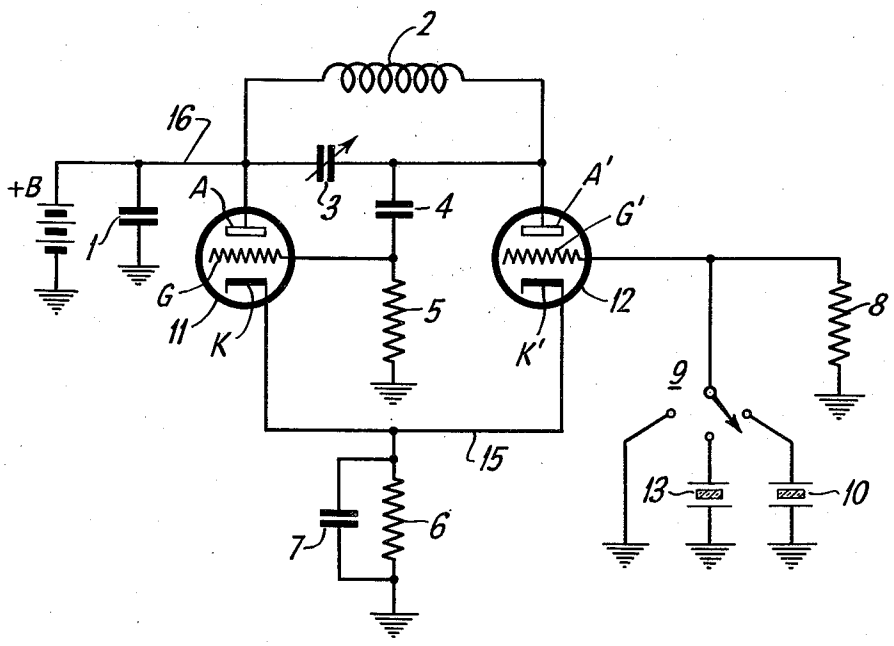
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VARIABLE FREQUENCY OSCILLATOR

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## VARIABLE FREQUENCY OSCILLATOR

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The present invention comprises an improved oscillator, and particularly a variable frequency oscillator having circuits for controlling the frequency thereof by means of piezo-electric crystals.

Heretofore, it has been customary to use either a variable oscillator or a crystal controlled oscillator. Attempts to combine the variable oscillator with crystal controlled features have not been successful in the past because of the complicated switching circuits employed which tended to detract from the stable and reliable operation of the oscillator as an adjustable unit.

The foregoing difficulties are overcome by the oscillator of the present invention which employs only a simple switch having a single arm and a multiplicity of contact positions. One of these contact positions of the switch connects directly to ground, while the other contact positions of the switch enable the selection of any one of two or more crystals to be used.

A detailed description of the oscillator of the invention follows, in conjunction with a drawing whose single figure illustrates two triode electron discharge devices 11 and 12. Tube 11 has an anode A, a grid G and a cathode K. Tube 12 has an anode A', a control grid G' and a cathode K'. Anodes A and A' are connected to opposite sides of a two-terminal parallel tuned circuit composed of an inductance 2 and a variable tuning condenser 3. The anode of tube 12 is connected to the control grid of tube 11 by coupling condenser 4. This control grid of tube 11 is maintained at substantially ground potential by resistor 5. The two cathodes of these tubes are connected together by lead 15 and are connected to ground through common cathode resistor 6, in turn, bypassed for radio frequency energy by compensating condenser 7. The positive terminal of a source of unidirectional anode voltage +B is connected to the anode of tube 11 by lead 16 and bypassed to ground by condenser 1. This same positive terminal supplies anode voltage to tube 12 through inductance 2. The control grid of tube 12 connects to the movable arm of a single pole multi-throw (multi-contact position) switch 9 and to resistor 8. Two of the contacts of switch 9 have associated therewith separate piezo-electric crystals 10 and 13 having different frequencies of operation. One terminal of resistor 8 is connected to ground. Resistors 5 and 8 are "grid leaks" and have a value of the order of 1 megohm. Although separate vacuum tubes have been shown, it should be understood that both triode electrode structures can be enclosed

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in a single evacuated envelope, and that, if desired, multi-grid tube structures can be employed instead of triodes.

When the arm of switch 9 is in the left hand or ground position, the oscillator becomes a variable frequency oscillator. The voltage which is applied to grid G of tube 11 is fed to the cathode circuit of tube 12. Utilizing the cathode circuit of tube 11 as an output circuit results in 100% inverse feedback and the voltage applied to the grid G of tube 11 appears unamplified on its cathode. Due to this high degree of inverse feedback, the grid of tube 11 may be swung over a wide range of voltages without drawing grid current so that the impedance presented to the tuned circuit 2, 3 by the grid is that of a negative biased or class A grid which is very high. In order to produce sustained oscillations, the feedback voltage fed from the tuned circuit 2, 3 is fed through the grid G of tube 11 through blocking condenser 4. This feedback voltage must be fed back to the grid G' of tube 12 with 180° phase reversal in order to produce oscillations. This is readily accomplished due to the fact the common cathode resistor 6 effects such reversal. A positive voltage on the grid G of tube 11 causes more current to flow through the cathode resistor 6 and thereby makes both cathodes K and K' more positive. The cathode K' of tube 12 becoming more positive is equivalent to the grid G' becoming more negative. Thus, a positive change on the grid G of tube 11 is equivalent to a negative voltage change on grid G' of tube 12 and the required 180° phase reversal is obtained. Tuned circuit 2, 3 is tuned to the required frequency of oscillation.

In one embodiment of the variable oscillator which was capable of being continuously tuned in a frequency range between 5 and 10 megacycles, it was found that condenser 7 greatly improved the constancy of the radio frequency output voltage.

Now if, by means of condenser 3, this oscillator is tuned to a frequency somewhat higher than the nominal frequency of a piezo-electric crystal 13 and switch 9 turned so as to connect piezo-electric crystal 13 to the control grid of tube 12, the oscillator will be controlled by this crystal. In a similar manner, another piezo-electric crystal 10 may be utilized or in fact, any number of piezo-electric crystals of different frequencies may be selectively inserted into the circuit, one at a time, merely by connecting the arm of switch 9 to the particular contact position in circuit with the crystal to be selected for controlling the frequency of the oscillator. When a crystal

is selected by the movement of the arm of switch 9, the precaution should be observed that the tuned circuit consisting of inductor 2 and condenser 3 be adjusted to a frequency somewhat higher than the nominal frequency of the crystal selected and to be used.

In the oscillator of the invention actually tried out in practice and which was tunable over a frequency range between 5 and 10 megacycles, it was found that this frequency adjustment higher than the nominal frequency of the crystal is not critical. Any setting of this frequency between a few hundred cycles above and a couple of megacycles above the crystal's nominal frequency will provide crystal control of the oscillator.

The term "ground" employed herein is deemed to be a point of reference potential and is not limited to an actual earthed connection.

What is claimed is:

1. An oscillator comprising first and second electron discharge electrode structures, each having an anode, a cathode and a grid, a variable frequency determining circuit having one terimal connected to the anode of said first structure and to the grid of the second structure, through a capacitor, a common resistor connecting said cathodes to a point of reference potential, means connecting the anode of the second structure to another terminal of said frequency determining circuit and to said point of reference potential for radio frequencies, a switch having a movable arm and a plurality of contacts, a direct current connection from said arm to the grid of said first structure, a direct connection from one of said contacts to said point of reference potential, whereby said oscillator operates as a variable frequency oscillator when said arm is on said one contact, and a piezo-electric crystal connected between another of said contacts and said point of reference potential, whereby the frequency of said oscillator is controlled by said crystal when said arm is on said last contact.

2. An oscillator comprising first and second electron discharge electrode structures each having an anode, a cathode and a grid, a two-terminal parallel turned circuit having a tuning element, connections from one terminal of said tuned circuit to the anode of said first structure and to the grid of said second structure through a capacitor, a resistor connecting the grid of said second structure to ground, a connection from the other terminal of said tuned circuit to the anode of said second structure, a connection of low impedance to radio frequency energy from the anode of said second structure to ground, a direct connection between said cathodes, a common direct current passing impedance between said last connection and ground, a bypass condenser in shunt to said common direct current passing impedance, a resistor connecting the grid of said first device to ground, a switch having a movable arm and a plurality of associated contacts adapted to be selectively engaged by said arm, a direct connection from said arm to the grid of said first structure, a direct current connection from ground to one of said contacts, whereby said oscillator operates as a variable frequency oscillator when said arm engages said one contact, and a crystal connected between another of said contacts and ground, said tuned circuit being tunable by said tuning element to a frequency above the nominal frequency of said crystal, whereby said oscillator is controlled by said crystal when said arm engages said last contact.



3. An oscillator comprising first and second thermionic discharge device electrode structures each having an anode, a cathode and a grid, a tunable resonant circuit coupled to the anode of said first structure and to the grid of said second structure through a capacitor, separate means for effectively maintaining the anode of said second structure and the grid of said first structure at ground potential for radio frequency energy, one of said means including a switch having a plurality of individually selectable contacts, and a connection from one of said contacts to ground, a direct connection between said cathodes, a common direct current passing impedance between said direct connection and ground, and a plurality of piezo-electric crystals having different frequencies of operation individually connected to different contacts on said switch other than said one contact, said tunable resonant circuit being tunable to frequencies higher than the nominal frequencies of said crystals.

4. An oscillator comprising first and second discharge device electrode structure each having an anode, a cathode and a grid, a parallel tuned circuit having a variable tuning element coupled between the anodes of said electrode structures, a capacitor coupling the anode of said first structure to the grid of said second structure, individual grid leak resistors between the grids of said electrode structures and ground, a bypass condenser coupling the anode of said second structure to ground, a common cathode resistor bypassed by a capacitor connecting said cathodes to ground, a source of anode polarizing potential coupled to the anode of said second structure, whereby the anode of said first structure is supplied with said polarizing potential through said tuned circuit, a switch having an arm directly connected to the grid of said first structure, a plurality of selectable contacts for association with said arm, a direct connection to ground from one of said selectable contacts, and a piezo-electric crystal connected between another of said selectable contacts and ground.

5. An oscillator comprising a pair of vacuum tube electrode sections each having an anode, a cathode and a grid, a resonant circuit coupled between said anodes, means for varying the effective frequency of said resonant circuit, means for capacitively coupling the grid of one of said sections to said resonant circuit, means coupling said cathodes together, an impedance connected from said cathodes to ground, a plurality of piezo-electric crystals of different frequencies, and switching means connected to the grid of said other section for selectively coupling any desired one of said crystals thereto.

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## REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

| Number | Name | Date |
|---|---|---|
| 2,066,027 | Braaten | Dec. 29, 1936 |
| 2,269,417 | Crosby | Jan. 6, 1942 |
| 2,323,956 | Yerian | July 13, 1943 |
| 2,441,570 | Glessner | May 18, 1948 |

OTHER REFERENCES

Wireless Engineer, November 1944, pages 521–26.