

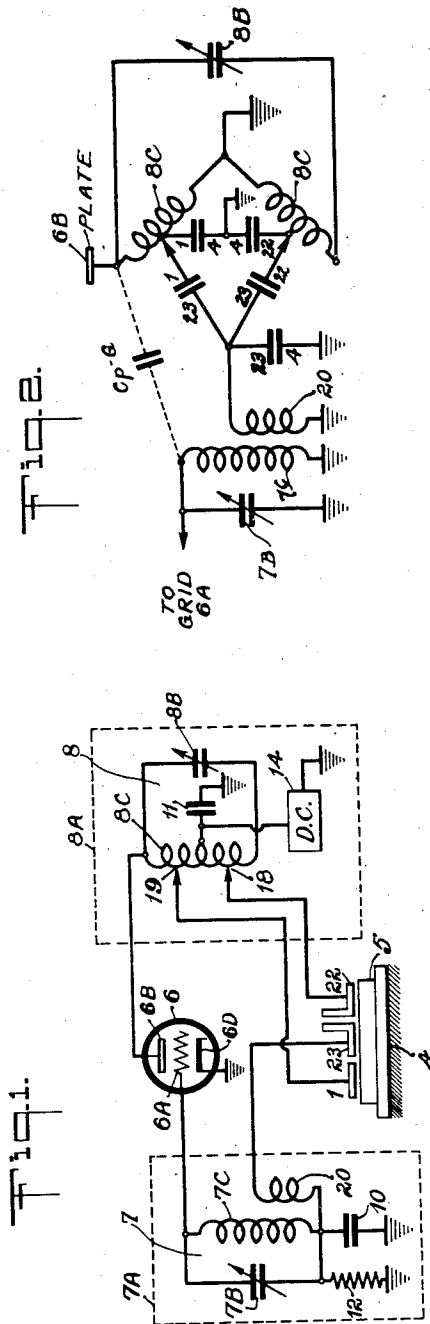
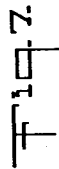
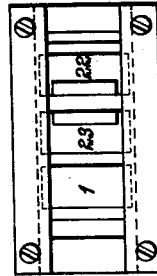
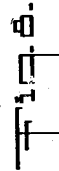
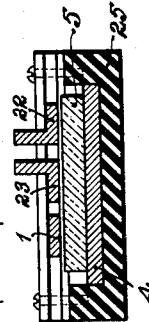
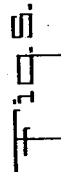
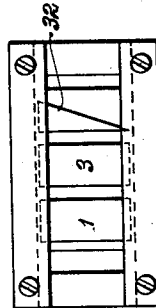
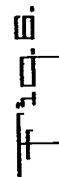
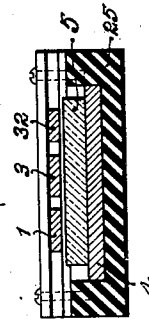
**March 6, 1945.**

**K. G. MacLEAN**

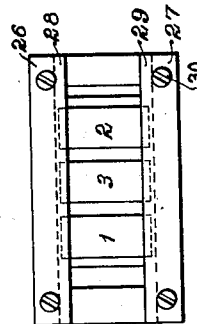
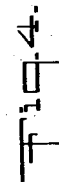
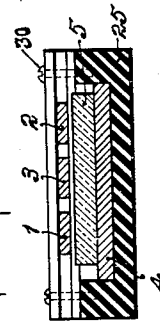
**2,370,979**

## CRYSTAL OSCILLATOR AND MOUNTING

Original Filed April 30, 1942



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## UNITED STATES PATENT OFFICE

2,370,979

## CRYSTAL OSCILLATOR AND MOUNTING

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Original application April 30, 1942, Serial No.  
441,191. Divided and this application January  
27, 1943, Serial No. 473,669

7 Claims. (Cl. 171—327)

This invention relates to new and useful crystal oscillator circuits and mounting means which are particularly adapted to radio transmitters. This application is a divisional application of my copending parent application Serial No. 441,191 filed April 30, 1942, which application contains claims directed to the oscillator circuit whereas this application contains claims directed to the crystal holder and mounting means.

An object of this invention is to provide novel crystal oscillator circuits and mounting means which give improved operating results, due to confining the oscillatory feedback circuit to that through the crystal.

Another object of this invention is to provide a means of obtaining harmonic frequencies from a crystal without unstable oscillations due to input and output circuits being tuned to the same frequency.

A feature of this invention resides in the dual use of crystal holder electrodes, so that they will act as the usual crystal electrodes and will also serve as plates or electrodes of neutralizing capacities for the several novel oscillating circuits which will be described in this specification.

The several features of this invention are described in more detail in the accompanying specification and with the aid of the accompanying drawing, in which

Fig. 1 is a typical circuit diagram of a crystal-controlled oscillator employing features of my invention.

Fig. 2 is a bridge circuit diagram of Fig. 1.

Fig. 3 is a plan view of the crystal holder employed in this invention.

Fig. 4 is a sectional view of Fig. 3.

Fig. 5 is a plan view of a modified crystal holder.

Fig. 6 is a sectional view of Fig. 5.

Fig. 7 is a plan view of a crystal holder which is particularly adapted for use in the oscillator circuit of Fig. 1.

Fig. 8 is a sectional view of Fig. 7.

Referring now in detail to the crystal controlled oscillator of Fig. 1 of the drawing, a typical circuit using a triode type of tube is shown and the quartz piezo-electric crystal 5 is provided with electrodes 1, 22 and 23. In this arrangement the plate grid capacity of the triode is also neutralized by suitably proportioning the active capacitive area of electrodes 22 and 23. As shown, crystal 5 rests upon a common or lower grounded electrode 4. Tube 6, to which the crystal is connected, has the usual control grid electrode 6A, plate 6B and cathode 6D. The input grid 6A is

connected to a tuned circuit 7 located within a completely shielded casing 7A. Tuned circuit 7 comprises variable condenser 7B and inductance 7C. Coil 7C has a coupling coil 20 connected to the lower portion thereof. The plate 6B is connected to a second tuned circuit 8, located within a shielded container 8A. Circuit 8 comprises variable condenser 8B and inductance 8C. Coil 8C is provided with adjustable taps 18 and 19. Electrodes 22 and 23 are preferably in the shape of angular members to give increased capacity by means of the increased area by having the extended flanges face each other. Electrodes 1 and 22 are connected to points of opposite polarity and are in shunt with a portion of inductance 8C. Tuned circuits 7 and 8 are designed to resonate at the crystal resonant frequency, or at some integral harmonic frequency of the crystal 5. 10 and 11 are grid and plate by-pass condensers respectively. A suitable grid bias resistor 12 is connected in shunt with condenser 10.

In the operation of the circuits shown in Fig. 1, oscillations take place only at the crystal frequency, or at an integral harmonic thereof, due to the isolation of tuned circuits 7 and 8 by shielded containers 7A and 8A and neutralization of capacity couplings. Capacity coupling from the crystal electrodes 1 to 23 is neutralized by a like capacity coupling of the opposite phase from electrodes 22 to 23, which is more clearly shown by the schematic radio frequency bridge circuit diagram of Fig. 2 wherein the electrode surfaces are indicated as a balanced capacitive arm on the left hand side of the bridge circuit. The inductive arm includes inductance 8C with variable condenser 8B connected in parallel therewith. To the left of the capacitive arm are connected inductance 7C and variable condenser 7B. The voltage operation is as follows: The electrodes 1 and 22 receive voltages of equal magnitude but opposite phase. Therefore, the net voltage induced in electrode 23 by the capacities formed by the crystal holder is zero. (This does not mean that 23 is at ground potential but that the capacity feedback has been balanced out.) The voltages on electrodes 1 and 22 also cause distortion of quartz 5 thereby causing a voltage to appear across the quartz under electrode 23 by means of the well known piezo-electric effect. Electrode 23 therefore now has the potential of the quartz applied to it. This provides voltage to grid 6A of proper phase to cause oscillations to be sustained. The object of the bridge circuit is thus obtained, i. e., the feedback is obtained only by virtue of the feedback through the quartz

whereas feedback through the crystal holder electrode capacities and through the plate grid capacity of the tube is neutralized.

It will be noted by this arrangement that the only feedback from plate 6B to grid 6A is due to the presence of the quartz crystal 5 in the circuit. A momentary variation of plate current, such as would occur when applying plate voltage, will place a voltage on electrodes 1 and 22. This applied voltage causes distortion of the crystal 5, and as a result, voltage is induced on electrode 23 and tube grid 6A. The phase of this voltage which electrode 23 receives is of the correct phase for sustaining the desired oscillations.

The crystal holder shown by Figs. 3 and 4 include a lower mounting member 25, which is preferably made of insulation material having the necessary requisite insulating qualities as is obtained in such materials as "Isolantite," or any suitable ceramic material. The electrodes 1, 2 and 3 are located above crystal 5 by means of two insulating strips 26 and 27, which are provided with slots 28 and 29 for locating the electrodes at a suitable height above crystal 5 to give the desired gap, or air space. The insulating strips 26 and 27 are secured to member 25 by suitable screws 30. This type of holder is particularly adapted for use with well screened tubes where it is not necessary to neutralize plate to grid capacity in the tube.

The crystal holder shown in Figs. 5 and 6 is substantially similar to that shown in Figs. 3 and 4, except that one of the electrodes as indicated at 32 is triangular in shape, illustrating that the electrodes need not have a symmetrical arrangement.

Figs. 7 and 8 show a modified holder, in which the electrodes 22 and 23 are angular in shape to give the desired increased capacity between electrodes to neutralize the plate-grid capacity of a triode as in Fig. 1. The above mentioned circuits and crystal holder arrangements may also be used with push-pull arranged tubes if a holder having four upper electrodes is used and connected, so that the electrodes effectively neutralize capacitive couplings through the crystal.

By way of further explanation in connection with the oscillator of Fig. 1, the crystal 5 is provided with a ground electrode 4, and three upper electrodes 1, 22 and 23. The voltage impressed on electrode 1 may be adjusted so as to excite the crystal 5, or, in other words, this voltage may be considered feedback voltage for the production of oscillations under control of the crystal. When the crystal oscillates an exciting voltage is picked up by means of electrode 23 and impressed upon the grid of tube 6. Undesirable feedback capacity through the electrodes 1-23 may be neutralized by means of the other crystal electrode capacity 22-23, while 22-23 simultaneously balances out the plate to grid capacity  $C_p-G$  in Fig. 2.

In Fig. 1, the feedback electrode may be considered electrode 1, and the grid exciting electrode to be 23. Crystal electrode 22 is provided to balance out or neutralize straight capacity effects, it being noted that electrodes 22 and 23 are provided with upstanding marginal edges which serve to augment the natural capacity between 22 and 23.

#### What I claim is:

1. A piezo-electric crystal holder comprising an insulating member, a common electrode located within said insulating member, a piezo-electric crystal located above said electrode, a plurality of slotted strips having lateral slots and a plurality of electrodes arranged within said slots and located above said crystal to be in electrostatic relationship therewith.
2. A piezo-electric crystal holder comprising an insulating member, a common electrode located within said insulating member, a piezo-electric crystal located above said electrode, a plurality of slotted insulating strips having lateral slots and a plurality of electrodes, one of which has an area different from the other electrodes, said last mentioned electrodes arranged within said slots and located above said crystal to be in electrostatic relationship therewith.
3. A piezo-electric crystal holder comprising an insulating member, a common electrode located within said insulating member, a piezo-electric crystal located above said electrode, a plurality of slotted insulating strips having lateral slots and a plurality of electrodes, at least two of which are of angle-iron shape, said last mentioned electrodes arranged within said slots and located above said crystal to be in electrostatic relationship therewith.
4. A piezo-electric crystal holder comprising a casing, a common electrode located within the lower portion of said casing, a piezo-electric crystal located above said common electrode, a plurality of slotted strips having lateral slots, a plurality of electrodes located above said crystal and insulatingly arranged within said slots and secured to the upper portion of said casing, each of said electrodes being spaced apart and in electrostatic relationship with said crystal.
5. A piezo-electric crystal holder comprising a casing, a common electrode located within the lower portion of said casing, a piezo-electric crystal located above said common electrode, a plurality of lateral slots in the sides of said casing, a plurality of electrodes located above said crystal and insulatingly secured to the upper portion of said casing, one of said electrodes having a shape different from that of the other electrodes, each of said electrodes being spaced apart and in electrostatic relationship with said crystal, and the electrodes which are located above the crystal being arranged in said slots.
6. A piezo-electric crystal holder comprising a casing, a common electrode located within the lower portion of said casing, a piezo-electric crystal located above said common electrode, a plurality of electrodes located above said crystal and insulatingly secured to the upper portion of said casing, one of said electrodes having a triangular shape, each of said electrodes being spaced apart and in electrostatic relationship with said crystal.
7. A piezo-electric crystal holder comprising a casing, a common electrode located within the lower portion of said casing, a piezo-electric crystal located above said common electrode, a plurality of electrodes located above said crystal and insulatingly secured to the upper portion of said casing, two of said electrodes being of angle-iron shape and arranged to face each other, all of said electrodes being spaced apart and in electrostatic relationship with said crystal.

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