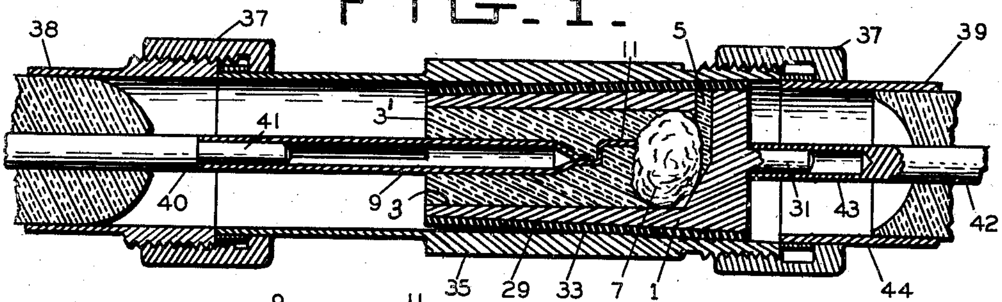
Aug. 27, 1946. F. L. SALISBURY 2,406,405

COAXIAL CONDENSER CRYSTAL AND METHOD OF MAKING SAME

Filed May 19, 1941

FIG-1.



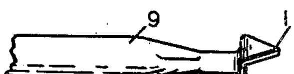


FIG-2.

FIG.4. FIG.6.

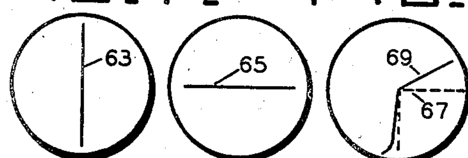
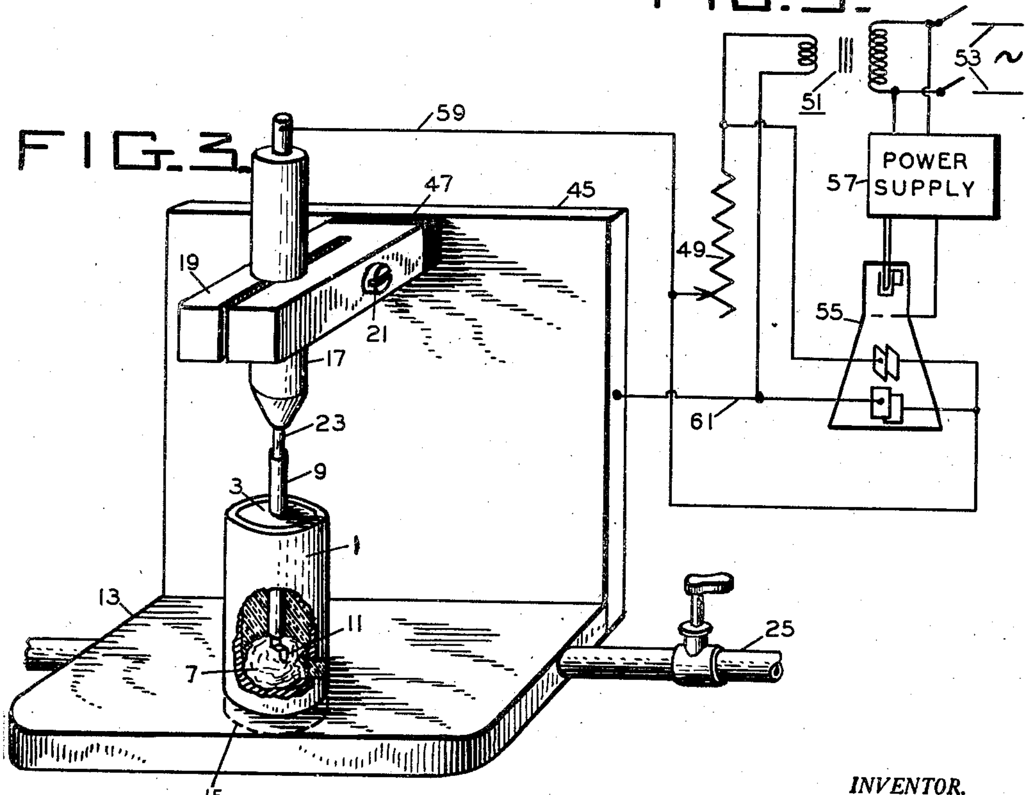


FIG.5.

FIG.3.



INVENTOR.
FREDERICK L. SALISBURY

BY Herbert H. Thompson
HIS ATTORNEY.

Patented Aug. 27, 1946 2,406,405

UNITED STATES PATENT OFFICE

2,406,405

COAXIAL CONDENSER CRYSTAL AND METHOD OF MAKING SAME

Frederick L. Salisbury, Hempstead Gardens, N. Y., assignor to Sperry Gyroscope Company, Inc., Brooklyn, N. Y., a corporation of New York

Application May 19, 1941, Serial No. 394,239

8 Claims. (Cl. 250—31)

1

This invention relates to mountings for crystals such as are used for rectifiers or detectors, and to a method for making these mountings.

In the well-known "cat's-whisker" type of crystal mounting, the crystal is held in a conducting body which forms one terminal, and the second terminal, or "cat's-whisker" is held against a sensitive spot on the crystal. It is not only difficult to find a sensitive spot on the crystal suitable for use, but it has been exceedingly difficult or impossible in devices heretofore used to keep the "cat's-whisker" in contact with such a spot. Mechanical vibration, temperature variations, change in humidity of surrounding atmosphere, oxidation of wire, etc., all tend to impair this contact and hence the efficiency and effectiveness of the crystal.

It is an object of the present invention to provide an improved crystal mounting which is stable in operation and in which the contact between crystal and "cat's-whisker" is substantially not affected by vibration, moisture, temperature or other influences to which crystal contacts have heretofore been subject.

It is another object of this invention to provide an improved crystal mounting which is sealed from the atmosphere and is mechanically secure against vibration, thus being suitable for use under conditions of change in temperature, humidity, pressure and vibration, as, for example, are found on airplanes.

It is still another object to provide a crystal mounting in which the "cat's-whisker" is permanently sealed in place by a thermoplastic dielectric material having high efficiency at ultra high frequencies, thereby permitting the crystal to be satisfactorily used at such high frequencies.

It is a further object of this invention to provide a novel method of manufacturing a mounted crystal unit which makes it possible to manufacture such units in extremely small size and of high efficiency, such as are necessary for use with ultra-high frequency circuits.

A further object is to provide a useful mounting for a crystal which is easily adapted to be connected in a concentric transmission line circuit.

Another object is to provide a useful crystal mounting for use with a concentric transmission line system which has a distributed by-pass capacitance built into the crystal mounting.

Still another object is to provide a mounting for a crystal inside a section of concentric transmission line, whereby the crystal is electrically shielded from extraneous electric fields.

Further objects and advantages will become

2

apparent in the following specification and drawing, wherein,

Fig. 1 is a section along the axis of a complete crystal mounting and adaptor for concentric transmission lines;

Fig. 2 is an enlarged fragmentary view of the crystal engaging tip of the "cat's-whisker";

Fig. 3 shows the testing and assembling device for the crystal mounting of Fig. 1; and

Figs. 4 to 6 diagrammatically show cathode ray tube indications under various conditions to explain the testing of the crystal in the device of Fig. 3.

Fig. 1 shows the completely assembled crystal rectifier or detector. This is made of a holder 1, of brass or any other conductive material, provided with a recess 3 of suitable diameter. A small outlet or bleeder hole 5 is provided from the outside of holder 1 to the bottom of recess 3. A piece of crystal 7 having unidirectional conducting properties, such as zincite, silicon, Carborundum, galena, hertzite, molybdenum, etc., is forced into recess 3 so as to make good electrical and mechanical contact with the inner walls of holder 1. Before placing the crystal in position it may be tested, in the manner to be described below, to insure that a sensitive portion is placed facing the opening of recess 3.

The holder 1 and crystal 7 are then heated together by any suitable means, as by being placed on the surface of an electric iron. When hot, some thermoplastic substance 3' having good dielectric qualities at ultra-high frequencies of the order of 10^9 cycles per second, such as various types of materials known as polystyrene, is placed within the recess 3. It should be noted here that any thermoplastic material having electrical properties suited to the intended use of the crystal may be used. When properly heated, the thermoplastic material becomes semi-fluid and flows around the crystal 7. All air is forced out the bleeder hole 5 and the thermoplastic material thoroughly wets and surrounds the exposed surface of crystal 7 and fills holder 1 so that, after cooling, the crystal 7 is kept completely separated from and independent of all atmospheric influences.

While the thermoplastic material is still plastic, the "cat's-whisker" conductor 9 is placed roughly concentrically within recess 3. The conductor 9 is shown in Fig. 2 as made of metal tubing, flattened at one end, which is formed with an offset sharpened tip 11. The particular shape of the "cat's-whisker" 9 is convenient for applicant's method of manufacture, as will be apparent, but any type of wire or other small conductor may be used.

The entire unit as thus far assembled is then placed in proper position on a cooling and mounting base 13 (Fig. 3). This position may be marked by any suitable means, such as by a recess as at 15 or a holding jig may be used. The unit is thereby held immediately under the roughly concentric with an adjusting member 17 which is adjustably held in a split clamp 19 and fastened therein by some means such as a screw 21. Member 17 has a reduced portion 23 which fits snugly into the hollow portion of "cat's-whisker" conductor 9, which is thus held by member 17 roughly in a position coaxial with recess 3. Member 17 is then manipulated as by turning with clamp 19 loosened until the "cat's whisker" 9 is in contact with an optimum sensitive spot on crystal 7, as indicated on the test device to be described below. The finding of the sensitive spot is aided by the off-setting of portion 11 of conductor 9, as this permits a large part of the outward facing surface of crystal 7 to be explored. After such a sensitive spot has been found, clamp 19 is fastened to hold member 17 in position while the thermoplastic material cools and hardens. The cooling is expedited by running cooling water through suitable passage means in metal base 13, as by pipe 25. The "cat's-whisker" 9 is thereby cast rigidly into the proper position. If no sensitive spot is found before the thermoplastic material hardens, the unit is removed and reheated and the process is repeated.

By the above method I secure a fixed crystal unit with "cat's-whisker" 9 firmly and permanently secured in place. The contact between crystal 7 and "cat's-whisker" 9 is completely sealed off from the atmosphere, and good permanent contact is secured to the crystal 7. The unit so obtained is found to be extremely stable in its characteristics over wide changes of conditions of use. It is especially resistant to vibration, and is therefore very useful on airplane installations.

After cooling, the base of crystal holder 1 is placed in an adjustably eccentric chuck of a lathe, while conductor 9, now a fixed part of the unit, is used to center the unit in the lathe. The outside of holder 1 is now turned down on the lathe to roughly cylindrical shape but having a slight taper 29, and it is made concentric with member 9. If conductor 9 did not harden into place exactly coaxial with recess 3, the walls of holder 1 will not be of uniform thickness, but this is immaterial. The unit is now placed in a tapered chuck which fits the taper formed on the unit, and a tip 31 is formed by turning down the end of the unit. This tip 31 is also formed concentric with the outside of the unit and with conductor 9. An insulating tape having good dielectric properties at the operating frequencies is now wound on the tapered portion, as at 33, and the wound unit is then forced into a mating taper in body 35 which has standard clamp adaptors 37 at each end whereby the completed unit may be connected to concentric transmission lines such as 38, 39. With such connection, conductor 9 may slide over the inner conductor 40 of transmission line 38, as at 41, and tip 31 may slide into the inner conductor 42 of the other transmission line 39, as at 43. It is obvious that either or both conductor 9 and tip 31 could slide over or under its corresponding connecting member.

The tape 33 forms the dielectric of a distributed capacitance whose electrodes are holder 1 and body 35. The capacitance acts as a distributed bypass condenser for the waves rectified by the crystal 7. Furthermore, the construction is such that all parts of the crystal circuit are fully shielded, since everything is within body 35 which acts as a continuation of the outer conductor 44 of transmission line 39. The output transmission line 39 may be replaced by an ordinary shielded cable if high frequency efficiency is not necessary for the rectified currents.

The above is, of course, only one way of adapting the crystal holder 1 of the invention to a particular use. The method of mounting the crystal 7 above described may obviously be used to mount this crystal in an opening in any metallic body whatsoever, and is not restricted to the particular type shown. Successful crystal mountings have been made in the end of a 10–32 screw, and it is possible to make a mounting by the method described in an opening as small as .060 inch deep and .050 inch wide.

The method of testing the crystal or to determine when the "cat's-whisker" 9 is in contact with a suitable sensitive spot will now be explained. Referring to Fig. 3, it will be seen that clamp 19 is insulated from base 13 and bracket 45 as by an insulating block 47. Conductor 9 which is one terminal of crystal 7, is connected as through members 17 and clamp 19 and by means of a conductor 59, to a resistor 49 which is connected in turn to one terminal of the secondary winding of stepdown transformer 51 energized from an A. C. supply line 53. The holder 1, which acts as the other terminal of the crystal 7, is connected, for example, through base 13 and bracket 45 and by means of conductor 61 to the other side of the secondary winding of transformer 51, which is designed to have suitable secondary voltage chosen so as to prevent any damage to the crystal 7. Resistor 49 prevents excessive current from flowing in the crystal circuit. A standard oscillograph 55 is energized from the same supply line 53 through its usual power supply 57. One pair of deflecting plates of oscillograph 55, such as the horizontal deflecting plates, is connected across resistor 49. The other pair, such as the vertical deflecting plates, is connected across conductors 59 and 61, which are connected to the crystal 7, so that this pair is energized by the voltage across crystal 7. The usual amplifiers may be used for amplifying the voltages applied to the deflecting plates, if desired. If conductors 59 and 61 were open-circuited, the voltage across resistor 49 would be zero and that across conductors 59, 61 would be maximum. Accordingly, a trace 63 such as that shown in Fig. 4 would be obtained. If conductors 59 and 61 were short-circuited, their potential difference would be zero, while the voltage across resistor 49 would be maximum so that the trace 65 shown in Fig. 5 would be obtained. It thus will be seen that the cathode ray oscillograph trace indicates, by its slope, the impedance of the circuit connected to conductors 59, 61. A vertical trace 63, having infinite slope, indicates infinite impedance (open-circuit). A horizontal trace 65, having zero slope, indicates zero impedance (short-circuit). Since horizontal deflection is proportioned to current through the crystal 7, and vertical deflection is proportional to voltage across crystal 7, the slope of the trace, which is therefore proportional to voltage divided by current, will always indicate the true impedance of the crystal 7. A theoretically perfect crystal should be a perfect short-circuit for half-cycles of applied A. C. of one polarity, and a perfect open-circuit for half-cycles of the other polarity, giving a trace 67 as shown in dotted lines in Fig. 6. Such a perfect trace 67 is rarely obtained. A good trace 69 often realized is shown in full lines in Fig. 6. Hence, in exploring the crystal 7 with the "cat's-whisker" 9, the latter is manipulated until a trace at least as good as 69 is obtained, and the "cat's whisker" 9 is then held in position until the thermoplastic material sets, thereby yielding a permanent crystal rectifier or detector having the desirable qualities set forth above.

Although the invention has been illustrated by one embodiment, it is evident that many different embodiments of the invention could be made without departing from the scope thereof. It is therefore intended that the above description shall be interpreted as illustrative only, and not in a limiting sense.

Having described my invention, what I claim and desire to secure by Letters Patent is:

1. A concentric transmission line mounting for a crystal comprising a shielding outer conductor, an inner conducting body insulated from said outer conductor and having a cavity therein, a crystal fitting snugly into the cavity so as to make intimate contact with the walls thereof, a wire serving as a terminal for said crystal, and insulating material holding said wire in electrical contact with said crystal.

2. The method of making a mounted crystal which comprises the steps of forming a recess in a body of electrically conductive material, forming a bleeder hole at the bottom of said recess, forcing a unidirectionally conducting crystal into said recess to make intimate contact with the walls of said recess, placing a thermoplastic substance in said recess, heating said body and substance above the temperature at which said substance becomes plastic, whereby said substance will flow around said crystal and make intimate contact therewith, inserting a conductor into said plastic substance to make contact with said crystal, exploring the surface of said crystal until said conductor is in a position making contact with a sensitive spot of said crystal, holding said conductor in said position and simultaneously cooling said thermoplastic material to below its plastic temperature, whereby it solidifies and holds said conductor permanently in said position.

3. A shielded crystal mounting comprising a roughly cylindrical body having a recess substantially concentric thereof, a unidirectionally conducting crystal pressed into said recess, a wire held in contact with said crystal roughly concentric of said body and a tubular member placed outside said body and insulated therefrom, whereby said wire and said tubular member form input terminals to said crystal, said body and said tubular member form output terminals, and said body and tubular member form a by-pass condenser.

4. A device as claimed in claim 3 further comprising adapting means for connecting said input terminals to a concentric transmission line, and for connecting said output terminals to a shielded line.

5. A shielded crystal mounting comprising a conducting body having a recess therein, an unidirectionally conducting crystal seated within the recess in electrical contact with said body, a conducting member serving as a terminal for said crystal, and insulating material holding said conductor in electrical contact with said crystal, a tubular member placed outside said conducting body and means electrically insulating said member from said body whereby said conducting member and said tubular member form input terminals to said crystal, said conducting body and said tubular member form output terminals, and said body and said tubular member form a by-pass condenser.

6. In a mounting for a unidirectional conducting crystal, a body of electrically conducting material formed with a recess in which said crystal is seated in intimate contact with said body, a conductor extending into said recess into contact with a sensitive area of said crystal, solidified insulating means contained within said recess for retaining said crystal therein and surrounding and retaining said conductor in contact with said crystal within said recess, and substantially axially aligned connector terminals for said body and said conductor respectively projecting from opposite ends of said body.

7. In a mounting for a unidirectional conducting crystal, a member of electrically conducting material formed with a recess in which said crystal is seated in intimate contact with said member, a conductor extending into said recess into contact with a sensitive area of said crystal, solidified insulating means retaining said crystal in said recess and retaining said conductor in contact with said crystal, a second member of conducting material extending about said first member, and electrical insulation between said members.

8. A mounting for a unidirectional conducting crystal comprising a body of electrically conducting material formed with a recess in which said crystal is disposed in intimate contact with said body, a conductor in contact with a sensitive area of said crystal, insulating means securing said crystal to the walls of said recess and retaining said conductor in contact with said crystal, and substantially axially aligned connector terminals for said body and said conductor respectively projecting from opposite ends of said body.

FREDERICK L. SALISBURY.