March 9, 1948. H. M. BACH 2,437,660

END-LOADED PIEZO-ELECTRIC UNIT

Filed April 29, 1944 3 Sheets-Sheet 1

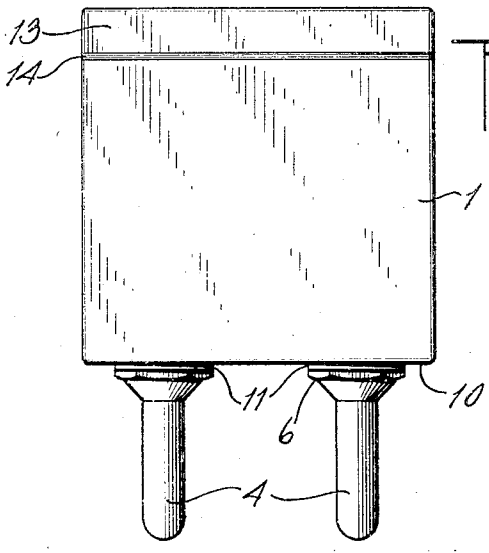


Fig. 1.

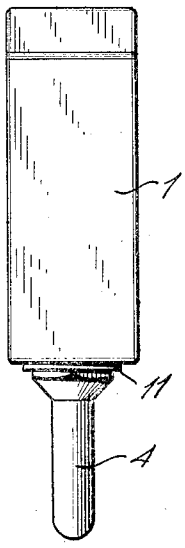


Fig. 2.

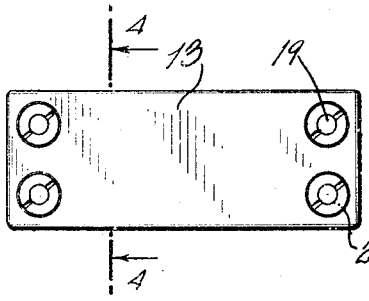


Fig. 3.

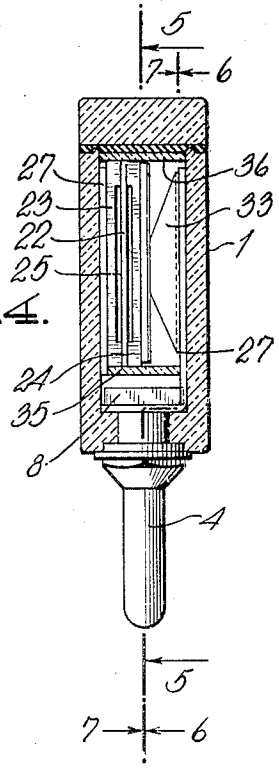


Fig. 4.

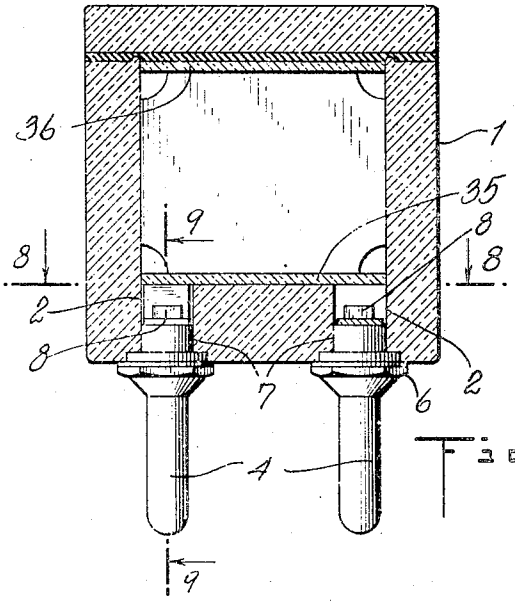


Fig. 5.

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END-LOADED PIEZO-ELECTRIC UNIT

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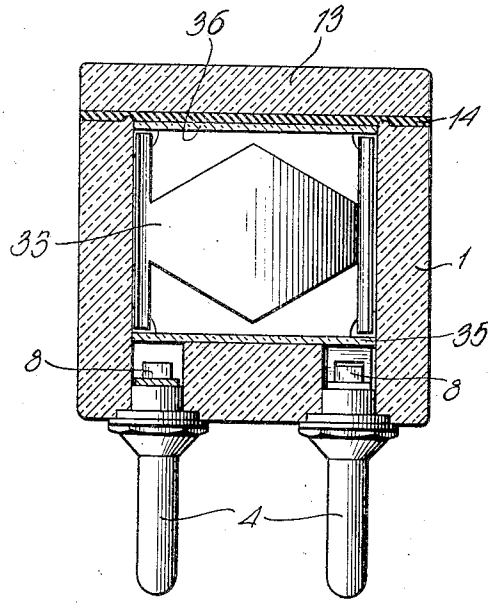


Fig. 6.

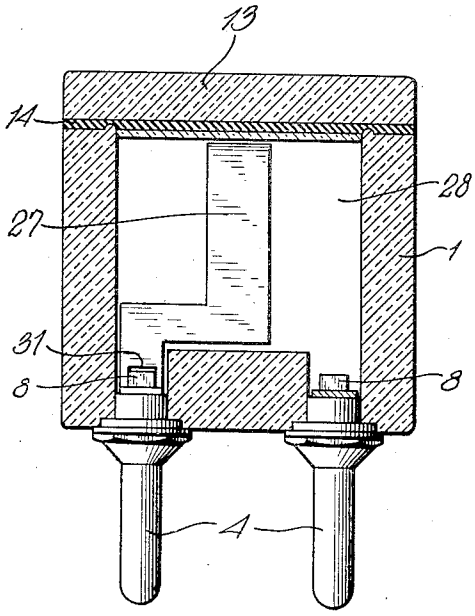


Fig. 7.

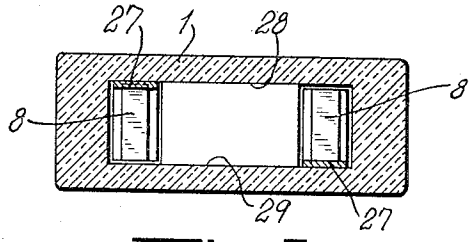


Fig. 8.

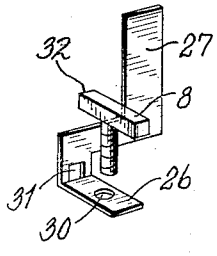
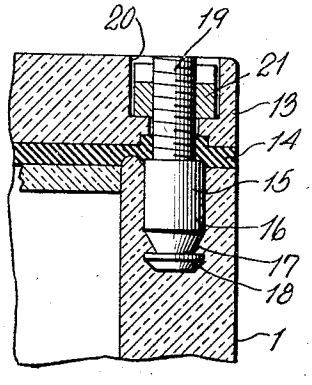


Fig. 11.

Fig. 10.



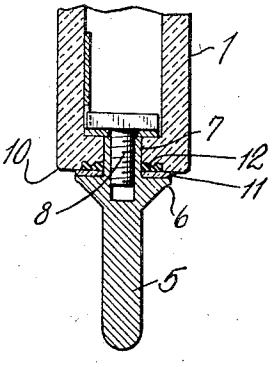


Fig. 9.

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END-LOADED PIEZO-ELECTRIC UNIT

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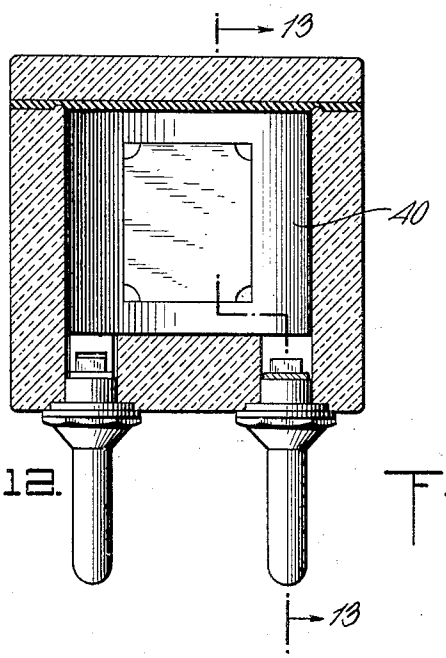


Fig. 12.

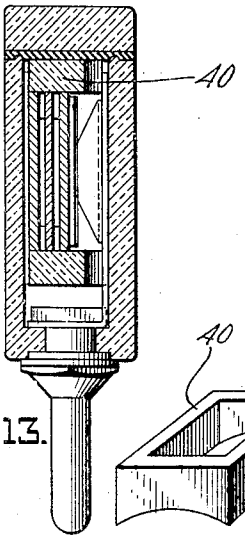


Fig. 13.

Fig. 12.a

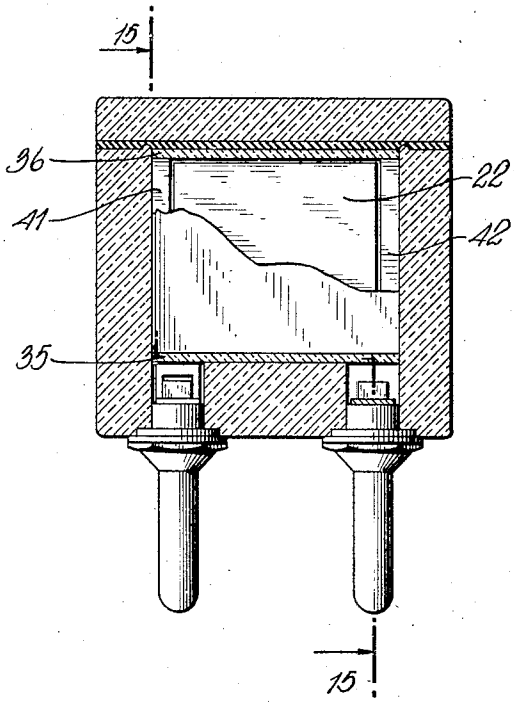


Fig. 14.

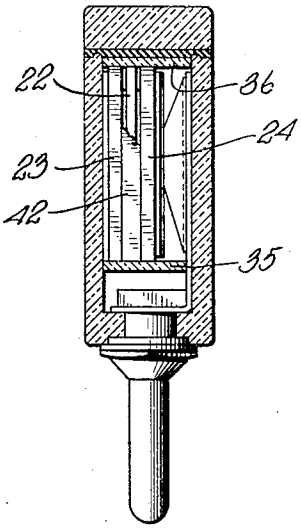


Fig. 15.

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Patented Mar. 9, 1948 2,437,660

UNITED STATES PATENT OFFICE

2,437,660

END-LOADED PIEZOELECTRIC UNIT

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Application April 29, 1944, Serial No. 533,316

9 Claims. (Cl. 171—327)

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This invention relates to piezo-electric devices and more particularly to improved housings and assembly and contact arrangements for such devices.

A principal object of the invention is to provide an improved piezo-electric device of the "end-loaded" type.

Another object is to provide an end-loaded crystal device which is designed so as to facilitate assembly and loading, and which is dust-proof, moisture-proof and gas-tight.

A feature of the invention relates to contacting arrangements, and to assembly fastening and retaining arrangements whereby the contact members also serve as assembly tools, and as a positive lock to prevent accidental loosening or turning of the contact prong fastening screws.

Another feature relates to a T-shaped fastening bolt and cooperating perforated contact strip for facilitating location and tightening of the contact assembly.

Another feature relates to an improved housing having a non-metallic cover with intervening sealing gasket. The body of the housing to which the cover is attached is provided with special threaded inserts which are previously and permanently molded and anchored into the housing. As a result, the sealing gasket and cover plate can be easily aligned, and fastening of the cover plate does not result in twisting of the gasket.

Another feature relates to a crystal housing having a specially molded externally threaded insert for allowing a cover plate and rubber gasket to be easily aligned for fastening, and avoiding the difficulties heretofore found to exist when the cover plate is fastened by removable screws threaded into internally tapped inserts. One of these difficulties was the existence of metal shavings, or dust which lodged at the bottom of the insert and prevented the proper tightening of the fastening screws.

A further feature relates to a sealed crystal housing in which a rubber or similar sealing gasket is employed in conjunction with a Bakelite strip or spacer. The gasket in addition to sealing the housing also acts as a retainer and cushion for the said spacer to prevent bodily displacement of the assembled unit within the housing.

Another feature of the invention relates to a holder which has the contacting system to the electrodes arranged symmetrically with respect to the two external contact prongs. As a result,

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it is possible to design the internal contacts so as to have a predetermined maximum or calculated optimum inherent electrostatic capacitance. In accordance with this feature the internal contact strips are made narrow, their narrow limit being the width of the smallest crystal electrode that is used in the holder. Heretofore it has been necessary when the same size holder is to receive crystals of different sizes, to provide contact strips which extend over substantially the entire width of the housing cavity so as to insure contact regardless of whether wide or narrow electrodes are used. The narrowing of the contact strips in accordance with the invention and their symmetrical location with respect to the center of the device, has the effect of limiting the effective shunt capacitance across the crystal which is of great importance in certain types of oscillator systems or circuits.

A further feature relates to a novel form of pressure contact spring for piezo-crystal units, which is especially designed so that the spring pressure on the crystal remains constant and substantially uniform over a very wide range of ambient temperatures e. g., −60° C. to +90° C.

A further feature relates to a novel coiled spring pressure arrangement wherein the coiled spring is especially designed so as to have uniform pressure or stiffness characteristics, and also as to electrical functioning characteristics so as to correlate the latter as a useful adjunct of an oscillator circuit in which the crystal unit is connected.

A still further feature relates to the novel organization, arrangement and relative location of parts which cooperate to constitute an improved piezo-crystal device of the end-loaded type.

Other features and advantages not specifically enumerated will be apparent after a consideration of the following detailed descriptions and the appended claims.

In the drawing, which shows certain preferred embodiments,

Fig. 1 is a plan view of the assembled device according to the invention.

Fig. 2 is a side elevation of Fig. 1.

Fig. 3 is a top-end view of Fig. 1.

Fig. 4 is a sectional view of Fig. 3, taken along the line 4—4 thereof.

Fig. 5 is a sectional view of Fig. 4, taken along the line 5—5 thereof.

Fig. 6 is a sectional view of Fig. 4, taken along the line 6—6 thereof.

Fig. 7 is a sectional view of Fig. 4, taken along the line 7—7 thereof.

Fig. 8 is a sectional view of Fig. 4, taken along the line 8—8 thereof.

Fig. 9 is an enlarged sectional view of the prong fastening and sealing arrangement.

Fig. 10 is an enlarged sectional view of the special arrangement for fastening the cover and gasket in place.

Fig. 11 is a perspective view of the contact strip and T-bolt fastening.

Fig. 12 is a view similar to Fig. 5, but of a modification.

Fig. 12a is a perspective view of the spacer frame of Fig. 12.

Fig. 13 is a sectional view of Fig. 12, taken along the line 13—13 thereof.

Fig. 14 is a view similar to Fig. 12, but of a still further modification.

Fig. 15 is a sectional view of Fig. 14, taken along the line 15—15 thereof.

Fig. 16 is a plan view of one embodiment of the pressure spring according to the invention.

Fig. 17 is a side view of Fig. 16.

Referring to Figs. 1 to 5, the device comprises an enclosing housing 1 of Bakelite or other suitable insulation material which can be molded in one piece to flat box-like shape, having its top end open and its bottom end provided with openings 2 for the plug-in prongs 4. Each of the prongs has an integral polygonal flange or shoulder 6, and a cylindrical end 7 which is internally threaded to receive the T-shaped fastening bolt 8 as shown more clearly in Fig. 9. The bottom face 10 of the housing is circularly recessed around each opening 2 to receive a sealing gasket 11 of rubber, neoprene or the like. Preferably, the under-cut face 10 is provided with a circular ridge or rib 12 which cooperates with gasket 11 to increase the sealing efficiency. Likewise, the top open end of housing 1 is closed by a cover plate 13 and an intervening sealing gasket 14. Housing cover 13 is preferably molded of a "laminated" phenolic known as BM9725—Rogers board—which has much higher flexural strength than usual mold materials, thus affording better seal. The inner edge of the top surface is provided with a sealing rib for purposes similar to ribs 12, and as described in detail in U. S. Patent No. 2,329,321. The underface of 13 around holes 20 is counterbored to enhance sealing by allowing the gasket to ride up against stud 19.

For the purpose of facilitating the assembly and fastening of the cover and gasket, there are molded into the top face of housing 1, adjacent the corners, four metal inserts 15 (Fig. 10) each comprising a knurled cylindrical shank 16 terminating at its lower end in a circularly undercut portion 17 and tip portion 18 whereby the insert is rigidly anchored in place during the molding operation. The other end 19 of the shank 16 is of reduced diameter and passes through corresponding openings in gasket 14 and cover 13. Cover 13 has circular recesses 20 to freely receive the internally threaded split-top nuts 21. Preferably, although not necessarily, the members 19 and 21 have left-handed threads and the ends of members 19 project so that nuts 21 cannot be turned by an ordinary screw-driver.

In the case of the usual internally tapped insert, its length is limited substantially to a maximum of twice the diameter of the tapped hole. The inserts must be held by pins (fitted into the tapped hole) in the mold and the pins will be sheared off in the molding if the insert length exceeds twice the diameter of the holding or loading pins. Since the tapped hole is "blind" (to prevent Bakelite filling tapped hole) the tapping can only run part way down the hole, in order to leave room for the end of the tap and to leave room for the metal waste resulting from the tapping. Hence the thread length available in the insert is limited to a few threads. With the externally threaded insert as disclosed, all of the above-mentioned difficulties are eliminated. Dirt and mold powder, chips, etc., cannot lodge in the insert, which can be any length necessary for mechanical strength and it can be made more readily on automatic screw machines.

A further advantage of the threaded insert is that a material such as stainless steel may be used which is much stronger than brass. Brass must be used on internally tapped insert because of manufacturing impossibility of tapping the short blind internally tapped insert. Brass inserts strip in the ratio of 1 to 10. The stainless externally threaded insert is much stronger and does not "turn off" or strip.

While any well-known form of crystal-electrode unit may be employed, it is preferred to employ a unit such as shown in detail in U. S. Patent No. 2,329,321, and comprising a crystal plate 22 (Fig. 4) which is sandwiched between a pair of metal electrodes 23, 24. These electrodes have their corners struck up or otherwise offset as by swedging so as to provide corner lands defining an air gap 25 between the crystal plate and each of the electrodes. In order to make electric contact between the prongs and the respective electrodes, special contact strips 27 are provided one of which is shown in perspective in Fig. 11. Each strip is formed of stainless steel and the lower end 26 is bent at an angle greater than 90° e. g., 91° and fits freely in the opening 2. With this arrangement, when part 26 is fastened against the prong shank, the part 27 is spring-pressed flat against the inside wall 28 of the housing (Fig. 7). The other contact strip is assembled in the opposite relation so that its vertical leg 27 is spring-pressed flat against the inside wall 29 (Fig. 8). In order to fasten the contact strips in place each strip has an opening 30 through which freely passes the threaded shank of the corresponding T-bolt 8. Each contact strip also has a rectangular opening 31 to receive the laterally extended end 32 of the T-bolt (Fig. 11), thus preventing the latter from turning when the contact prong is tightened. Furthermore, since the housing cavity is relatively narrow, it is not convenient to use screw drivers or the like to fasten ordinary slotted-head screws in place. With the arrangement as described, the bolts can be pre-assembled on their respective contact strips and can be easily lowered into place within the cavity. Because of the relation between the bolt head and opening 31 (Fig. 11), as the bolt is tightened it causes the end 27 of the contact strip to be pressed flush against the housing wall.

It will be noted that the contact strips 27 are much narrower than the walls 28 and 29 and the strips are offset so that they are symmetrically disposed with respect to the center line of the unit, notwithstanding that the two contact prongs are brought out at the same end of the unit and in the same plane. Heretofore, it has been necessary to employ contact plates which extended almost entirely across the width of the housing. Consequently, these prior con-

tact strips introduced an undesirable electrostatic capacity in shunt to the crystal. With the contact arrangement as shown, the width of the contact strips 27 may be no greater than the width of the smallest crystal electrode that is used in the housing, it being understood that the housing is capable of accommodating crystals and electrodes of greatly varying widths, for example by using a special spacer frame to make up the difference in width between the crystal unit and the inside dimensions of the housing cavity (Figs. 12 and 13). The advantages of this definite control of the maximum inherent capacitance between the contact strips and the crystal will be explained in further detail in connection with Figs. 18, 19 and 20.

In order to prevent dislocation of the crystal-electrode assembly, there is interposed between the electrode 24 and contact strips 27 a specially designed spring plate 33 which is shown in detail in Figs. 16 and 17. This spring is fashioned out of spring stock, preferably of the alloy commercially known as "Inconel," and the main body portion is substantially rhombic or diamond shaped and terminates in curved back bearing edges which are straight and parallel. This spring is, in accordance with one of the features of the invention, designed to meet two conditions which are of peculiar importance in the piezo-crystal art. (1) Its force on the crystal must remain constant over a very wide range of ambient temperature e. g., —60° C. to +90° C. (2) It must be able to withstand excessive shocks e. g., those encountered in drop testing of the entire device, without exceeding the elastic limit. I have found that by giving the spring plate the shape shown and by properly proportioning its dimensions, these objects are simultaneously achieved. The spring possesses minimum stiffness or "K," where "K" equals dF/dH, dF/dH being the rate of change of spring force with height H (Fig. 17), for a given length L and width D (Fig. 16). In order to prevent the spring exceeding its elastic limit, its effective height H cannot be reduced below a certain minimum and for this reason the length L is slightly less than the width of the housing cavity. This allows the spring to act as a uniform pressure device over the desired ambient temperature range. In addition when the assembly as a whole is subjected to a shock which tends to reduce the height H below a value that would exceed the elastic limit, the length L increases sufficiently to engage the side walls of the cavity. This effectively limits the reduction in height for excessive shocks. One spring that was found to possess the desired uniform spring pressure and which was protected against excessive shock had the following dimensions when made of "Inconel." Thickness is .007 inch, L is .900 inch, W is .785 inch and stiffness is 29.52 lbs./inch. Such a spring in normal service conditions will operate over a temperature range of —60° C. to +90° C. with a restoring force (for an average fixed height H), which does not change from its normal value (i. e. value at 25° C.–10° C.) when subjected to the said variation in ambient temperature. The assembly is spaced from the bottom of the housing by a Bakelite strip 35, and a similar Bakelite strip 36 engages the top of the assembly. When the cover plate is fastened in place it causes the rubber gasket adjacent the sealing rib to be slightly displaced downwardly to provide a resilient cushion between member 36 and the cover plate.

In assembling the device, the prongs carrying their respective sealing washers are fitted into the opening 2. The T-bolts previously assembled in their contact strips are lowered into the cavity so that the bolts 8 are in registry with the prongs. The latter are then turned to fasten the contact strip rigidly in place. Then the Bakelite strip 35 is dropped into place. The parts 23, 24, 25 and 33, are previously assembled in a special open-ended jig, which can be aligned with the housing cavity and the assembled parts can then be ejected from the jig directly into the said cavity. The Bakelite strip 36 is then placed in position, and then the gasket and cover plate are positioned, whereupon nuts 21 are tightened to seal the cavity.

In the event that the crystal-electrode unit is smaller than the housing cavity, it may be preassembled inside a rectangular mask or frame 40 (Figs. 12 and 13) of Bakelite which closely fits the cavity. The end walls of this frame may be cut away (Fig. 12a) to facilitate removal of the assembly from the holder.

Instead of using a crystal-electrode unit wherein the crystal is clamped between electrodes as in Figs. 1 to 12, the electrodes may be separated along their opposite lateral edges by glass spacers 41, 42 (Figs. 14 and 15), in which event the thickness of the crystal plate is approximately .001 to .0003 inch less than the thickness of the glass spacers 41, 42. Spacers 41, 42, may be of glass, ceramic, quartz or other similar insulating material.

When it is desired to seal the holder with a gas content therein, at atmospheric pressure, the device is assembled as above described and the top cover plate is fastened tightly. Then one of the contact plugs is loosened. The unit can then be flushed under a bell jar and then filled with the desired gas or mixture of gases at atmospheric or slightly higher than atmospheric pressure. The device is then removed from the bell jar and the loosened plug is tightened to seal the gas inside the housing.

While certain specific embodiments have been disclosed, it will be understood that various changes and modifications may be made without departing from the spirit and scope of the invention.

What I claim is:

1. A piezo-electric device comprising a housing of insulation material having one end open for loading a crystal-electrode unit therein, a plurality of metal inserts molded directly into and anchored in the body of the housing adjacent the open end, a sealing gasket and a cover plate of insulation for sealing said end, said metal insert having an external threaded portion adapted to pass through corresponding openings in the gasket and cover, and threaded nuts for said external threaded portions of the inserts for fastening said cover and gasket without subjecting the gasket to twisting.

2. A piezo-electric device comprising a housing of insulation material having one end open for loading the crystal-electrode unit therein, a pair of contact prongs, a corresponding pair of metal contact strips one for each electrode, and a pair of T-bolts for fastening the contact strips internally to respective prongs, the fastening being effected by turning the prongs externally.

3. A piezo-electric device according to claim 2

in which each contact strip has its lower end bent at right angles and provided with an opening for the passage of the T-bolt, the unbent portion of the strip having an opening to receive the end of the bolt head to prevent the bolt turning when the prongs are externally turned for fastening.

4. A piezo-electric device comprising a flattened box-like housing of insulation material, a pair of openings at one end of the housing to receive the internally threaded shanks of a pair of contact prongs, a pair of L-shaped contact strips within the housing, and a pair of T-bolts one for each contact strip for fastening it to a corresponding prong, the contact strips having their main body portions resting flat against opposite interior walls of the housing.

5. A piezo-electric device according to claim 4 in which the external surface of the housing surrounding said pair of openings has circular sealing ribs, and a sealing washer is located between each rib and an integral flange on the corresponding contact prong.

6. A contact plate for end-loaded piezo-crystal housings comprising a metal strip having its lower end bent substantially at right angles, an opening in said bent end to receive a threaded T-bolt, and another opening in the unbent portion to receive the head of the T-bolt whereby said contact plate can be used as a holding tool to locate the bolt with respect to an internally threaded prong, the head of the bolt cooperating with said other opening to allow downward pressure to be exerted on the contact plate during assembly without dislodging the bolt.

7. A piezo-electric device comprising a flattened box-like housing of insulation material, a pair of prongs fitted into one end of the housing, each of the prongs having an internally threaded shank to receive a T-bolt interiorly of the housing, a pair of contact plates having right-angled portions for clamping between the head of the T-bolt and the said threaded shanks, a crystal-

electrode unit within the housing cavity, a rigid spacer strip at the end of the unit and substantially flush with the top open end of the housing, a sealing gasket and cover plate for sealing said open end, and means for fastening said gasket and cover plate comprising metal inserts molded into the housing with upwardly projecting threaded shanks for passage through corresponding openings in the gasket and cover plate, said gasket engaging said rigid spacer strip and acting as a resilient cushion therefor.

8. A piezo-crystal device comprising a housing, a crystal and electrode unit within the housing, and a pressure spring in the form of a bowed plate the main body portion of which is substantially rhomboidal, said spring having smoothly rounded parallel bearing edges which rest against the wall of the housing cavity while the bowed portion presses against one of the crystal electrodes.

9. A piezo-electric device according to claim 2 in which said contact strip is in the form of a metal plate having one section substantially L-shaped in a plane parallel to the housing wall and another section extending substantially at right angles to the first section, the last section being assembled with respect to said T-bolt so that tightening of said bolt causes the first section to be pressed flat against said housing wall.

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