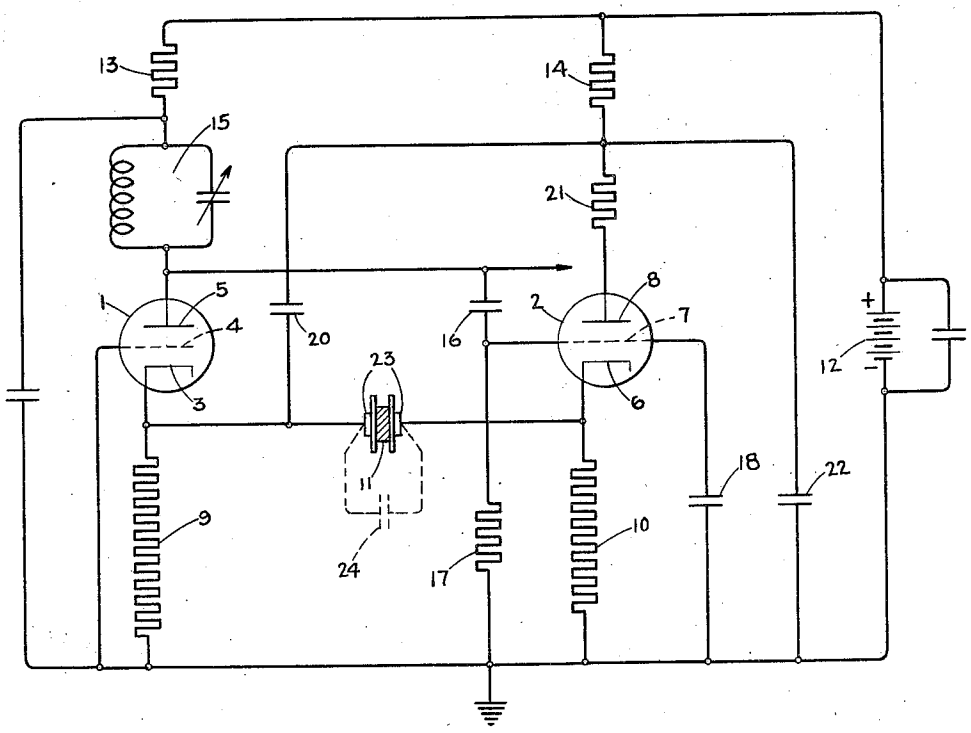
March 20, 1951 R. L. DOWNEY 2,546,027

NEUTRALIZED CRYSTAL OSCILLATOR

Filed May 28, 1949



Inventor:
Reginald L. Downey,
by Merton D Morse
His Attorney.

Patented Mar. 20, 1951 2,546,027

UNITED STATES PATENT OFFICE

2,546,027

NEUTRALIZED CRYSTAL OSCILLATOR

Reginald L. Downey, Syracuse, N. Y., assignor to General Electric Company, a corporation of New York

Application May 28, 1949, Serial No. 95,901

6 Claims. (Cl. 250—36)

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My invention relates to oscillation generators and more particularly to such generators in which the frequency is controlled by a piezoelectric crystal.

One type of such generator employs a pair of electron discharge devices and a circuit connection in which oscillations are supplied from the output of one of the devices through the other device to the cathode of the first device. A piezoelectric crystal is included in this connection to control the oscillations supplied through it and hence the frequency of oscillations generated.

One of the objects of my invention is to provide such a generator capable of operation over an extremely broad range of frequencies and in which the frequency of oscillations may be controlled at any frequency in the range by the crystal in said connection.

Commonly such crystals are mounted between the electrodes of a crystal holder, or they may be provided with electrodes plated upon the opposite surfaces of the crystal as described, for example, in Baldwin Patent No. 2,412,030, assigned to the same assignee as the present invention. The latter arrangement is commonly employed in the case of crystals operating at natural frequencies which are harmonics of a fundamental frequency of the crystal.

One of the objects of my invention is to provide such an oscillation generator in which the capacity between such electrodes is prevented from sustaining oscillations if the crystal becomes inoperative or is removed from the holder.

A further object of my invention is to provide means to neutralize the capacity between the electrodes of such a crystal.

The novel features which I believe to be characteristic in my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawing in which the single figure illustrates an embodiment of my invention.

Referring to the drawing, I have shown therein a pair of electron discharge devices 1 and 2. The discharge device 1 has a cathode 3, a control electrode 4 and an anode 5, while the discharge device 2 has a cathode 6, a control electrode 7 and an anode 8. The two cathodes 3 and 6 are connected to ground through respective cathode load resistances 9 and 10 and the cathodes are

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connected together by means of a piezoelectric crystal 11. This piezoelectric crystal may be of any of the usual types but frequently is one of the harmonic mode type such as is described in the above-mentioned Baldwin patent. Such crystals are commonly mounted between electrodes 23 in a suitable holder or are provided with electrodes which are plated upon the surface of the crystal. They operate at extremely high frequencies including frequencies which are harmonics of the fundamental frequency of the crystal.

Operating potential for the oscillator is supplied by a battery 12 to the anodes 5 and 8 of the two discharge devices through resistances 13 and 14, respectively. The anode circuit of discharge device 1 also includes a tuned circuit 15 which is resonant at the frequency of oscillations to be produced.

Oscillations generated in this circuit 15 are supplied through a coupling condenser 16 to the control electrode 7 of the discharge device 2. This control electrode 7 is connected to ground through a grid resistor 17 and also through bypass condenser 18.

Oscillations supplied through this coupling condenser 16 to grid 7 excite the latter discharge device and are reproduced thereby in the same phase upon resistance 10 connected between the cathode and ground. These oscillations are then fed back through the crystal 11 to the cathode 3 of discharge device 1 whereby they excite the latter discharge device to produce oscillations in the circuit 15. Such oscillations may be supplied to any desired load circuit, not shown, which may be coupled in any conventional manner, either inductively, capacitively, or both, to the circuit 15.

It is my desire to provide such a crystal oscillator which will operate at any frequency between 20 and 70 megacycles dependent, of course, upon the operating frequency of the crystal and the tuning of the circuit 15. It is also desired that in the event the crystal 11 becomes inoperative, as due to cracks or other imperfections therein, or in the event it be removed from the holder, any tendency of the system to continue generating oscillations be prevented. Sometimes it occurs, especially at the higher frequencies in the range, that due to capacity between the electrodes of the crystal (that is, the inherent capacity 24 represented in dashed outline between the platings on the crystal surface, or between the electrodes of the holder in which the crystal is mounted), the system continues to gen-

erate oscillations even if the crystal becomes inoperative or is removed from the socket.

Also, this interelectrode capacity 24 may permit oscillations at other than the desired crystal frequency when circuit 15 is incorrectly adjusted. In accordance with my invention, this is effectively prevented even at the highest frequencies in the operating range by the use of condenser 20 connected between the cathode 3 and the anode circuit of device 2. Resistances 14 and 21 are included in this anode circuit and are so proportioned relative to the capacitance of condenser 20 that oscillations supplied through the condenser to cathode 3 and to the electrode of the crystal adjacent cathode 3 neutralize oscillations supplied through the capacity 24 between the crystal electrodes. Since oscillations with respect to ground appearing upon the resistances 14 and 21 are of opposite phase to those appearing on resistance 10 with respect to ground, the oscillations supplied through condenser 20 are supplied to cathode 3 in opposite phase to those supplied through the capacity across the crystal. By properly proportioning the components of the circuit including condensers 20 and 22 and resistances 14 and 21, the desired neutralization may be effected.

It will be observed that discharge device 1 operates as a grounded grid amplifier, the grid electrode 4 being grounded and the cathode 3 being above ground due to resistance 9. The oscillations supplied to this amplifier are supplied to an input of low impedance and in phase with the amplifier output, which is supplied through the condenser 16 to device 2. Device 2 acts as an amplifier with a low impedance output which is supplied from resistance 10 to the crystal 11, this voltage being in phase with that supplied to grid 7. At the same time, it acts as a phase inverter to supply oscillations of opposite phase through condenser 20 to effect the desired neutralization.

While I have shown a particular embodiment of my invention, it will, of course, be understood that I do not wish to be limited thereto since different modifications may be made without departing from the spirit and scope of my invention, and I contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A crystal oscillator comprising a pair of electron discharge devices, each having an anode, a cathode, and a control electrode, a piezoelectric crystal, means impressing anode operating potentials on each of said devices through respective anode and cathode load impedances, means coupling the anode of one of said devices to the control electrode of the other, means regeneratively coupling the cathode of said other discharge device through said piezoelectric crystal to the cathode of said one discharge device so as to excite oscillations in said one device at the natural frequency of said crystal, and means to supply oscillations from the anode of said other device to the cathode of said one device in phase to neutralize oscillations supplied thereto through capacity effect across said piezoelectric crystal.

2. A crystal oscillator comprising a pair of electron discharge devices, each having an anode, a cathode, and a control electrode, a piezoelectric crystal, means impressing anode operating potentials on each of said devices through respective anode and cathode load impedances, means

coupling the anode of one of said devices to the control electrode of the other, means regeneratively coupling the cathode of said other discharge device through said piezoelectric crystal to the cathode of said one discharge device so as to excite oscillations in said one device at the natural frequency of said crystal, and a condenser connected between the anode of said other device and the cathode of said one device, said condenser being proportioned to neutralize the capacity across said crystal at a desired frequency.

3. A crystal oscillator comprising a pair of electron discharge devices, each having an anode, a cathode, and a control electrode, means coupling the anode of one of said devices to the control electrode of the other, a pair of resistances, each resistance being connected between ground and a respective one of said cathodes, means impressing anode operating potentials on each of said devices through respective anode impedances, means comprising a piezoelectric crystal connected between said cathodes for regeneratively coupling said devices for the generation of oscillations, and a condenser connected between the anode of said other device and the cathode of said one device having capacity of such value as to supply oscillations to said cathode equal in magnitude to the oscillations supplied through the connections to said crystal when said crystal is inoperative.

4. The combination in a crystal oscillator of a pair of electron discharge devices, each having an anode, a cathode, and a control electrode, means coupling the anode of one of said devices to the control electrode of the other, a pair of resistances, each resistance being connected between ground and a respective one of said cathodes, means impressing anode operating potentials on each of said devices through respective anode impedances, means comprising a crystal holder having opposite electrodes connected to said cathodes respectively and adapted to hold a piezoelectric crystal, said crystal regeneratively coupling said devices for the generation of oscillations and having a natural frequency equal to the frequency of oscillations to be produced, and a condenser connected between the anode of said other device and the electrode of said holder remote from said other device to supply oscillations to said last mentioned electrode equal to that supplied by capacity between said electrodes when said crystal is removed from said holder.

5. The combination in a crystal oscillator of a pair of electron discharge devices, each having an input circuit and an output circuit, means coupling the output circuit of one of said devices to the input of said other device and means coupling the output of said other device to the input of said first device, thereby to support the generation of oscillations, said last means including a path comprising a piezoelectric crystal through which said oscillations are transmitted, electrodes on either side of said crystal, and a neutralizing circuit extending from one electrode of said crystal to a point on one of said input and output circuits where oscillations appear having phase opposite to the phase of oscillations supplied through to said one electrode the capacity between said electrodes, said circuit being proportioned to prevent generation of oscillations due to said capacity between said electrodes.

6. A crystal oscillator circuit comprising first

and second electron discharge devices in cascade, said first device having a grounded grid input circuit and an output circuit tuned to a desired oscillation frequency, said second device having a grid circuit coupled to said output circuit and an anode circuit, said anode circuit including separate anode and cathode load impedances arranged to have oscillations of opposite phase developed thereon, a regenerative feedback connection between the cathodes of said devices for sustaining oscillations, said connection including a piezoelectric crystal and its holder electrodes, said crystal being series resonant at said desired frequency, said electrodes also having substantial capacity therebetween tending

to sustain spurious oscillations, and a degenerative feedback connection for neutralizing said spurious oscillations comprising a capacity connected between a point on said anode impedance and the cathode of said first device.

REGINALD L. DOWNEY.

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