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MOISTUREPROOF HOUSING FOR PIEZOELECTRIC ELEMENTS

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FIG. 1.

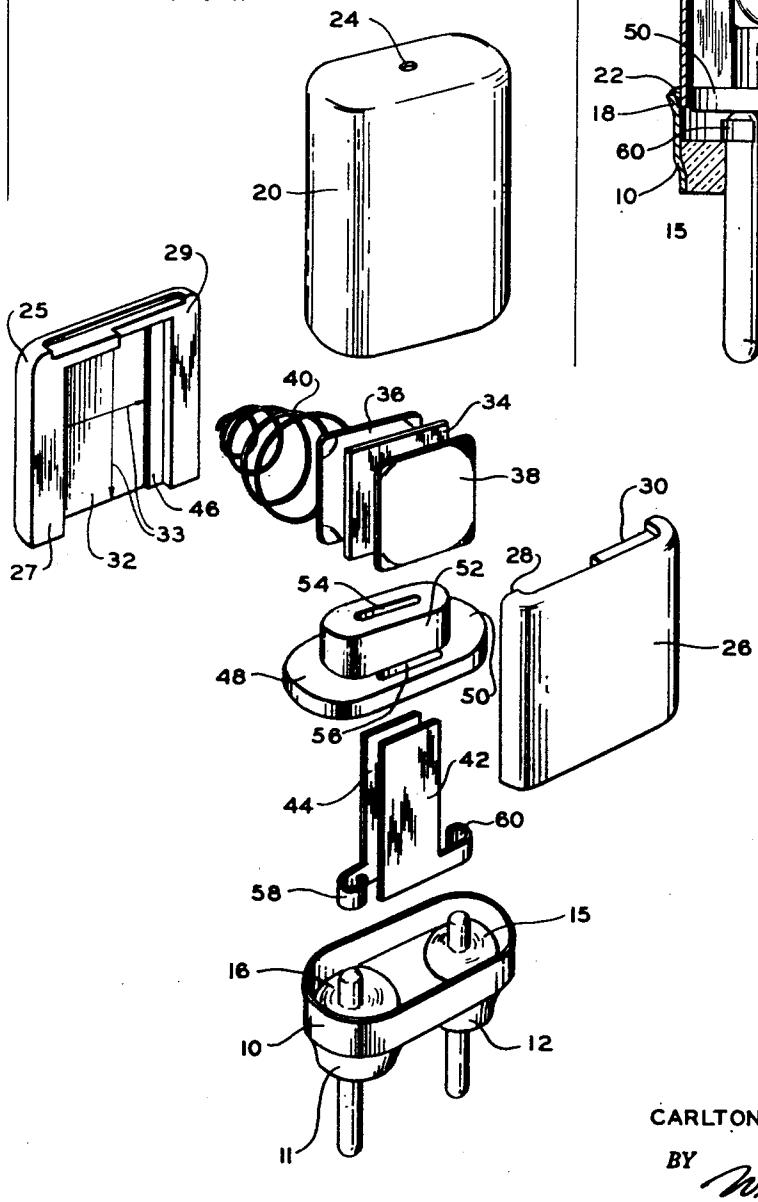
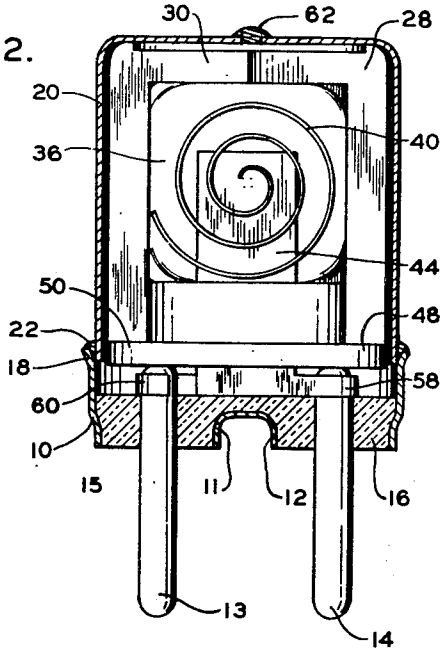


FIG. 2.



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MOISTUREPROOF HOUSING FOR PIEZO-ELECTRIC ELEMENTS

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This invention relates to piezo-electric elements which are used in the communication circuits for stabilizing the frequencies of oscillators and filter circuits; more particularly, the invention relates to a housing for such elements.

With the widening of the frequency spectrum of the carrier frequency waves, the requirements imposed upon the piezo-electric elements, from the point of view of their frequency stability and constancy of their activity, have been increasing at a very rapid rate, and they now reached such a level that even the presence of an insignificant amount of humidity in the housings surrounding and supporting the crystal was found to be detrimental to the maintenance of constant frequency and activity by the piezo-electric elements. Prior to the elimination of the so-called "aging phenomenon" which manifests itself as changes in the natural frequency of vibration and decreasing activity of the piezo-electric elements after completion of the lapping process, the presence of water vapor in the air surrounding the piezo-electric elements had two distinct and independent detrimental effects. One effect was the physical and chemical interactions between the water vapor and the disoriented layer produced on the quartz plates during the lapping process, these interactions producing the above mentioned frequency changes and loss of activity. Evolution of a process for eliminating the aging phenomenon (see U. S. patent application of V. E. Bottom, "Processing of piezo-electric elements," S. N. 575,109), eliminated the disoriented layer on the surfaces of the finished plates, and, as a consequence, eliminated the first effect. However, the second effect of the water vapor still remained, and its elimination became even more important with the aging-free elements, if one were to exploit fully the superior frequency and activity stabilities of the elements produced by the new process. The second effect of the water vapor is as follows: if the moisture present in the air surrounding the piezo-electric plate is allowed to condense on the surfaces of the plate, it acts as a damping means, decreasing the activity of the plate and broadening its frequency response, thus destroying in large measure its usefulness as a frequency control element. This is especially harmful at high frequencies.

The invention discloses a moisture-proof, hermetically-sealed housing for the piezo-electric element and its mountings, so that if the element is assembled in the environment of low relative humidity, it will retain its desirable frequency

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control characteristics, as well as its activity, even when the entire unit is operated under most unfavorable, relative humidities outside the housing. The housing is also provided with an opening for replacing the air within the housing with an inert gas, whereupon the housing is sealed with a metallic seal. When the housing is filled with the inert gas, the humidity factor is eliminated altogether.

Generally, the crystal holders known and used in the communication art are constructed in two parts: one being a base, and the other a hollow cover connected to the base. Sometimes the base is extended so as to form five sides of a box used for holding the piezo-electric plate and its mounting, the cover itself representing a plate fitting into a recess provided for this purpose in the four sides of the box. The box, cover, and base, as a rule, are made of fiber or synthetic resin, the three elements of the unit being made air-tight by providing a gasket between the cover and the box. This type of connection between the box and the cover is not adequate to prevent water vapor from leaking into the unit through the joint, and the synthetic resin used for making the base and the cover, as a rule, is unfavorably affected by high humidity of the surrounding air, so that when the units are exposed to high humidity over a long period of time, the water vapor eventually penetrates the inner chamber of the unit.

The invention discloses a housing for the piezo-electric element which is capable of withstanding exposure to high humidity for an indefinite length of time, thus protecting the resonator and the metallic elements used for mounting this resonator within the housing. The invention also discloses a mounting for the piezo-electric plate, the mounting being particularly suitable for its use in connection with the disclosed housing.

It is, therefore, the object of this invention to provide a moisture-proof housing for the piezo-electric elements.

It is the additional object of this invention to provide a piezo-electric unit including a hermetically-sealed housing filled with an inert gas, and a mounting for the piezo-electric plate fitting into the housing.

The novel features which are believed to be characteristic of the invention are set forth in the appended claims. The invention itself, however, both as to its organization and method of construction, together with the further objects and advantages thereof, may best be understood

by reference to the further description in connection with the accompanying drawing, in which:

Figure 1 is an exploded, perspective view of the unit; and

Figure 2 is an elevational view of the unit with one side of the cover, and one half of the ceramic frame and base removed.

Referring to the drawings, the holder includes a base frame 10 stamped of a "Kovar" metal (54% iron; 28% nickel; 18% cobalt), this metal having the thermal coefficient of expansion equal to the thermal coefficient of expansion of "Pyrex" glass, G–705 F. M. (borosilicate glass). Frame 10 is provided with two cylindrical extensions 11 and 12 for accommodating connecting pins 13 and 14 which are held in the central position within the openings of the frame by glass seals 15 and 16. The glass seals may be made so as to extend across the entire frame 10 in the upper portion of the seal, as illustrated in Fig. 2. The cylindrical extensions 11 and 12 provide positive "seats" between the pins and the frame, the resulting structure possessing the desired rigidity and mechanical strength to withstand the stresses imposed upon them when the unit is inserted and taken out of the radio sockets. "Pyrex" glass, such as G–705 F. M., having the same thermal coefficient of expansion as "Kover" metal, and capable of "wetting" "Kovar" is used for insulatively connecting the frame and the pins to each other, the pins being also made of "Kovar" metal. The upper portion of frame 10 is provided with a flaring-out flange 18 which is so dimensioned that a metallic cap 20 fits into the flaring-out portion of frame 10, as illustrated more clearly in Fig. 2. Cap 20 is made of any noncorrosive material suitable for drawing and stamping operations, such as stainless steel or brass. Upon the insertion of the crystal and crystal mounting into the housing, cap 20 is soldered to base 10 by a soldering joint 22. The housing, therefore, consists of pins 13 and 14, which are secured to frame 10 by means of the glass seals 15 and 16, and cap 20 which is soldered to frame 10. The top of cover 20 is provided with an opening 24 which is used for evacuating the holder therethrough, and filling the holder with an inert gas, such as hydrogen, helium, or neon upon its evacuation, hydrogen, helium, and neon being fairly good conductors of heat and tending to keep the unit dry. The opening also acts as a vent for the expanding air within the housing during the soldering operation of the cover to the frame. Hole 24 is solder-sealed after the unit is filled with gas. The suggested combination of metal and glass, such as "Kovar-Pyrex," is the one that gives especially good results because, as mentioned before, the two substances have the same temperature coefficient of expansion, and it is capable of withstanding abrupt temperature changes without developing any mechanical failures. Moreover, the "Kovar-Pyrex" combination offers certain production advantages, since it does not require any special annealing subsequent to the completion of the sealing operation, and gradual cooling of the seal is all that is required. The invention is not restricted to this particular combination, and, therefore, other metal-to-glass seals may also be used, although their resistance to the thermal shocks, even if annealed, may not be as good as the thermal stability of the "Pyrex-Kovar" combination. The additional materials which may be used for accomplishing the sought results are: "Sylvania" No. 4 alloy (iron-nickel-chrome alloy in combination with "Corning" glass G–1; "Sealmet" of Allegheny Ludlum Steel Company in combination with "Corning" glass G–12, and other metal-to-glass seals known to the art. The all-metal container with a glass seal at its base will not absorb moisture, nor allow any leakage of moisture into the inner chamber of the housing, thus producing a hermetically-sealed crystal housing.

Any desired crystal mounting may be used in connection with the disclosed housing. However, Figs. 1 and 2 disclose a preferred form of mounting which possesses certain advantages outlined below. The mounting consists of a ceramic case formed by two ceramic side members 25 and 26 which, when closed, match each other with the flat surfaces 27, 28, 29, and 30. The side members are so proportioned that they loosely fit into the cover 20 of the housing, as illustrated in Fig. 2. The side members are provided with rectangular recesses, such as recess 32, a similar recess being provided in the side member 26. Mounted between the side members 25 and 26 are a piezo-electric plate 34, stainless steel plate-electrodes 36 and 38, a helical spring 40 and two Phosphor-bronze connectors 42 and 44, the stainless steel plates 36 and 38 contacting the plate, the connector 42 resting between plate 38 and side member 26, while connector 44 is placed between plate 36 and spring 40, as illustrated in Fig. 2, spring 40 maintaining positive contact between the connectors and the steel plates, as well as between the steel plates and the piezo-electric plate. Plate 38 rests on connector 42 whose thickness is slightly greater than the depth of the recesses in the ceramic members 25 and 26 for accommodating them. This recess is illustrated as a flat surface 33 between the side shoulders 46 in the side member 25. The ceramic case, together with its contents, rests on a ceramic base 48 shaped as two integral elliptical disks 50 and 52 provided with two slits 54 and 56 used for passing the electrodes 42 and 44 through the ceramic base, as illustrated more clearly in Fig. 2. The connectors are provided with lugs 58 and 60 which fit over the protruding upper portions of the pins 14 and 13, respectively. Irrespective of the type of crystal mounting used, the pins 13 and 14, or the two conductors connected to them, must protrude into the housing, as illustrated in the Figs. 1 and 2, in order to establish the connections between the mounting and the pins. The lugs, the upper portion of frame 10, and the protruding portions of the pins 13 and 14 are pretinned before the assembly of the unit. The unit is assembled by sliding the piezo-electric plate, the electrodes, and spring 40 into the ceramic case, then sliding the ceramic case into cover 20. Connectors 42 and 44 are then inserted into slits 54 and 56, and ceramic base 48, thereupon, is placed on top of pins 13 and 14, the lugs 58 and 60 fitting over the upper portions of the pins, as illustrated in Fig. 2. Cover 20 is then placed over the ceramic base 48 in such a manner that the upper portions of connectors 42 and 44 slide into engagement with the electrode-plates, and cover 20 slides into the upper portion of frame 10. Soldered joints between frame 10 and cover 20 (joint 18), and pins 13, 14, and lugs 60 and 58 are made in a high frequency furnace, opening 24 acting, during this soldering operation, as a vent hole for the heated expanding air within the holder which is free to escape from the holder without interfering with the formation of nonporous solder joint 18. It has been discovered

that the absence of such a vent hole during the soldering operation forces the heated air to escape through the molten solder of joint 18, thus creating a porous solder joint which is not capable of hermetically-sealing the housing. The next step in assembling the unit consists of evacuating the holder and filling it with hydrogen or any other inert gas (helium, neon argon, etc.), whereupon opening 24 is sealed with a solder seal 62.

The advantages of the disclosed unit may be summarized briefly as follows: it is not affected by external humidity and is capable of maintaining very high, external leakage resistance even when surrounded with air, saturated with water vapor; the unit is capable of resisting mechanical and thermal shocks, the mechanical shocks being absorbed by making the ceramic case as two, split side members 25 and 26 which can displace, with respect to each other and with respect to the housing, against friction. The same is true of the ceramic base 48. Such displacements do not alter the positive nature of the electrical contacts. The split construction of the ceramic case also facilitates the use of precise dies resulting in finer production tolerances. Moreover, assembling of the unit and alignment of the mounting is facilitated by using the disclosed arrangement of parts.

It is believed that the construction of the housing, as well as the advantages thereof, will be apparent from the foregoing description. It should be understood that while the invention has been described in one preferred form reasonable changes and modifications may be made without departing from the spirit of the invention, as sought to be defined in the following claims:

What is claimed is:

1. A piezo-electric unit comprising a moisture-proof, hermetically-sealed housing including a metallic cap and a metallic, glass-sealed base with two connecting pins protruding into said housing through said base; a piezo-electric plate and a mounting for said plate surrounded by said housing, said mounting including a mounting-base resting on the protruding portions of said pins and made of electrically insulating material, and a case made of electrically insulating material, said case resting on said mounting-base and fitting into said cap, said mounting-base and said case forming an inner chamber within said mounting for holding said piezo-electric plate, the electrodes for said plate, and connectors protruding into said chamber through said mounting-base, the upper end of said connectors making electrical contacts with said electrodes, and the lower end of said connectors making electrical contacts with said pins.

2. A piezo-electric unit as defined in claim 1 in which said case comprises two symmetrical side members, and said mounting-base comprises two integral plates, one of said plates resting on said pins, and the other plate protruding into said case so as to act as a support for said piezo-electric plate and said electrodes.

3. A piezo-electric unit as defined in claim 1 which further includes layers of soldering metal deposited respectively on the upper portion of said metallic base, the protruding portions of said pins, the lower ends of said connectors, and the lower portion of said metallic cap, said layers being used for establishing a metallic seal between said metallic cap and said metallic base, and soldered connections between said pins and said connectors.

4. A piezo-electric unit as defined in claim 1 which further includes layers of soldering metal deposited respectively on the upper portion of said metallic base, the protruding portions of said pins, the lower ends of said connectors, and the lower portion of said metallic cap, said layers being used for establishing a metallic seal between said metallic cap and said metallic base, and soldered connections between said pins and said connectors during the soldering operation of said unit, and an opening in said metallic cap, said opening acting as a vent during said soldering operation.

5. A piezo-electric unit as defined in claim 1 which further includes an atmosphere of inert gas filling said housing, and an opening in said metallic cap, said opening acting as a vent during the soldering operation of said cap to said base, and as a means for replacing the air in said housing with said inert gas upon the completion of said soldering operation.

6. A moisture-proof housing for a piezo-electric element comprising a metallic cap and a base, said base including a stamped, metallic frame, said frame forming the external member of said base, the upper portion of said frame making a sliding fit with said cap, and the lower portion of said frame having two bottom openings, two pins for establishing electrical connections of said element, a glass seal filling the bottom portion of said frame, and holding said pins in concentric relationship with respect to said openings, the inner ends of said pins protruding through said glass seal into said housing for establishing said electrical connections with the mountings of said piezo-electric element, said frame, pins, and glass seal having substantially equal thermal coefficients of expansion, and a solder seal between said cap and said frame for making said housing moisture-proof.

7. A moisture-proof housing for a piezo-electric element as defined in claim 6 which also includes an opening in said cap, said opening acting as a vent for expanding heated air within said housing when said solder seal is being made, an atmosphere of inert gas filling said housing, said gas replacing, through said opening, said air upon the establishment of said seal, and a metal seal applied to said opening upon filling said housing with said gas.

8. A moisture-proof housing for a piezo-electric element as defined in claim 6 which further includes hydrogen gas filling and sealed within said housing.

9. A moisture-proof housing for a piezo-electric element as defined in claim 6 which further includes helium gas filling and sealed within said housing.

10. A moisture-proof housing for a piezo-electric element as defined in claim 6 which further includes neon gas filling and sealed within said housing.

11. A moisture-proof housing for a piezo-electric element comprising a metallic cap, a base including a stamped, metallic frame, the upper portion of said frame being dimensioned to make a sliding fit with said cap and the lower portion of said frame having two cylindrical extensions, two pins for establishing electrical connections with said element, a glass seal filling said cylindrical extensions and extending to a level approximately midway between the upper and lower edges of said frame, the upper surface of said seal forming the floor surface of said housing, said seal holding said pins in centrally disposed

relationship within said cylindrical extensions, so as to make the inner ends of said pins protrude through said glass seal into said housing for establishing said electrical connections, said frame, pins, and glass seal having substantially equal thermal coefficient of expansion, and a solder seal applied along the junction line between said cap and said frame, subsequent to the insertion of said element into said housing, for making said housing moisture-proof.

12. A moisture-proof housing for a piezo-electrics element comprising a cap and a base, said base including a frame, said frame forming the external member of said base, the upper portion of said frame making a sliding fit with said cap, the lower portion of said frame having two bottom openings, two pins for establishing electrical connections of said elements, an insulation seal filling the bottom portion of said frame, and holding said pins in concentric relationship with respect to said opening, the inner ends of said pins protruding through said insulation seals into said housing for establishing electrical connection with the mountings of said element, said frame, pins and insulation seal having substantially the same thermal coefficient of expansion, and sealing means between said cap and said frame for making said housing moisture-proof.

13. A moisture-proof housing for a piezo-electric element comprising a cap and a base, said base including a frame, said frame forming the external member of said base, the upper portion of said frame making a sliding fit with said cap, the lower portion of said frame having at least one bottom opening, at least one pin for establishing an electrical connection of said element, an insulation seal filling the bottom portion of said frame, and holding said pin within said

opening, the inner end of said pin protruding through said insulation seal into said housing for establishing electrical connection with a mounting of said element, said pin, frame, and insulation seal having substantially the same thermal coefficient of expansion, and sealing means between said cap and said frame for making said housing moisture-proof.

14. A moisture-proof housing for a piezo-electric-element comprising a cap and a base, said base including external means for receiving said cap, said base having at least one opening therein, and at least one terminal member for establishing an electrical connection of said element, an insulation seal filling said opening and holding said terminal member within said opening, one end of said terminal member protruding through said insulation seal into said housing for establishing electrical connection with a mounting of said element, said base, terminal member, and insulation seal having substantially the same thermal coefficient of expansion, and sealing means between said cap and said base for making said housing moisture-proof.

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