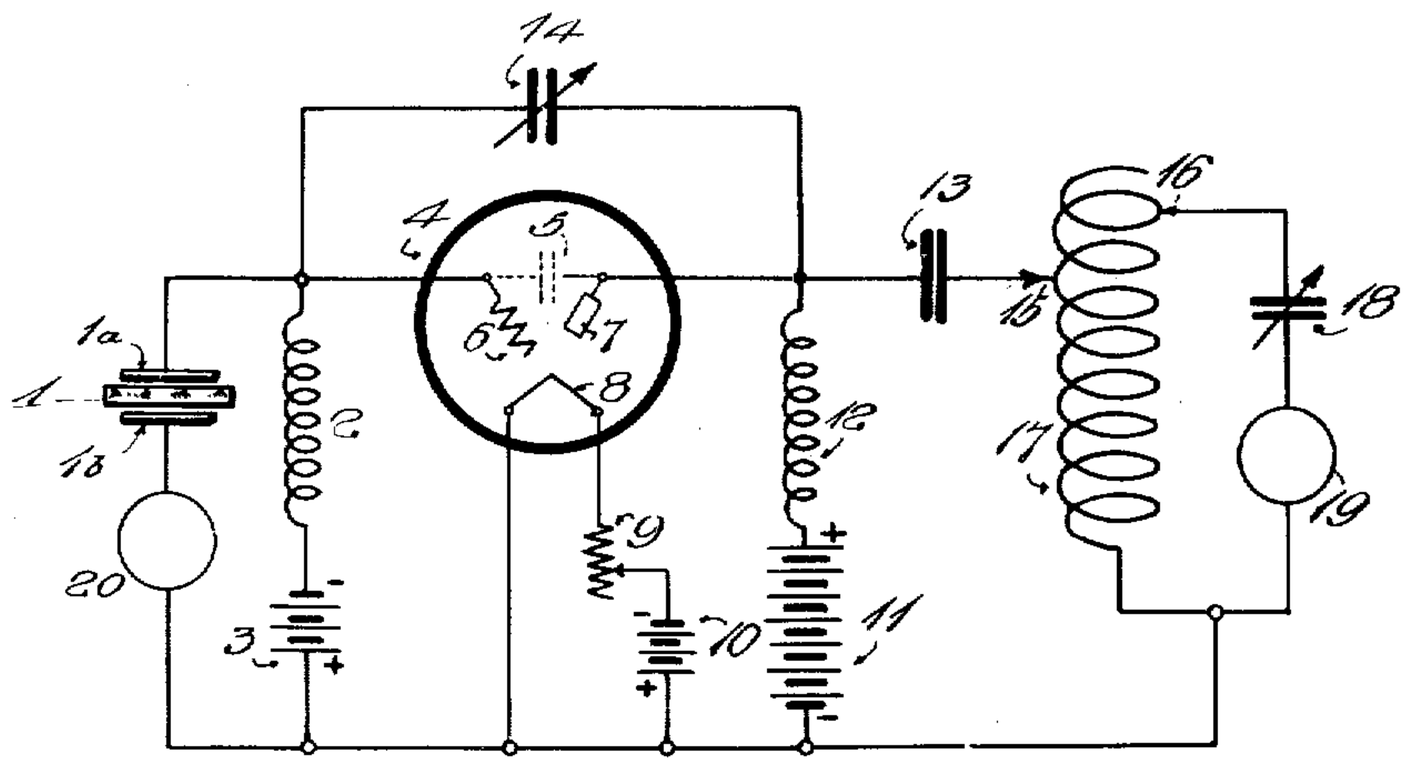
Sept. 4, 1928. 1,683,130

L. A. GEBHARD

PIEZO ELECTRIC CRYSTAL CONTROLLED OSCILLATOR

Filed Dec. 16, 1926



INVENTOR.

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UNITED STATES PATENT OFFICE.

LOUIS A. GEBHARD, OF WASHINGTON, DISTRICT OF COLUMBIA, ASSIGNOR TO WIRED RADIO, INC., OF NEW YORK, N. Y., A CORPORATION OF DELAWARE.

PIEZO-ELECTRIC CRYSTAL-CONTROLLED OSCILLATOR.

Application filed December 16, 1926. Serial No. 155,236.

My invention relates broadly to high frequency signal transmission circuits and more particularly to an improved piezo electric crystal controlled oscillator circuit.

One of the objects of my invention is to provide a circuit arrangement for controlling the feedback of energy in a piezo electric crystal oscillator circuit for relieving the strain upon the crystal.

Another object of my invention is to provide means for obtaining maximum output from a piezo electric crystal in an electron tube oscillator circuit while maintaining minimum strain upon the crystal.

My invention will be more fully understood from the specification hereinafter following by reference to the accompanying drawing which shows diagrammatically the improved piezo electric crystal oscillator circuit of my invention.

In crystal controlled transmitter design it is desirable to arrange the circuits of the crystal oscillator to deliver as much useful energy output as is possible. This results in a reduction in the number of stages of amplification required for a certain output with the attendant economy in the number of tubes, condensers, coils and other apparatus; it simplifies the construction, manipulations and normal operation of a transmitter by reducing the number of controls to a minimum.

The drawing shows my improved crystal oscillator. Reference character 1 represents the crystal disposed between plates 1^a and 1^b connected to the grid 6 and filament 8 of tube 4. Meter 20 reads the alternating current through the crystal 1. The tube is supplied with a negative grid bias from source 3 through choke coil 2. The tube filament 8 is lighted from source 10 controlled by rheostat 9. Plate 7 of tube 8 is supplied by source 11 through choke coil 12; 13 is a plate by-pass condenser connecting the circuit including coil 17 and variable condenser 18 to the tube. This latter circuit affords a proper output circuit for the tube. Tap 16 and condenser 18 are adjusted to proper frequency as determined by crystal 1. They are adjusted until the circuit is inductively reactive at the point just before it is to become purely resistive. Tap 15 is adjusted until maximum output is obtained. Ammeter 19 reads the current through the condenser 18 and aids in the adjustment of the circuit.

In the operation of the crystal oscillator, sufficient energy is fed over through the inter-element capacity 5 between plate 7 and grid 6 of tube 4 to support the losses in the crystal itself plus the energy necessary to control the grid-filament circuit which in turn controls the plate-filament circuit to develop the variations in plate voltage and current supporting oscillations in the output circuit.

In present day commercial tubes the inter-element capacity 5 is comparatively high. This results in a large feedback from output to crystal circuit and, therefore, large currents through the crystal 1. The crystal will carry a certain current safely, but beyond this point it will be destroyed. There is a certain value of feedback which gives best output with lowest strain on the crystal. If the feedback is reduced beyond this point the circuit refuses to oscillate or at least to start oscillating. If the feedback is increased beyond this point the current through the crystal becomes greater which means unsafe operation. In order to reduce the crystal current in this case the plate supply voltage from source 11 is reduced with a corresponding reduction in output.

My invention permits operation of the oscillator circuit at the optimum feedback with the use of different tubes and crystals by a control of the feedback. This is done by reducing the inter-element capacity 5 of tube 4 in its design to a point less than optimum value and then by variable capacity 14 increase it to the desired value. The design of the tubes must be such that even in quantity production the inter-element capacity 5 will always be lower than the desired value.

By means of the adjustment 14, it is possible to obtain maximum output from a given crystal with minimum strain upon the crystal with tubes of various inter-element capacities.

It is possible to make crystals which are poor oscillators give a fair output and in some cases make crystals oscillate which would not do so without the adjusting condenser 14 and with a tube of low inter-element capacity.

While I have described a preferred em-

bodiment of my invention, I desire that it be understood that modifications may be made and that no limitations upon my invention are intended other than are imposed by the scope of the appended claims.

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

1. A piezo electric crystal control system comprising an electron tube having grid, filament and plate electrodes, an input circuit interconnecting said grid and filament electrodes, an output circuit interconnecting said plate and filament electrodes, an oscillatory circuit connected with said output circuit, a piezo electric crystal element connected in said input circuit and a variable condenser coupling said input and output circuits for maintaining the current through said piezo electric crystal element below a predetermined value for relieving the strain upon said piezo electric crystal element while sustaining oscillations at maximum amplitude and at the frequency of said piezo electric crystal element in said oscillatory circuit.

2. A piezo electric crystal control circuit comprising an electron tube having grid, filament and plate electrodes, an input circuit interconnecting said grid and filament electrodes, an output circuit interconnecting said plate and filament electrodes, a source of potential connected in each of said circuits, a radio frequency choke coil disposed in series with said sources of potential in said input and output circuits, a piezo electric crystal device connected in said input circuit and in shunt with said choke coil and a source of potential therein, an oscillatory circuit connected in shunt with said output circuit and across said choke coil and source of potential therein, and a variable condenser having its opposite sides connected to one terminal of each of said choke coils for providing a path for controlling the current between said input and output circuits and maintaining the current through said piezo electric crystal device below a predetermined value while sustaining oscillations at the frequency of said piezo electric crystal device in said oscillatory circuit.

3. In a piezo electric crystal control circuit, an electron tube having grid, filament and plate electrodes, an input circuit interconnecting said grid and filament electrodes, an output circuit interconnecting said plate and filament electrodes, a piezo electric crystal device ground to a predetermined frequency characteristic and connected in said input circuit, an oscillatory circuit connected with said output circuit, and a variable condenser connected across the grid and plate electrodes of said electron tube supplementing the inter-element capacity of said tube for controlling the transfer of energy between said circuits and maintaining the current through said piezo electric crystal device below a predetermined value for protecting said device against excessive currents while oscillations of the frequency of said piezo electric crystal device are sustained in said oscillatory circuit.

LOUIS A. GEBHARD.

DISCLAIMER

1,683,130.—*Louis A. Gebhard*, Washington, D. C. PIEZO-ELECTRIC CRYSTAL-CONTROLLED OSCILLATOR. Patent dated September 4, 1928. Disclaimer filed October 1, 1932, by the assignee, *Wired Radio, Inc.*

Hereby enters a disclaimer to claim 1 of said patent, which is in the following words, to wit:

"1. A piezo electric crystal control system comprising an electron tube having grid, filament and plate electrodes, an input circuit interconnecting said grid and filament electrodes, an output circuit interconnecting said plate and filament electrodes, an oscillatory circuit connected with said output circuit, a piezo electric crystal element connected in said input circuit and a variable condenser coupling said input and output circuits for maintaining the current through said piezo electric crystal element below a predetermined value for relieving the strain upon said piezo electric crystal element while sustaining oscillations at maximum amplitude and at the frequency of said piezo electric crystal element in said oscillatory circuit."

[*Official Gazette October 25, 1932.*]

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

1. A piezo electric crystal control system comprising an electron tube having grid, filament and plate electrodes, an input circuit interconnecting said grid and filament electrodes, an output circuit interconnecting said plate and filament electrodes, an oscillatory circuit connected with said output circuit, a piezo electric crystal element connected in said input circuit and a variable condenser coupling said input and output circuits for maintaining the current through said piezo electric crystal element below a predetermined value for relieving the strain upon said piezo electric crystal element while sustaining oscillations at maximum amplitude and at the frequency of said piezo electric crystal element in said oscillatory circuit.

2. A piezo electric crystal control circuit comprising an electron tube having grid, filament and plate electrodes, an input circuit interconnecting said grid and filament electrodes, an output circuit interconnecting said plate and filament electrodes, a source of potential connected in each of said circuits, a radio frequency choke coil disposed in series with said sources of potential in said input and output circuits, a piezo electric crystal device connected in said input circuit and in shunt with said choke coil and a source of potential therein, an oscillatory circuit connected in shunt with said output circuit and across said choke coil and source of potential therein, and a variable condenser having its opposite sides connected to one terminal of each of said choke coils for providing a path for controlling the current between said input and output circuits and maintaining the current through said piezo electric crystal device below a predetermined value while sustaining oscillations at the frequency of said piezo electric crystal device in said oscillatory circuit.

3. In a piezo electric crystal control circuit, an electron tube having grid, filament and plate electrodes, an input circuit interconnecting said grid and filament electrodes, an output circuit interconnecting said plate and filament electrodes, a piezo electric crystal device ground to a predetermined frequency characteristic and connected in said input circuit, an oscillatory circuit connected with said output circuit, and a variable condenser connected across the grid and plate electrodes of said electron tube supplementing the inter-element capacity of said tube for controlling the transfer of energy between said circuits and maintaining the current through said piezo electric crystal device below a predetermined value for protecting said device against excessive currents while oscillations of the frequency of said piezo electric crystal device are sustained in said oscillatory circuit.

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[*Official Gazette October 25, 1932.*]