmonics appear in relatively close order to insure accuracy and minimize the necessity for interpolation. Close spacing of harmonics requires a fairly low fundamental frequency, perhaps on the order of 20 kilocycles, and a crystal of this frequency is usually bar cut and is somewhat erratic in performance under small changes in temperature. For this reason it is preferable to employ a mas-

ter oscillator having a crystal frequency of 100 kilocycles or higher, so cut as to be less affected by temperature changes, and to use its output to stabilize the lower frequency oscillator.

One outstanding feature of this invention is that the master oscillator must be functioning in order to derive any output of useful amplitude from the locked oscillator. In the absence of a master oscillator signal, the locked oscillator reverts to a feebly oscillating condition and the output becomes so small that it is no longer useful for such purposes as required by heterodyne frequency meters or frequency meters or frequency calibration equipment. The harmonic frequencies are always of less amplitude than the fundamental and in this case they virtually disappear. Thus there is produced in effect an automatic shutdown of the apparatus when there is a failure of the primary frequency standard.

Another important feature of the invention is that the locked oscillator may be converted by a simple switching operation to a non-oscillating condition and be employed as a non-linear amplifier, known as a distortion amplifier. The output then comprises the fundamental frequency of the master oscillator plus a series of higher order harmonics, due to the non-linearity of the amplifier.

One of the principal objects of the invention is to provide an improved oscillator system which is more accurate in operation and more flexible in application.

Another object is to provide a novel form of oscillator system which will furnish a positive indication of improper functioning of frequency determining components.

Still another object is to provide an improved oscillator system in which one of the component elements may selectively function as an oscillation generator or as a non-oscillating distortion amplifier having a non-linear plate current characteristic.

Other objects and advantages will in part be specifically set forth and in part be obvious when the following specification is read in connection with the drawing in which:

The single figure of the drawing is a schematic diagram of the improved oscillator system and is to be considered only as illustrating a present preferred embodiment of the invention without, in any sense, constituting a limitation in scope.

Referring in more detail to the drawing, the numeral 1 indicates a piezo-electric crystal connected between the control grid 2 and cathode 3 of the master oscillator tube 4. A high resistance

grid leak 5 is in shunt with the crystal 1. The anode 6 of the master oscillator tube is connected to a parallel tuned circuit comprising an inductance 7 and a variable condenser 8, by means of which the anode circuit may be tuned to present an inductive reactance at the frequency of the crystal 1. A bypass condenser 9 is connected between the low potential end of the inductance 7 and ground, and potential is supplied to the anode 6 through a voltage dropping resistor 10 connected to a point between the inductance 7 and bypass condenser 9. A milliammeter 11 is placed in the anode supply circuit to indicate operation of the master oscillator tube 4.

The output of the master oscillator is led through a coupling condenser 12 to a triple grid tube 13 and connected to the injector grid 14 thereof. In this instance the injector grid is the grid positioned farthest from the cathode. A grid leak 15 of high resistance is connected between the injector grid 14 and ground. The oscillator portion of the tube 13 comprises the cathode 16, the first grid 17, and the second grid 18 which serves as the anode of the oscillator section. The anode proper of the tube is indicated at 19, and constitutes a collector element for the space current flowing in the tube. The oscillation circuit comprises a center tapped inductance 20 effectively connected for alternating current to the first grid 17 through a coupling condenser 21. For alternating current, the center tap of inductance 20 is effectively grounded through the plate bypass condenser 22. As illustrated, the upper portion of the inductance 20 comprises the grid inductance, and the lower portion comprises the plate inductance, being connected at the lower end to the effective anode of the oscillator section, namely, the second grid 18. The plate portion of the inductance is tuned by the condenser 23, which is shunted by the variable trimmer condenser 23a. It is apparent that the tuning condenser 23 may also be variable if desired. The second grid 18 and the anode 19 receive operating potential through the voltage dropping resistor 24 which is connected in the power supply circuit. A bleeder resistance 25 maintains a suitable load on the power supply during standby periods. The anode 19 receives supply voltage through a choke coil 26 and a filter resistance 27, and an output coupling condenser 28 passes the alternating current component of the system to any desired utilization means.

Control of the apparatus is effected by a three section, three position gang switch, indicated generally as S. The sections A, B, and C, are operated in unison by a single control member, as schematically indicated by the dotted lines leading to the respective sections. Section A comprises a wiper 29 and contacts 30, 31 and 32. When the wiper 29 engages contact 31, a shunt circuit is completed around the filter resistor 27. The contacts 30 and 32 are idle, having no circuit connections. Section B has a wiper 33 and contacts 34, 35 and 36. The contact 34 is connected through the bleeder resistance 25 to ground. The anode circuit of the master oscillator 4 connects directly to the contact 35, while the anode 19 and second grid 18 of the tube 13 are connected through the voltage dropping resistor 24. Contact 36 is connected directly to contact 35. The switch section C comprises a wiper 37 and contacts 38, 39, and 40. The contacts 38 and 40 are idle, however, engagement of the wiper 37 and contact 39 connects an oscil-

lator detuning condenser 41 of relative large capacity in parallel with the tuning condenser 23 and trimmer condenser 23a.

As an aid in explaining the operation of the invention it will be assumed that the crystal controlled master oscillator is tuned to a frequency of 100 kilocycles per second, and that the locked oscillator which is controlled by the former is tuned to approximately 20 kilocycles per second. The 100 kilocycle frequency appears on the injector grid 14 of the locked oscillator tube 13 and is coupled only through the electron stream of the tube to the 20 kilocycle circuit. This mode of coupling insures that changes of loading will not be reflected back to the master oscillator and that currents through the crystal will not become excessive. Assuming that the locked oscillator has been tuned initially to a frequency in the close vicinity of 20 kilocycles, the fifth harmonic will be close to 100 kilocycles. The crystal stabilized 100 kilocycle output of the master oscillator will then coact with the fifth harmonic of the locked oscillator and draw it into exact coinciding relationship. The controlled frequency is thus locked in step with the master reference frequency and the derivation of the expression locked oscillator is apparent. By this action the fundamental and the lower harmonic frequencies of the locked oscillator are pulled into an exact submultiple relationship and the higher harmonics of the 10th, 15th and 20th order, and so on, become exact multiples of the 100 kilocycle master frequency. The expression "harmonically related" as employed in the claims is intended to include the foregoing mathematical relation between the reference frequency and the controlled frequencies produced by the locked oscillator.

When the wiper arms of the switch S are in upper position, namely, engaging the contacts 22, 36 and 40, the tube 13 is tuned to oscillate at approximately 20 kilocycles by the frequency determining circuit including tuning condenser 23 with its shunt trimmer condenser 23a and the plate portion of inductance 20. The coupling condenser 21 is of such low value that the tube 13 will oscillate very feebly and erratically when no master frequency is applied to the injector grid 14. The master oscillator frequency appearing on the injector grid 14 is much larger in amplitude than is the output of the locked oscillator in the absence of this control frequency. Thus the master oscillator in effect bolsters up the performance of the locked oscillator. Upon failure of the master frequency source, the output of tube 13 is so reduced in amplitude that no usable signal remains. Thus, the effective output of the system ceases in the absence of a stabilizing master reference frequency, and there is no possibility of obtaining a frequency outside of the control range imposed by the crystal.

With the switch S in intermediate position, the tube 13 no longer oscillates. It becomes instead a non-linear amplifier for the 100 kilocycle master oscillator, exhibiting this fundamental frequency and a series of related harmonics in the output circuit. The changeover is accomplished by the connection through contact 39 of switch section C of the large capacity detuning condenser 41. The capacity of this condenser is such that when it is placed in parallel with the tuning condenser 23 and the trimmer 23a, the total capacity of the three condensers is large enough to prevent the establishment of an os-

cillating condition in the circuit. At the same time there is established through contact 31 of switch section A a shunt circuit around the filter resistance 27, and a more favorable energy transfer results for the 100 kilocycle frequency.

When the switch S is in the lower position, the sections A and C are on idle contacts 30 and 38, respectively. Section B removes anode supply potential from both tubes and through contact 34 connects in a bleeder resistance 25 which maintains an equivalent drain on the power supply. Voltage fluctuations are thus prevented in case other apparatus is concurrently powered from the same source.

In the ordinary usage of an oscillator system of the described type as a frequency calibration device or as a heterodyne frequency meter, the outputs of the oscillator and the device to be calibrated or measured are combined in a non-linear mixing device and adjustments are made to produce a zero beat condition between them. In case the tuning of the locked oscillator deviates too widely from 20 kilocycles, the locked oscillator will pull out of step with the master oscillator and will be without control.

If this happens under the above stated usages, the operator is warned immediately by a fixed frequency, audible howl which overrides all other indications, and which can be eliminated only by adjusting the trimmer condenser 23a to bring the tuning closer to 20 kilocycles. The howl diminishes in pitch as this is done, and disappears when the normal locked relation of the oscillators is resumed. It is believed that this howl results from a beat developed between

the master frequency and the proximate fifth harmonic of the controlled frequency when they fall out of step. The presence of the non-linear mixing device renders the howl audible at the difference frequency of the two signals.

The oscillator system comprising this invention may obviously be used to advantage in radio transmitting apparatus where operation on any of several frequencies in harmonic relation is desired.

While the invention has been illustrated and explained in a preferred embodiment, it is apparent that many different uses and applications may readily be conceived, each with attendant advantages appertaining to this invention, and many changes and modifications may be made by anyone skilled in the art without departing from the spirit and scope of the invention as defined in the following claim.

What is claimed is:

In an oscillation system, a source of reference frequency, a multi-element space discharge tube, a frequency determining circuit connected to three elements of said tube and comprising an oscillator section, said circuit being tuned to a frequency in harmonic relation with said reference frequency, a fourth element in said tube connected with said source of reference frequency and arranged to modulate the electron stream in said tube, an anode in said tube being connected to an output circuit, and selectively controlled circuit means for reducing said oscillator section to a non-oscillating condition whereby said tube is converted into a distortion amplifier.

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