Feb. 20, 1951 E. L. MINNICH 2,542,045

PIEZOELECTRIC CRYSTAL SYSTEM

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FIG. 1

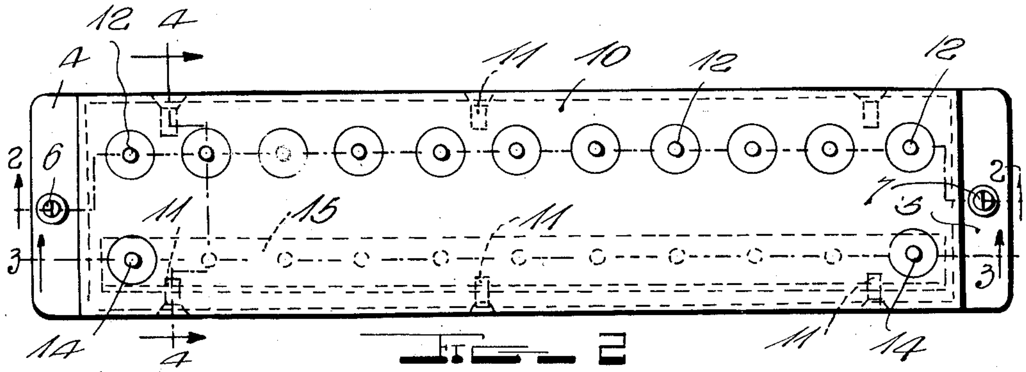



FIG. 2

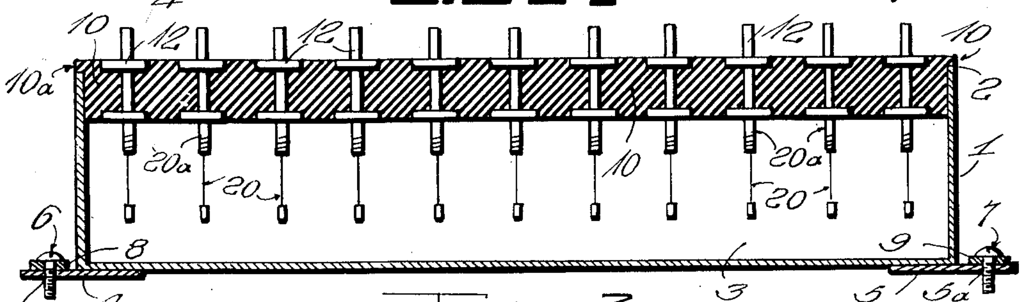



FIG. 3

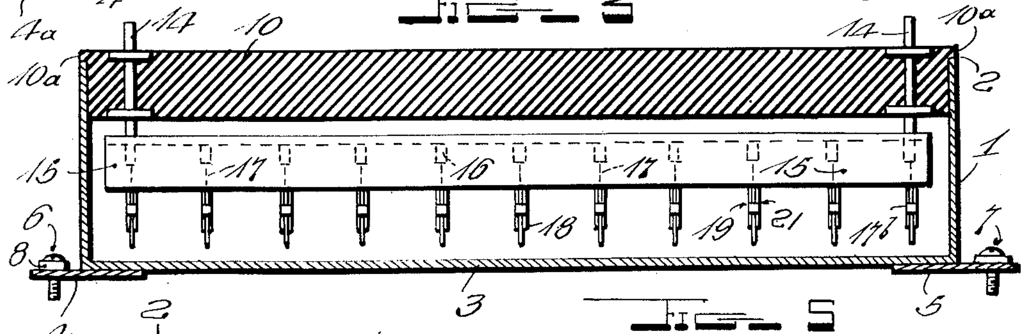
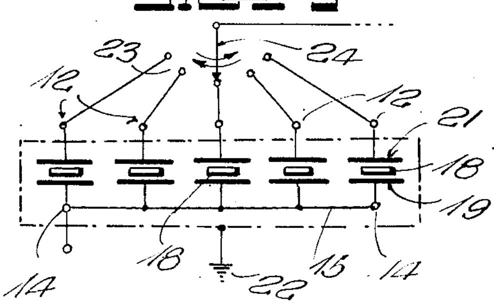



FIG. 5



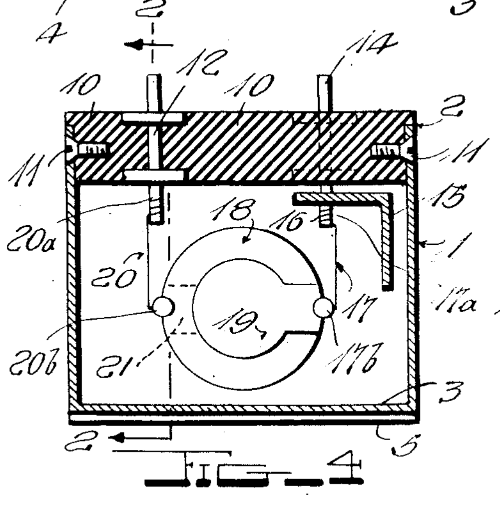




FIG. 4

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FIG. 6

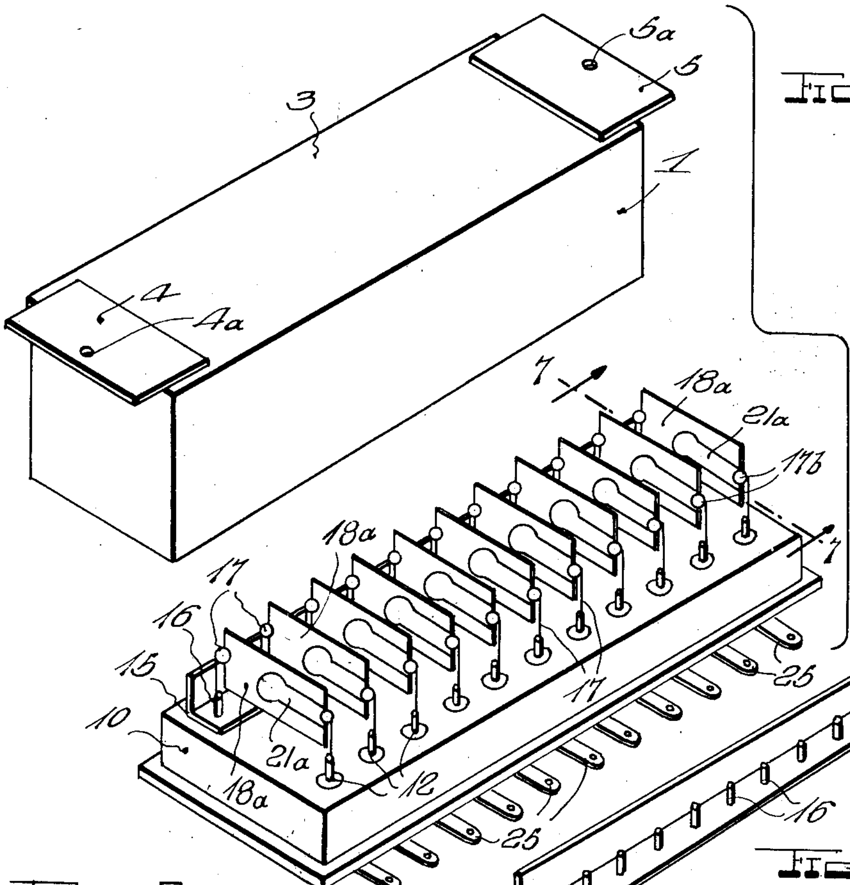

FIG. 8

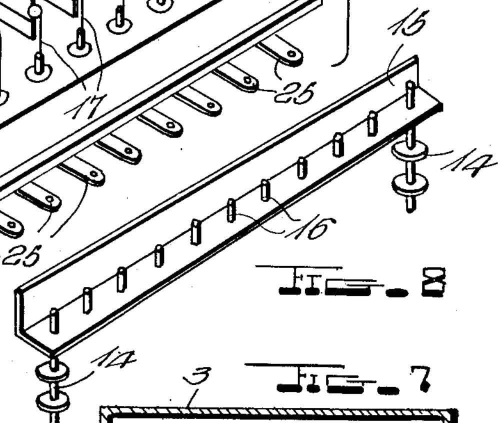

FIG. 9

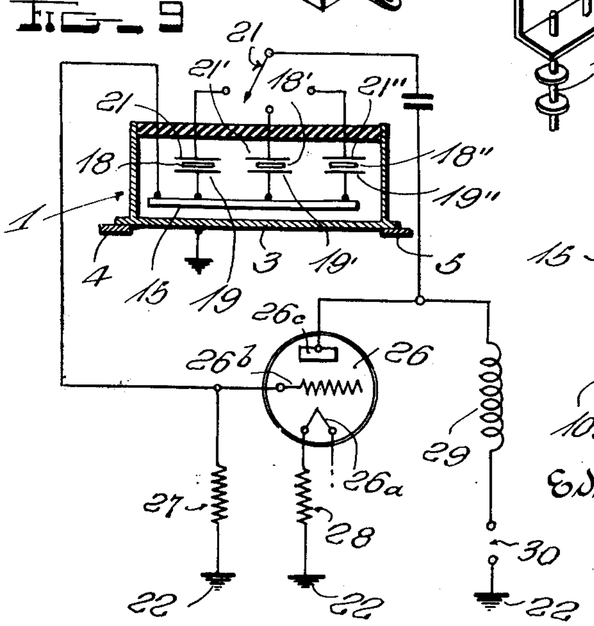

FIG. 7

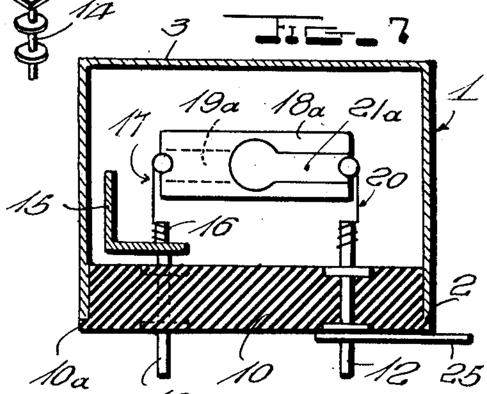

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FIG. 10

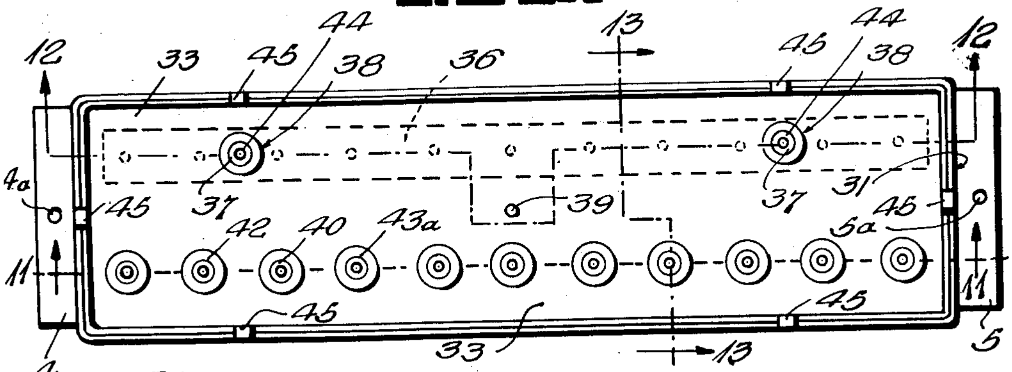

FIG. 11

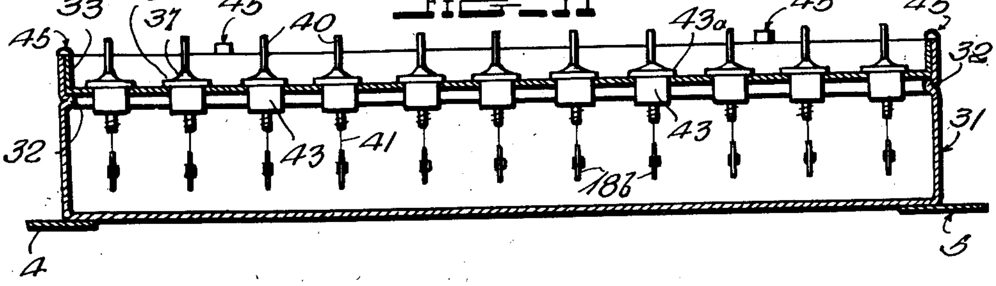

FIG. 12

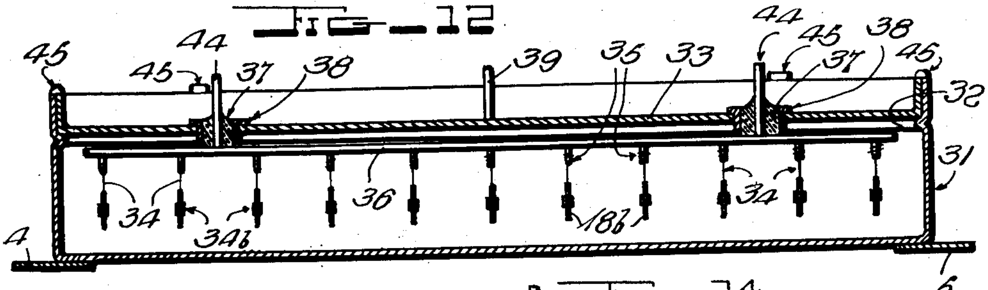

FIG. 13

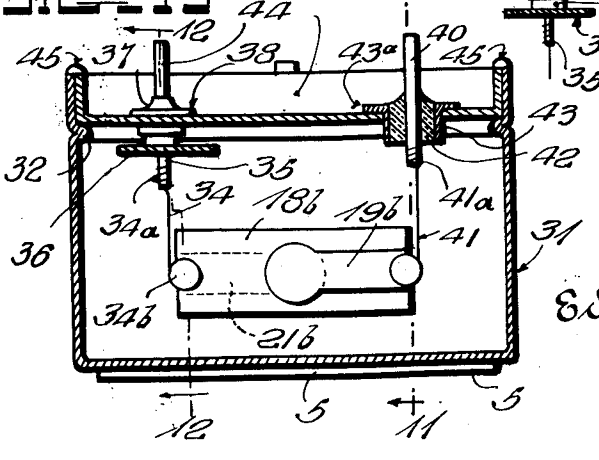

FIG. 14

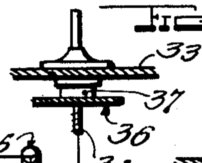

FIG. 15

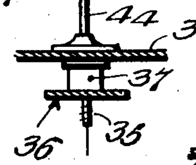

FIG. 16

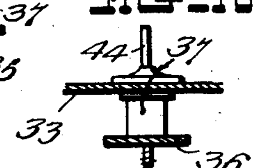

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FIG. 17

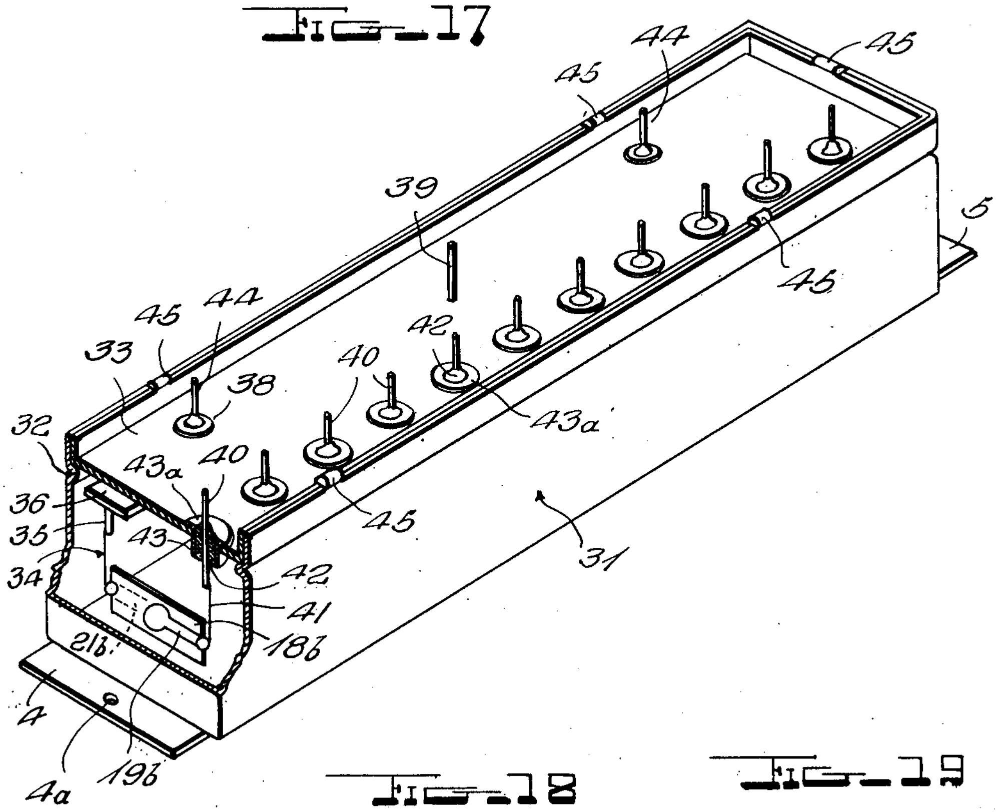



FIG. 18

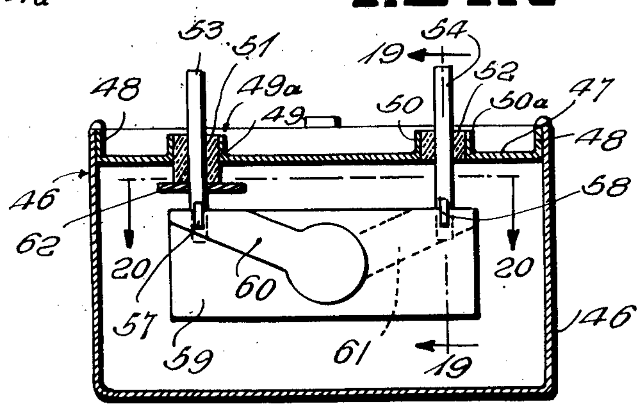
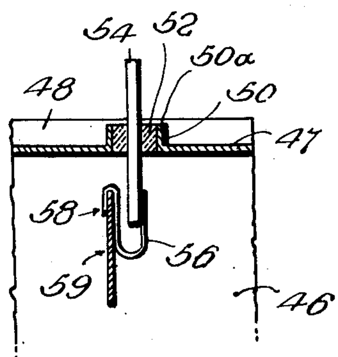



FIG. 19



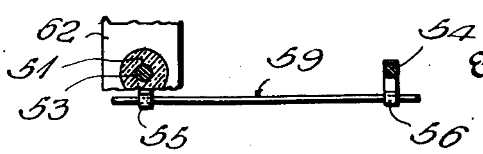




FIG. 20

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Patented Feb. 20, 1951

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# UNITED STATES PATENT OFFICE

2,542,045

## PIEZOELECTRIC CRYSTAL SYSTEM

Edward L. Minnich, Carlisle, Pa., assignor to Selectronics, Inc., Carlisle, Pa., a corporation of Pennsylvania

Application March 7, 1949, Serial No. 79,939

7 Claims. (Cl. 171—327)



My invention relates broadly to piezo electric crystal apparatus and more particularly to a construction of multiple piezo electric crystal holder and mounting means for associating the crystals with electrical circuits.

One of the objects of my invention is to provide an improved mounting means for a multiplicity of piezo electric crystals of different frequency characteristics which may be associated within an extremely small and compact area and selectively employed for controlling various electrical circuits.

Another object of my invention is to provide a mounting means for a multiplicity of piezoelectric crystals within a metallic housing including means for electrically shielding the crystals and capacitatively relating the shielding means to the associated mounting means in such a manner that certain electric condensers normally required in the co-acting electric circuits may be omitted and eliminated, thus saving cost in production of electrical apparatus employing such circuits.

Another object of my invention is to provide a means for mounting a multiplicity of piezo-electric crystals with respect to a supporting plate within a single metallic housing sealed to this supporting plate in a manner that the presence of dust, moisture, and gases will have no effect on the operating functions of the crystal within this metallic housing.

Still another object of my invention is to provide a means for mounting a multiplicity of piezo electric crystals with respect to a supporting plate within a metallic housing in such manner that the crystals are closely associated and yet electrically insulated one from the other for individual selection and operation in co-acting electrical circuits.

Other and further objects of my invention reside in the construction of mounting means for piezo electric crystals as set forth more fully in the specifications hereinafter following by reference to the accompanying drawings, in which:

Figure 1 is a top plan view of the multiple piezo electric crystal holder of my invention; Fig. 2 is a longitudinal sectional view through the multiple piezo electric crystal holder taken substantially on line 2—2 of Fig. 1 and Fig. 4; Fig. 3 is a longitudinal sectional view through the multiple piezo electric crystal holder taken substantially on line 3—3 of Fig. 1; Fig. 4 is a transverse sectional view taken substantially on line 4—4 of Fig. 1; Fig. 5 is a schematic wiring diagram illustrating the manner of selecting the individual piezo electric



crystals in the multiple piezo electric crystal apparatus of my invention; Fig. 6 is a perspective view of the multiple piezo electric crystal holder showing the parts of the holder in juxtaposition ready for assembly in a compact assembly; Fig. 7 is a transverse sectional view taken through the assembled piezo electric crystal holder shown in Fig. 6 with the parts assembled, the view being taken substantially on line 7—7 of Fig. 6; Fig. 8 is a perspective view showing the capacitor element employed within the casing of the apparatus; Fig. 9 is a schematic view showing the circuit arrangement by which certain condensers in the oscillator are compensated for and omitted or eliminated by use of the construction of multiple crystal holder of my invention; Fig. 10 is a top plan view of a modified form of multiple piezo crystal apparatus employing my invention in which individual insulators are employed for insulating the piezo electric crystals from the metallic housing of the piezo electric crystal apparatus; Fig. 11 is a longitudinal sectional view taken substantially on line 11—11 of Fig. 10 and Fig. 13; Fig. 12 is a longitudinal sectional view through the multiple piezo electric crystal apparatus taken substantially on line 12—12 of Fig. 10 and Fig. 13; Fig. 13 is a transverse sectional view taken substantially on line 13—13 of Fig. 10; Figs. 14, 15 and 16 show modified arrangements for fixing the effective capacity of the capacitor that is built into the multiple crystal holder by spacially relating the capacitor strip by differing dimensional amounts with respect to the casing; Fig. 17 is a perspective view of the piezo electric crystal apparatus shown in Figs. 10–13 with parts broken away to illustrate the internal construction more clearly; Fig. 18 is a transverse sectional view through a modified form of multiple piezo electric crystal apparatus embodying my invention; Fig. 19 is a fragmentary longitudinal sectional view taken substantially on line 19—19 of Fig. 18; and Fig. 20 is a horizontal sectional view taken substantially on line 20—20 of Fig. 18.

I have developed the apparatus of my invention to meet the requirements of electronic apparatus employing multiple piezo electric crystals. In certain forms of radio broadcast receivers a multiplicity of piezo electric crystals are employed of the order of twenty-one or more. The problem of mounting such crystals within the allowable extremely small area in such manner that adequate insulation is assured for the individual crystals is a very severe one. I have shown a multiple piezo electric crystal holder herein in which the overall length of the casing constituting the crystal housing for housing eleven crystals is but $4\frac{5}{16}''$, while the overall width of the casing is but $1\frac{1}{16}''$, and the heighth is but $\frac{7}{8}''$.

I provide a construction of multiple crystal holder which assures adequate insulation for the individual piezo electric crystals within the casing which forms an electrical shield. A capacitor member is built into the piezo electric crystal holder and electrically connected with one side of each of the piezo electric crystals and spacially related to the electrical shield constituting the casing. This arrangement when connected with an electron tube oscillator circuit completes a capacitative feed-back path for the oscillation circuit, thereby enabling the feed-back condenser normally required in the oscillation circuit to be omitted and eliminated. This reduces expense in manufacture and production of radio broadcast receivers of the multiple piezo electric crystal type which in a mass production program may involve very sizeable amounts. The apparatus of my invention involves novel mounting means for the individual piezo electric crystals by which adequate support of each of the piezo electric crystals within the shielded housing is assured in a very practical manner. I may employ piezo electric crystals of various cuts and types as typified for example by the circular crystal of Fig. 4 or the rectangle crystals of Figs. 6, 7, 13 and 17, 18, 19 and 20.

Referring to the drawings in detail, reference character **1** designates the metallic shielding container or tank having an open supporting or top peripheral edge **2** with a closed metallic bottom **3**. Extension lug members **4** and **5** are secured to opposite ends of the external face of the closed bottom **3** of the shielding container **1**. The lugs **4** and **5** each contain apertures **4***a* and **5***a* that permit the passage of securing screws **6** and **7** which extend through the washers **8** and **9** and enter the supporting surface such as the chassis of associated electronic apparatus, which may be a radio receiver and the like.

A panel formed from insulation material **10** having a peripheral flange **10***a* thereon enters the open end **2** of the tank **1** and is secured with respect to the tank **1** by appropriate securing screws **11**. I mount a multiplicity of terminal posts **12** corresponding in number to the number of piezo electric crystals supported in the holder on the panel of insulation material **10** in a row extending longitudinally of the holder as shown in Figs. 1 and 2.

In positions transversely opposite each of the end terminal posts in the row of terminal posts **12** I provide terminal posts **14** insulatingly and spacially related thereto. Terminal posts **14** serve as supports and electrical connectors for the capacitor strip **15** which extends longitudinally of the casing **1**. The strip **15** is formed from metal stock approximately .040″ to .050″ thick and $\frac{1}{4}''$ wide. In the dimensional example heretofore given this strip is approximately 4″ in length. In the form of my invention shown in Figs. 1–8 the capacitor strip **15** is in the form of an angle with one side thereof, approximately $\frac{1}{4}''$ wide, extending in spacial capacitive relation with the side of metallic container **1**. This forms a condenser in the circuit path of each of the crystals. Small studs **16** are welded or otherwise secured to strip **15** and project therefrom in an upright position serving as supports for springs **17**. In the dimensional example heretofore referred to these studs are spaced approximately $\frac{3}{8}''$ apart which permits mounting of a plurality of spaced crystals within the container **1** without mutual contact. Springs **17** connect with one of the ends of the several piezo electric crystals **18** shown in Fig. 4 and establish electrical and mechanical connection with electrode **19** thereon. The other ends of the piezo electric crystals **18** are supported in springs **20** projecting from terminal posts **12** and establishing electrical and mechanical connection with electrodes **21** on the opposite faces of the crystals.



The terminal posts **12** and **14** have annular flanges thereon that are embedded in the insulation material of panel **10** for solidly anchoring the posts in the panel. The posts **12** and **14** project through the material of panel **10** and provide external connection means to the electronic oscillator system outside of the casing **1**. The terminal posts **14** adjacent opposite ends of casing **1** serve as both electrical connecting means and mechanical supports for the strip **15**.

The springs **17** and **20** which serve as supporting members for the individual piezo electric crystals **18** comprise coils of spring wire **17***a* and **20***a* which respectively embrace the inwardly directed studs **16** and the inwardly directed terminal posts **12**. The other ends of springs **17** and **20** terminate in looped or coiled ends **17***b* and **20***b* disposed in the same plane in spaced positions within the container **1** to grip the electrodes of the piezo electric crystal **18** therebetween.

Each piezo electric crystal **18** has the opposite conductive electrodes **19** and **21** which are secured to opposite faces of the piezo electric crystal intimately connected with the spring wire loops or coils **17***b* and **20***b* by low melting point metal which assures a rigid mechanical support between the spring wires **17** and **20** and the piezo electric crystal **18** and a highly conductive electrical connection with the electrodes **19** and **21** of the crystal **18**. This connection is so sturdy and reliable that even though the multiple piezo electric crystal holder is subjected to very substantial vibration or in fact, mechanical shock, the crystals are retained in the grip of the spring wire coils or loops **17***b* and **20***b*.

In Fig. 5 I have illustrated the circuit arrangements for the piezo electric crystal elements from which it will be noted that one longitudinal row of terminals is constituted by capacitor strip **15**, capacitatively related to the metallic wall of container **1** which is grounded at **22**. The other row of terminals is constituted by spaced terminal posts **12** which individually connect with the opposite sides of each of the piezo electric crystal elements. The several piezo electric crystal elements connect to contacts arranged compactly in the arc of a circle as represented at **23**, over which the switch arm **24** operates to select a particular piezo electric crystal from the group of piezo electric crystals **18**. In Fig. 5 I have schematically shown only five piezo electric crystals but it will be understood that any multiple number of such elements may be employed.

In Fig. 6 I have shown the shielded container **1**, removed from the panel **10** of insulation material and disposed in juxtaposition with respect thereto, and showing in perspective view the piezo electric crystal elements which are normally housed within the container. The piezo electric crystal elements in this arrangement are rectangular, as shown at **18***a*, instead of circular as shown in Fig. 4 at **18**, but all other details are arranged as explained in connection with Figs. 1–5. The posts **12** in this arrangement are illustrated as having solder lugs 25 connected to the externally projecting stems of the terminal posts and extending in spaced relation beyond the periphery of the panel 10 for permitting individual electrical connection to be readily made thereto. The electrodes on the surfaces of the piezo electric crystals are arranged in a manner explained in connection with Fig. 4 but by reason of the rectangular shape of the crystals the electrodes are elongated as represented at 19a and 21a of Figs. 6 and 7.

Fig. 7 illustrates on a somewhat larger scale the manner in which the rectangular piezo electric crystals are spacially disposed within container 1 while capacitative coupling is established between strip 15 and the metallic wall of container 1.

In Fig. 9 I have represented the electrical circuit of the electron tube oscillator which is associated with the multiple piezo electric crystals within the container 1. The metallic wall of the metallic container or tank 1 forms one capacity area of an electrical condenser in co-action with the capacitor strip 15. Electron tube oscillator 26 is schematically shown as including cathode 26a, control grid 26b and an anode 26c. The control grid 26b is connected in the input circuit of the oscillator through the impedance 27 to ground 22. Cathode 26a is connected through impedance 28 to ground 22. Anode 26c is connected with the output circuit of the oscillator including radio frequency choke coil 29 and high potential source indicated at 30, and ground connection 22. The piezo electric crystal element represented at 18, 18′, 18″, etc. have the electrodes 19, 19′, 19″ etc., thereof, respectively connected to capacitor strip 15.

The electrical capacity between electrodes 19, 19′, 19″ and the metallic container 1 is established by the spacial relation of metallic strip 15 and the metallic wall of the container 1. The electrical capacity thus provided constitutes a feed-back path for oscillations between the input and output circuits of the oscillator 26. This capacity compensates for and takes the place of an external condenser which must normally be included in the input circuit of the oscillator in shunt with impedance 27 in the input circuit. Accordingly, by spacially relating capacitor strip 15 to metallic container 1 internally of the container, the essential feed-back capacity may be provided between the input or output circuits of the oscillator without the necessity of installing the separate condenser normally required. This results in a very appreciable saving in a manufacturing and production program where many thousands of such condensers would be required.

In Figs. 10–20 I have shown a modified form of multiple crystal holder embodying my invention in which the metallic housing 31 is substituted for the shielding container or tank 1. The metallic housing 31 has a peripheral bead 32 adjacent the extremity of the edge thereof which provides a peripheral seat for the inverted metallic pan member 33.

The inverted metallic pan 33 is peripherally supported by the peripheral seat 32 when the pan 33 is frictionally forced into the housing 31. The pan 33 forms a support for the multiplicity of piezo electric crystal elements. In this arrangement one row of piezo electric crystal element supports represented by the resilient wire-like spring elements 34 are attached by coils 34a to studs 35 depending from capacitor strip 36 and terminate in loops 34b which embrace the ends of piezo electric crystal elements 18b for establishing electrical connection with the electrode surface 19b and 21b as represented in Fig. 13. The capacitor strip 36 is insulatingly and spacially mounted with respect to pan 33 by means of terminal posts 44 that pass through bushings 37 of insulation material supported in sleeve-like bushings 38 extending through the pan 33. A common terminal connection for the container 31 projects from the rear of pan 33 as shown at 39. The co-acting opposite terminals for each of the multiple number of piezo electric crystal elements are insulated from the metallic pan 33.

Terminal posts 40 individual to each of the resilient wire-like members 41 are gripped by the coiled ends 41a of the resilient wire-like members 40 as shown in Fig. 13. The terminal posts 40 pass through bushings formed by insulation material 42 carried in sleeve-like members 43. The sleeve like members 43 each have annular flanges 43a thereon and are seated in a longitudinally extending row of apertures provided in pan 33. The insulation material 42 is vitreous or is formed from composite insulation material and substantially insulates terminal post 40 from contact with metallic sleeve 43 or metallic pan 33. The terminal posts 40 project beyond the peripheral limits of pan 33 and enable electrical connections to be made thereto for completing circuits to the individual piezo electric crystal elements.

The opposite extremities of the metallic housing 31 or the pan 33 may be rolled over to provide a peripheral interlocking joint, or spaced lugs 45 may be provided on housing 31 and may be rolled over the peripheral edge of pan 33 to secure pan 33 is position against peripheral seat 32 and within housing 31.

The same method of mounting the metallic housing 31 is provided as is employed in the arrangement of Figs. 1–8; that is, lugs 4 and 5 are perforated at 4a and 5a for the passage of securing screws.

The electrical capacity referred to in Fig. 9 is inherently provided in the multiple piezo electric crystal holder of Figs. 10–13, eliminating and replacing feed-back condenser normally required in the oscillator circuit. In order that different values of capacity may be provided within the crystal holder I may selectively fix the length of insulation bushings 37 as represented in Figs. 14, 15 and 16 to fix the spacial relation of capacitor strip 36 and the metallic pan 33. For example, the short bushing 37 in Fig. 14 provides a relatively high capacity value; the bushing 37 of greater length shown in Fig. 15 provides a capacity of lower value, while the bushing 37 of the longest length as shown in Fig. 16 provides an effective capacity within container 31 of the smallest value.

The manner of supporting the piezo electric crystals in the form of my invention illustrated in Figs. 10–13 is the same as that described in connection with the form of my invention shown in Figs. 1–8, and I have applied similar reference characters to corresponding parts of the crystal and the electrodes thereof by adding the subscript a to the crystal and the electrodes thereof.

In Figs. 18–20 I have illustrated a further modified form of multiple crystal holder in which a metallic housing 46 is provided, closed on all sides except one which is closed by a metallic pan 47 having a peripheral edge 48 operative to engage the edge of housing 46. The pan 47 is apertured in transverse aligned positions at 49 and 50 with outstruck sleeves 49a and 50a co-extensive with the pan 47. The sleeves 49a and 50a are filled with insulation material 51 and 52 forming supports for the pin members 53 and 54.

The pin members 53 and 54 each carry spring strips on the ends thereof as represented at 55 and 56. The spring strips 55 and 56 are each folded upon themselves to form spring clamping jaws 57 and 58. These spring clamping jaws grip and engage opposite sides of the piezo electric crystal which in this instance is represented by reference character 59 with opposite electrodes 60 and 61 thereon. The electrodes 60 and 61 extend from the center of crystal 59 to opposite corners serving as a metallic coating which is gripped by the spring clamping jaws 57 and 58. Solder or low melting point metal is applied between the metallic electrode 60 and spring jaw 57 and between metallic electrode 51 and spring jaw 58 for electrically and mechanically maintaining the piezo electric elements in position in the multiple piezo electric crystal holder. This clamping method is comparable to the clamping method employing the spring coils or loops of Figs. 1–13, in that the piezo electric crystal elements are maintained in position and cannot be accidentally or readily shaken or displaced from the securing means.

The capacitor strip 62 is mounted on pin members 53 spaced from pan 47 by the insulation supports 51 in capacitative relation to the underside of pan 47. An electrical circuit grounded to the metallic housing 46 inherently places the electrical capacity existent between the ground and one of the electrodes of the piezo electric crystals in shunt with the input circuit of the oscillator in the manner explained in connection with the circuit of Fig. 9.

With the advent of piezo electric crystal apparatus functioning on many closely adjacent frequencies in multiple signaling channels, the importance of the multiple piezo electric crystal apparatus of my invention will be appreciated. The large number of individual piezo electric crystal elements of different frequency characteristics may be mounted within an extremely small space on racks or adjacent an apparatus chassis for efficiently providing for the selective operation of numerous electrical circuits on closely adjacent frequencies.

One of the advantages arising out of the application of the multiple crystal holder of my invention results from the fact that it is difficult and costly to finish a crystal to a precise frequency, and the wider the finishing tolerance, the lower the production cost. Crystals which cover the broadcast band may be ground to a relatively wide finish frequency tolerance by controlling the amount of plating on the surfaces of the crystals, and then grouping or classifying these crystals as to the number of cycles to which they may be high or low with respect to the precise frequency or desired frequency. The crystals may be classified in at least three groups, as being high, medium (or on), and low, and may include two other classifications, as extremely high and extremely low frequency tolerance crystals.

An oscillator circuit does have some influence on the frequency of the crystal, and if the grid to ground capacity of a Pierce oscillator, for example, is varied the frequency is changed appreciably and may bring the crystals into tolerance, providing they are finished at some frequency not too far removed from the desired frequency. If the crystal is higher than the desired frequency



the capacity would be increased across the grid to ground. Conversely, if the crystal frequency is lower than the desired frequency, the capacity is reduced.

From the foregoing it will be understood that the holder may be made in three to five steps with respect to the value of this built-in capacitor, which is connected between the grid of the oscillator and the ground. The crystals noted as "high" or "extremely high" are put in holders with the maximum value of inbuilt capacity. The crystals classified as "low" or "extremely low" are put in a holder with the minimum capacity, and those crystals classified as "medium" or "on" would go into a holder with an average or medium value of capacity. As hereinbefore stated this makes the finishing operation a little more simple, thereby reducing manufacturing costs. This is a substantial advantage to the crystal manufacturer and can be passed on to the customer in lower price.

While I have described my invention in certain of its preferred embodiments I realize that modifications may be made in the arrangement of parts and elements of the apparatus and I desire that it be understood that no limitations upon my invention are intended other than may be 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 multiple piezo electric crystal apparatus comprising in combination, a metallic electrically conductive housing closed on all sides except one, a plate member of insulation material fitting into the open side of said housing, a multiplicity of supports projecting from said plate member in spaced, substantially parallel relation into a position interiorly of said housing, a multiplicity of piezo electric crystal elements carried by said supports and terminal members extending from said supports to a position externally of said housing for providing an electrical connection with said piezo electric crystal elements.

2. A multiple piezo electric crystal apparatus comprising in combination, a metallic housing open at one side thereof, a multiplicity of piezo electric crystal elements supported in spaced substantially parallel planes within said housing, a plate member closing one side of said housing, a metallic capacitor disposed within said housing and coacting with one side of said housing and with said piezo electric crystal elements.

3. In a multiple piezo electric crystal holder, an electrically conductive housing open at one side thereof, a supporting base of insulating material closing said open side, a pair of spaced terminal members carried by said base, a metallic member disposed within said housing and having a plane surface extending substantially parallel to one of the inner faces of said electrically conductive housing, pin members projecting from said member, resilient wire-like members secured to said pin members, resilient loops on the ends of said wire-like members, independent terminal members mounted on said base, resilient wire like members secured to said independent terminal members, resilient loops on said last mentioned wire-like members, and piezo electric crystals having opposite electrodes gripped by said resilient loops.

4. In a piezo electric crystal holder, a base of insulation material, an electrical shield fastened to said base, terminal members embedded in said base, inwardly directed pins on said terminal

members, resilient wire-like members carried by said pins, resilient loops on said wire-like members, coacting terminal members embedded in said base, a metallic strip mounted on said last mentioned terminal members and having a coextensive portion disposed in substantially parallel spaced relation to a portion of said electrical shield, pins carried by said strip, resilient wire-like members carried by said last mentioned pins, resilient loops on said last mentioned wire-like members directed toward said first mentioned resilient loops in coplanar relation thereto, and piezo crystals having electrodes on opposite faces thereof gripped between said loops and establishing electrical connection with the respective terminal members.

5. In a piezo electric crystal holder a metallic housing open at one side thereof, a metallic base telescopically engageable within the open side of said metallic housing, terminal members insulatingly supported in said metallic base and projecting into said metallic housing, a capacity area carried by one of said terminal members in a position inside said metallic housing and spacially related to said metallic base, a piezo electric crystal having electrodes on opposite faces thereof and resilient engaging means carried by said terminal members for supporting and establishing electrical connection with said piezo electric crystal, said capacity area forming with said metallic base a predetermined electrical capacity.

6. In a multiple piezo electric crystal holder, a metallic housing open at one side thereof, a metallic base telescopically engageable within the open side of said housing, a longitudinally extending linear row of bushings of insulation material projecting through said metallic base at spaced intervals, metallic terminal members projecting through the bushings in the said row and directed inwardly into said housing, resilient means on the ends of said terminal members, a pair of bushings of insulation material disposed in said base in spaced transverse alignment to the aforesaid bushings, separate metallic terminal members disposed in said last-mentioned pair of bushings, a metallic member supported on said last-mentioned terminal members and insulated from said metallic base, resilient means supported by said metallic member and directed inwardly into said housing and respectively in transverse alignment with the aforesaid resilient means, and piezo electric crystals extending transversely of said housing and gripped in mechanical supporting and electrical relation by said resilient means in closely adjacent substantially parallel planes.



7. In a multiple piezo electric crystal holder, a metallic housing open at one side thereof, a metallic base telescopically engageable within the open side of said housing, two longitudinally extending rows of bushings of insulation material projecting through said metallic base, the bushings in one of said rows being disposed at spaced intervals, while the bushings in the other row comprise a single respective bushing in transverse alignment with the end bushings in said first-mentioned row, metallic terminal members projecting through the bushings of said first-mentioned row and directed inwardly into said housing, separate metallic terminal members disposed in the bushings of the other of said rows in transverse alignment with the end terminal members in said first-mentioned row and insulated from said metallic base, a capacitor strip mounted on said last-mentioned terminal members and extending in spaced substantially parallel insulated relation to said metallic housing, resilient means supported by each of said terminal members and said capacitor strip, and piezo electric crystals extending transversely of said housing and gripped in mechanical supporting and electrical relation by said resilient means in closely adjacent substantially parallel planes.

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