

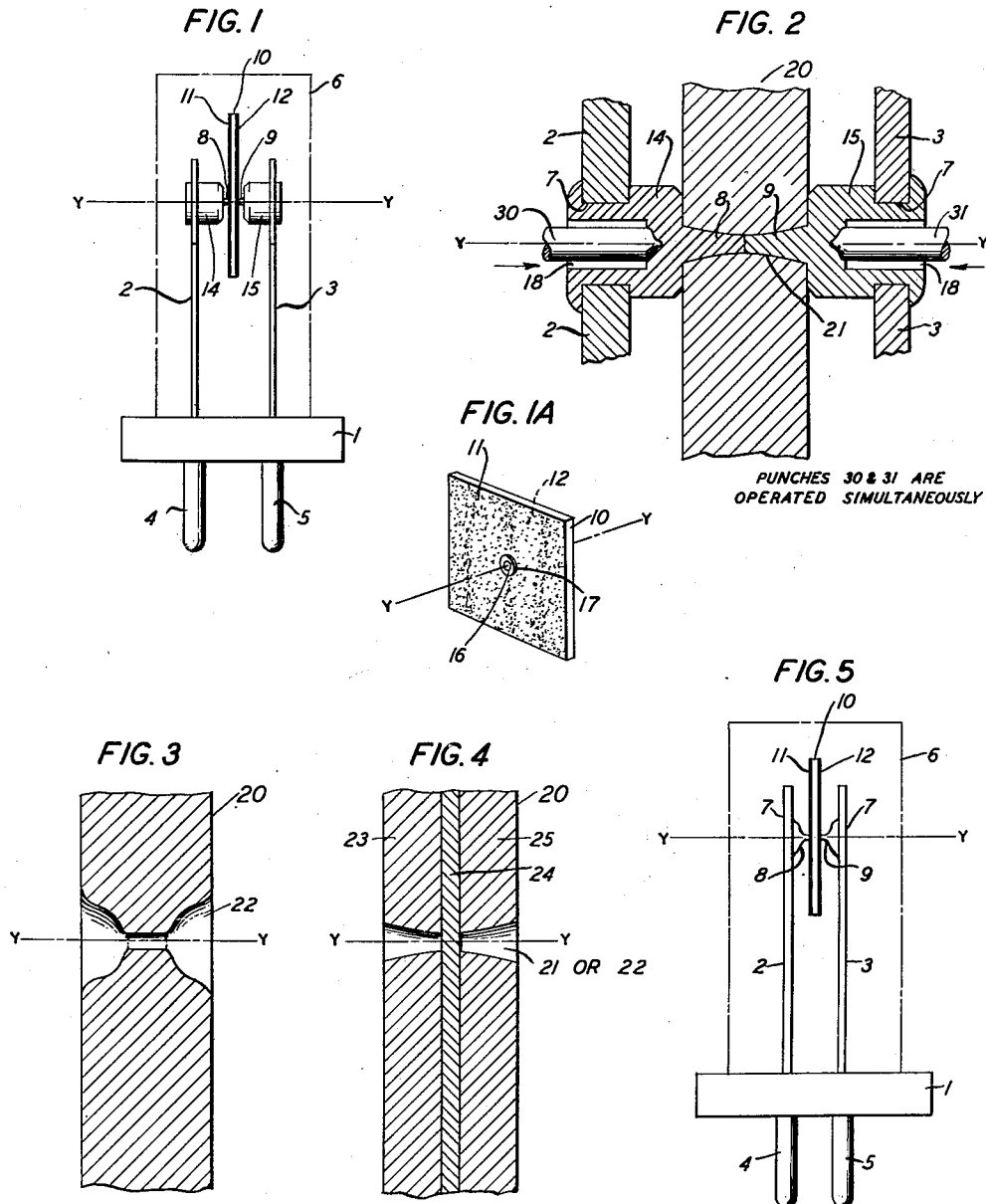
Nov. 27, 1951

J. F. BARRY
ELECTRIC CONTACTS

2,576,437

Filed May 10, 1946

3 Sheets-Sheet 1

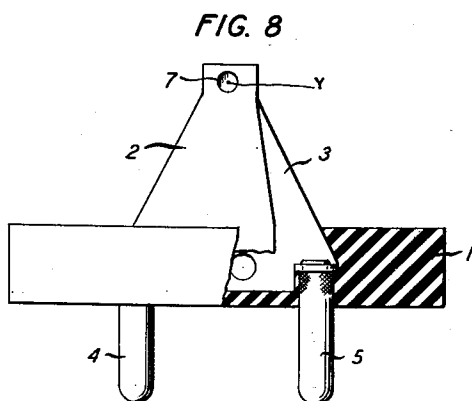
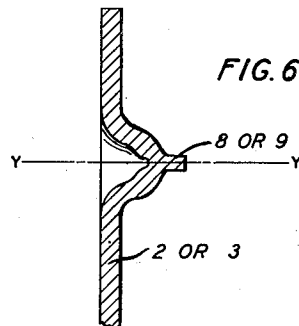
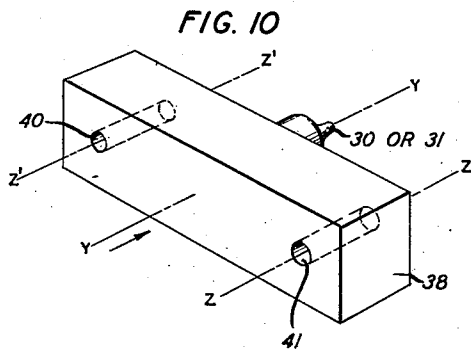
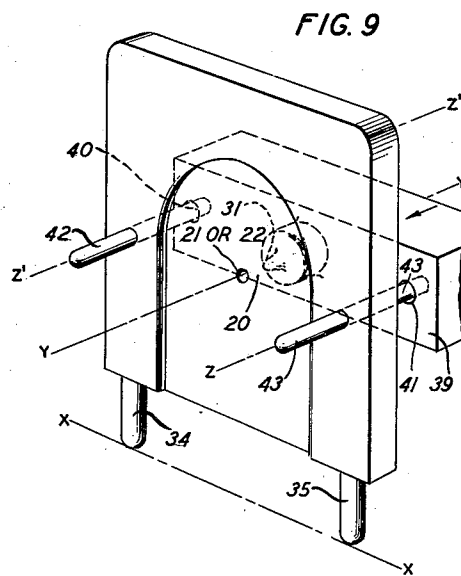
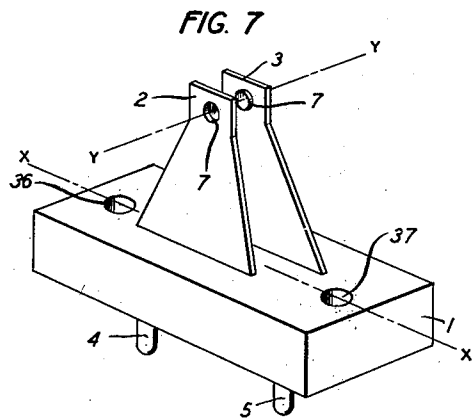


INVENTOR
J. F. BARRY
BY *W. J. O'Neill*
ATTORNEY

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ELECTRIC CONTACTS

3 Sheets-Sheet 2



INVENTOR
J. F. BARRY
BY *W. J. O'Neill*
ATTORNEY

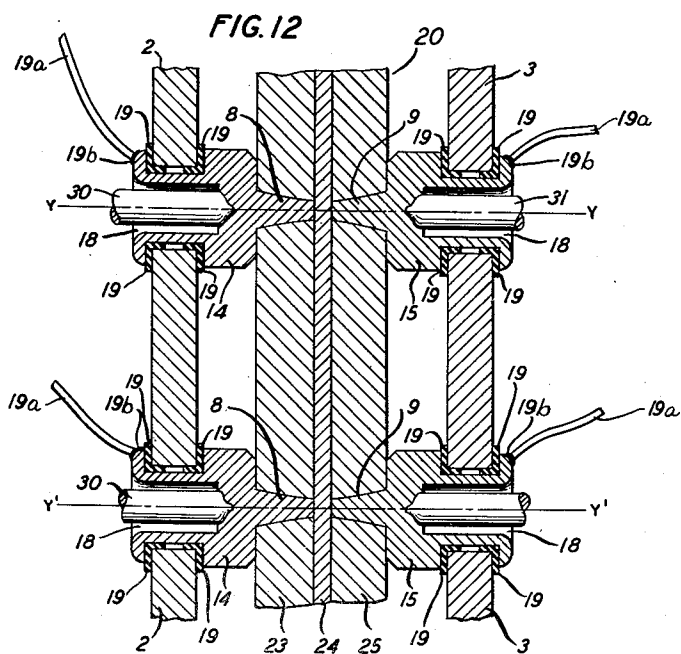
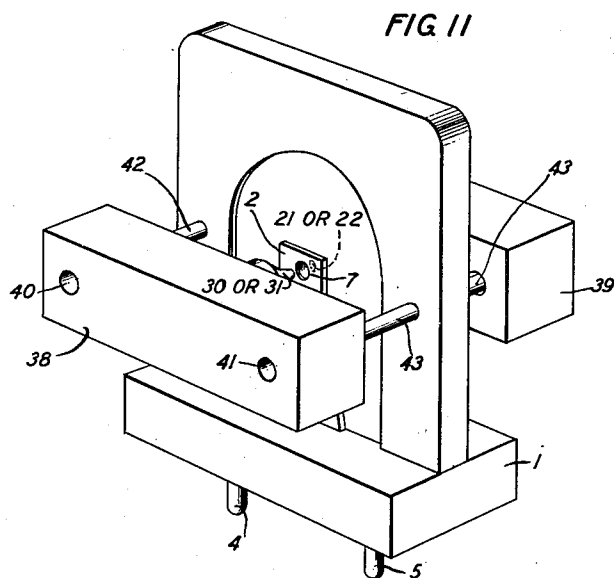
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J. F. BARRY
ELECTRIC CONTACTS

2,576,437

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3 Sheets-Sheet 3



INVENTOR
J. F. BARRY
BY *W. J. O'Neill*
ATTORNEY

UNITED STATES PATENT OFFICE

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ELECTRIC CONTACTS

Joseph F. Barry, Summit, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

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2 Claims. (Cl. 78—17)

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This invention relates to electric contacts and particularly to extruded contacts adapted for use in mounting a quartz or other piezoelectric crystal body, or for use as electrical contact elements generally.

One of the objects of this invention is to insure a predetermined alignment or arrangement for contact elements.

Another object of this invention is to provide aligned contact elements formed from the contact supporting material itself.

Another object of this invention is to provide oppositely extruded clamping pins suitable for mounting a piezoelectric crystal body.

Another object of this invention is to provide a fixed reference axis, as with respect to the base of the crystal holder, for not only locating the axis of the extruded contact elements but also for allowing crystal elements of different square face dimensions to be readily centered about the same fixed axis referred to, when the crystal element is assembled between the extruded contact elements by means of a suitable fixture.

Another object of this invention is to provide an improved pressure type crystal mounting suitable for mass production and having good mechanical and electrical performance.

For mounting and establishing electrical connections with quartz and other piezoelectric crystal elements, it is often advantageous to employ one or more pairs of oppositely disposed clamping points or pins between which the electroded crystal element may be firmly and resiliently clamped under sufficient pressure, applied by a suitable spring or pair of springs, to prevent bodily movement or displacement of the crystal element out of its clamped position.

In such pressure type crystal clamping arrangements, it is desirable that the aligned clamping contact pins or elements be disposed exactly or precisely opposite each other for such reasons as to reduce distortional strains in the crystal element itself as a result of small bending moments that may be occasioned by non-aligned clamping contact points, to permit very small clamping areas to be used where it is desired to contact a small crystal element only at or as near as possible to the node thereof, and for other reasons.

In such pressure type mounting arrangements, various means have been resorted to heretofore in order to align or adjust the relative positions of the pair of clamping contact pins in opposite positions with respect to each other. For ex-

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ample, the springs carrying the clamping pins have been made adjustable in the two transverse directions in order to adjust the position and align the clamping pins oppositely, the final clamping pins have been staked and soldered in oppositely aligned holes in the springs, and other arrangements have been resorted to with the object of providing easily, quickly and cheaply a pair of clamping contacts that might be relied upon in mass production to obtain precisely opposite contacts at all times.

In accordance with this invention, the electroded crystal body may be mounted between a pair of extruded contact points or pins which are exactly or precisely aligned with respect to each other and which may be composed of any suitable cold-flowing metallic conductive material soft enough to be imbedded, under spring pressure, in the small irregularities occurring in the surface of the electroded crystal plate. To obtain the desired result of an exact or precise alignment of the pair of contact points, the pair of contact points may be simultaneously extruded into the same cavity of a suitable die, one contact point being extruded from each side of the die, whereby an exact or accurate alignment of the pair of contact points is insured, with none but rough tolerance necessary in the over-all fabrication of the mount since the contact points may be extruded as a last or final step in the fabrication thereof. Accordingly, close tolerances in other parts of the mount are not necessary in the manufacture of the unit since the end requirement of contact point alignment is met automatically by proper design of the die. Moreover, uniformity of product may be obtained in mass production since extra work is not necessary by the operator in order to obtain good mechanical and electrical stability and a good reactance-resistance ratio Q for the mounted crystal body. An advantage of special interest is that the alignment as well as the shape and size of the contact pins or points may be obtained directly by proper design of the die, rather than by subsequent adjustment of component parts of the crystal mount, to obtain a precise alignment of the contact points.

The extruded clamping pin type of pressure mounting provided in accordance with this invention is suitable for continuous line assembly manufacture with a minimum of waste in processing. Should a completed crystal unit fail because of a defective crystal, the crystal may be discarded and the mount reused. Conversely, if a particular mount is defective, the crystal

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may be salvaged and used again without re-processing. The assembled unit has good mechanical and electrical properties, and is free from such electrical troubles as cavity resonances.

While this invention is described particularly in connection with a method of securing the precise alignment of contact points for holding a crystal body with reference to the center line of the contact points, it may be applied to contact points for mounting other types of vibrating systems, and to contact points generally where a precise alignment or arrangement of contact members is desired to be obtained, especially where large scale production is concerned.

For a clearer understanding of the nature of this invention and the additional advantages, features and objects thereof, reference is made to the following description taken in connection with the accompanying drawing, in which like reference characters represent like or similar parts and in which:

Fig. 1 is an edge view of a crystal unit provided with extruded metal contact pins between which the crystal body is clamped;

Fig. 1a is a perspective view of an electroded crystal element provided with a centering washer on each major face thereof;

Fig. 2 is an enlarged sectional view of the extruded metal contact members shown in Fig. 1, and of a punch and die section which may be utilized to extrude such contact members;

Figs. 3 and 4 are enlarged sectional views, illustrating alternative forms of cavity arrangements for the die section shown in Fig. 2;

Fig. 5 is an edge view of a crystal unit which is similar to that shown in Fig. 1 but which is provided with crystal clamping contact members extruded directly from the mounting springs, instead of from metal plugs inserted therein as illustrated in Fig. 1;

Fig. 6 is an enlarged sectional view of the extruded metal contact members shown in Fig. 5;

Figs. 7 and 8 are perspective and side views, respectively, of the mount as shown in edge view in Figs. 1 and 5;

Figs. 9 and 10 are perspective exploded or disassembled views of a die and punch arrangement which may be used with the mount shown in Fig. 7 to form extruded metal contacts thereon;

Fig. 11 is a perspective view of the component parts shown in Figs. 7, 9 and 10 assembled for use; and

Fig. 12 is an enlarged sectional view similar to Fig. 2 but showing two pairs of insulated extruded metal contact members provided on a single pair of springs.

Referring to the drawing, Fig. 1 is a somewhat enlarged edge view of a pressure type crystal unit provided with oppositely extruded metal contact pins 8 and 9 adapted for holding and establishing individual electrical connections with the electroded piezoelectric crystal body 10. The holder as illustrated in Fig. 1 may consist of a molded insulating supporting base 1 carrying on one side thereof, two separate upright cantilever springs 2 and 3 which may be composed of Phosphor bronze, steel or other suitable conductive spring material, and carrying on the other or lower side thereof two separate plug-in type terminal pins 4 and 5, which may be individually electrically connected with the two springs 2 and 3, respectively. The springs 2 and 3 may be fabricated from suitable sheet metal material by a

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punching and forming operation, after which they may be staked and welded or otherwise securely connected to the respective terminal pins 4 and 5 in order to obtain a good electrical connection therewith. The springs 2 and 3 and the pins 4 and 5, when so combined, may be rigidly molded into the supporting base 1. The base 1 may be provided with any suitable enclosing cover 6 to form a sealed or evacuated enclosing container for the crystal unit. The base 1, the springs 2 and 3, the terminal pins 4 and 5 and the cover 6 may be provided in other forms. The container base 1 and cover 6 may comprise a sealed molded type plastic container, or a sealed metal container which may be provided with suitable means for insulating the springs 2 and 3 from each other.

After molding the fixed ends of the cantilever springs 2 and 3 and the respective terminal pins 4 and 5 into the phenolic or other suitable base 1, the top portion or free ends of each of the cantilever springs 2 and 3 may be provided with pressure type extruded metal contact points or pins 8 and 9 of small diameter, such as of the order of .010 inch diameter, which may be used to clamp therebetween, under pressure from the springs 2 and 3, a quartz or other suitable piezoelectric crystal element 10. The crystal plate 10 may be provided with suitable opposite conductive electrodes 11 and 12 as illustrated in Figs. 1 and 1a. The pressure with which the electroded crystal body 10 is held between the extremities or tips of the clamping pins 8 and 9 may be predetermined by the springs 2 and 3, dependent upon their composition, spacing, thickness, and length or height between the supporting base 1 and the longitudinal axis Y—Y of the pair of clamping pins 8 and 9.

The crystal element 10 may be, for example, a CT or DT cut quartz crystal plate operated in the face shear mode of motion as disclosed, for example, in United States Patent 2,268,365 issued December 30, 1941, to G. W. Willard. Such face shear mode crystal elements 10 have a node 16 or point of minimum motion adjacent the center of the major faces of the crystal plate 10, and the electroded crystal body 10 may be there nodally mounted and electrically connected by means of the extruded clamping pins 8 and 9. Where the crystal element 10 is a face shear mode quartz crystal element as particularly illustrated in Figs. 1 and 1a, the thickness thereof may be made of the order of .02 inch or other suitable thickness value, and the major face edges thereof may each be made of 0.1 inch and upwards according to the value of the desired frequency, the frequency, in the case of such a face shear mode crystal plate 10, being determined mainly by the values of the length and width edge dimensions of the square or nearly square major faces of the crystal plate 10.

While a particular type of crystal element 10 has been illustrated in the drawing, it will be understood that the invention may be utilized for nodally mounting other forms of crystal elements such as those operated in longitudinal or other face modes of motion, or for mounting crystal plates operated in a thickness mode of motion at a frequency which is dependent mainly upon the thickness or thinnest dimension thereof, or for mounting crystal bodies generally.

The electrode coatings 11 and 12, which may be disposed on the surfaces of the bare crystal plate 10, may comprise thin films of baked metallic paste such as baked silver paste, or coatings of other conductive material such as films of silver,

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gold, aluminum or other conductive material deposited by evaporation in vacuum, spraying, painting or by other suitable process directly onto the opposite major faces of the crystal element 10. Where the electrodes 11 and 12 are composed of baked silver paste coatings, the coating material 11 and 12 may be conveniently applied by spraying a solution of the silver paste in liquid form onto the faces of the crystal plate 10, and thereafter baking the sprayed silver material onto the crystal plate 10 at a suitable elevated temperature. After such baking, the silver coatings 11 and 12 may be burnished. The process is adaptable to a continuous belt spraying and baking operation for mass production purposes, and results in coatings 11 and 12 of good mechanical properties. If desired, small silver washers 17 may be sweated by soldering to the baked silver paste coatings 11 and 12 on each major face of the crystal element 10 in the nodal region 16 thereof to provide retaining seats for nodally positioning the extreme tips of the clamping pins 8 and 9 therein. Such silver washers 17 are illustrated in Fig. 1a.

As illustrated in Figs. 1 and 2, the crystal holder may comprise the two springs 2 and 3 having extrudable metal plugs or inserts 14 and 15 therein at 7 from which the fine contact points 8 and 9 are extruded for holding the electroded crystal element 10 therebetween, the extruding operation being done after the springs 2 and 3 are assembled in the supporting base 1, so that when the contact points 8 and 9 are extruded from the oppositely disposed metal inserts 14 and 15 of the springs 2 and 3 into a suitable die 20 having a single cavity of the correct shape, length and diameter, the extruded contact points 8 and 9 are in exact or precise alignment with respect to each other. With this type of assembly the electroded crystal plate 10 may be inserted between the tips of the spring-operated contact points 8 and 9 by means of any suitable spreader (not shown) adapted for spreading the springs 2 and 3 apart sufficiently to permit inserting the crystal element 10 between the tips of the contact points 8 and 9 at the nodal region 16 of the crystal element 10. When the crystal plate 10 is properly centered, releasing the spreader referred to allows the springs 2 and 3 to exert their own clamping pressure on the crystal element 10 in order to hold it tightly in position between the tips of the clamping pins 8 and 9. The crystal plate 10 may be centered at the nodal region 16 thereof by any convenient means such as by a washer 17, or by using an indexing tool which may, if desired, be coordinated with the die tool 20 used for extruding the contact points 8 and 9. Suitable holding tools may be used in the subsequent adjustment of the frequency of the crystal plate 10 so that it need not be removed from its clamped position between the contact points 8 and 9.

The stiffness of the cantilever springs 2 and 3 is important and may be made of a value to exert a suitable pressure such as of the order of one to two pounds load on the crystal body 10 disposed between the clamping pins 8 and 9. For this purpose the separation between the extreme tips of the clamping pins 8 and 9 may be made of a value from .001 inch to 0 inch before insertion of the crystal element 10 therebetween, or of other suitable value to permit firmly holding the crystal element 10 to be clamped between the tips of the clamping pins 8 and 9.

Where it is desired to conserve the use of Phos-

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phor bronze material, the springs 2 and 3 may be made of clock spring steel, for example, and small brass plugs or other cold-flowing metal inserts 14 and 15 may be staked in position in suitable openings in the springs 2 and 3 in the region 7 of the longitudinal axis Y—Y along which the clamping pins 8 and 9 are to be extruded from the metal comprising the inserts 14 and 15. The springs 2 and 3, when composed of steel, may be plated with zinc or other suitable plating material to reduce corrosion. If zinc plating is so used, an alcohol and water wash may be afterwards used to remove the excess plating salts from the zinc-plated springs 2 and 3.

The springs 2 and 3 may be made of equal size, shape and thickness, or one of the springs 2 and 3 may be made substantially thicker or heavier than the other as illustrated by the springs 2 and 3 in Fig. 2, thus in effect permitting one of the springs 3 to bend less than the other spring 2 in order to minimize the effects of weaving of the springs 2 and 3 which might tend to bring the coaxial clamping pins 8 and 9 out of alignment. If the heavier spring 2 is so used, it may be made from .04 inch thick sheet metal stock, and the lighter one from .02 inch stock for example. The heavier spring 2 may, if desired, serve as an index guide for the punch and die tools 20, 30 and 31 used for embossing and extruding the clamping pins 8 and 9, and also it may serve as a guide for the tool used for inserting and centering the electroded crystal element 10 in place between the tips of the extruded pins 8 and 9.

As illustrated in Figs. 1 and 2, the metal plugs or inserts 14 and 15 may each be constructed from a short section of cold-headed brass wire, or from other suitable cold-flowing material, of the order of $\frac{3}{16}$ inch diameter or other suitable size, formed into metal plugs 14 and 15 each having a hollow cavity 18 in one side thereof. The brass inserts 14 and 15 may be inserted in close-fitting circular holes provided at 7 in each of the springs 2 and 3 and may be spun over to secure the metal inserts 14 and 15 firmly to the respective springs 2 and 3 as illustrated in Fig. 2; or as illustrated in Fig. 12 when it is desired to insulate the metal plugs 14 and 15 from the springs 2 and 3. The contact points 8 and 9 are extruded from the brass inserts 14 and 15 by means of any suitable punch members 30 and 31 insertable in the oppositely disposed cavities 18 of the brass plugs 14 and 15, as illustrated in Fig. 2. The punch may comprise any suitable pair of coaligned punch members 30 and 31 adapted to cold press and extrude metal simultaneously from the brass plugs 14 and 15 into the opposite end openings of the cavity 21 in the die 20, for forming the coaxially-aligned clamping contacts 8 and 9 carried by the pair of springs 2 and 3. The pressure to be applied inwardly to the punch members 30 and 31 may be of the order of 2,000 pounds or of other pressure value suitable for extruding part of the metal from the plugs 14 and 15 into the opposite end openings of the cavity 21 in the die 20, as illustrated in Fig. 2.

Fig. 2 illustrates an enlarged sectional view of a small section of the die 20 which may be used for extruding thereinto the clamping pins 8 and 9 from the metal inserts 14 and 15, as illustrated in Figs. 1 and 2, or directly from the metal springs 2 and 3 as illustrated in Fig. 5. As particularly shown in Fig. 2, the die 20 is used for extruding metal from the metal inserts 14 and 15 of Figs. 1 and 2. The extruding punch mem-

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bers 30 and 31 are operated inwardly, as indicated by the arrows in Fig. 2. As illustrated in Fig. 2, the die 20 may be provided with a single cavity 21 of nearly uniformly tapered diameter along its length, the end openings at the two opposite sides of the cavity 21 being of slightly larger circular area than that at the center region within the cavity 21.

The die 20 may be provided with a cavity 21 of any suitable shape having end openings at the opposite sides thereof, the cavity 21 in the die 20 being made of a size and shape corresponding to the size and shape desired for the extruded contact members 8 and 9 to be formed therein, and the die 20 being located between the pair of springs 2 and 3 with the opposite end openings of the die 20 disposed adjacent the opposite metallic portions 14 and 15 of the springs 2 and 3 that are to be extruded into the opposite end openings in the die 20. The dimensional area of the extreme tips of the clamping pins 8 and 9 is more or less critical since the reactance-resistance ratio Q of the crystal element 10 at resonance is a function of the area of contact therewith by the tips of the pins 8 and 9 and of the force exerted by the springs 2 and 3. The end portions of the pins 8 and 9 may be made to have a slight draft as illustrated in Fig. 2 in order to facilitate their removal from the ends of the opening 21 in the die 20. The shape of the cross-sectional area of the pins 8 and 9 back from the extreme tips thereof to the springs 2 and 3 is not highly critical, and may increase more or less gradually in cross-sectional area, and the shape of the cavity of the die 20 may be made to conform thereto as illustrated by the die cavity 22 in Fig. 2 and by the die cavity in Fig. 3.

Fig. 3 is an enlarged view in cross-section of the die section 20, showing an alternative form that may be used for the shape of the cavity of the die 20. As illustrated in Fig. 3, the die 20 may have a single cavity 22 of substantially enlarged diameter at the two opposite end openings thereof which are disposed adjacent the metallic portions, comprising the plugs 14 and 15 or the springs 2 and 3, that are to be extruded into the end openings of the cavity 22 in the die 20 by means of any suitable punch members 30 and 31. The oppositely disposed punch members 30 and 31 may be used as illustrated in Fig. 2 to simultaneously extrude the metal from opposite parts 14 and 15 carried by the springs 2 and 3. The metal is extruded inwardly into the two opposite end openings in the cavity 22 of the intermediate die 20, thereby providing a quick and easy method of forming a pair of extruded contacts 8 and 9 that are disposed exactly opposite each other without any subsequent positioning or adjustment.

As illustrated in Fig. 4, the die 20 of Figs. 2 and 3 may be made in three parts 23, 24 and 25, the thin separator plate 24 being placed between the two outer parts 23 and 25. In this arrangement, the thickness of the thin center plate 24 may be made of a value corresponding to a desired separation between the tips of the clamping surfaces at the extreme ends of the two contact members 8 and 9, and also may be used to insure a flat, concave, convex or other predetermined contour for the clamping surfaces at the tips of the two contacts 8 and 9 which are used to contact directly with the electroded crystal element 10. Also, the position of the thin separator 24 between the two end plates 23 and 25

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of the composite die 20 illustrated in Fig. 4 may be made to correspond to desired predetermined relative lengths for the two extruded clamping pins 8 and 9 which may be made of equal or unequal lengths relative to each other. The partition plate 24 of Fig. 4 may be used with a die 20 having a cavity of the shape illustrated by the cavity 21 in Fig. 2 or by the cavity 22 in Fig. 3, or having a cavity of other shapes.

Fig. 5 is an edge view of a pressure type crystal unit similar to that illustrated in Fig. 1, but having the pair of clamping pins 8 and 9 extruded directly from the springs 2 and 3. For this purpose, each of the springs 2 and 3 may, if desired, be embossed with a slight prominence at 7 in the region of the longitudinal axis Y—Y thereof, and the clamping pins 8 and 9 may be extruded directly from the spring material at 7.

The cantilever springs 2 and 3 may be punched from Phosphor bronze sheet metal strips, and the contact pins 8 and 9 may be obtained by extruding a part of the top portion of the cantilever springs 2 and 3 into the die cavity 21 or 22 which is made of a small diameter to suit the clamping members 8 and 9. In this way, the two small clamping pins 8 and 9, which are used for directly holding the electroded crystal element 10, are provided in precise alignment with respect to each other, the springs 2 and 3 providing the necessary holding pressure of about one to two pounds applied to the electroded crystal plate 10.

The die 20 used in forming the clamping members 8 and 9 of Fig. 5 may be of the form described in connection with Fig. 1 and illustrated in Figs. 2, 3 and 4. Where a die section 20 having a cavity 21 of the form shown in Fig. 2 is used, the shape of the resulting extruded clamping contact members 8 and 9 will be of a contour as illustrated in greatly enlarged scale in Fig. 2. And where a die section 20 having a cavity 22 of the form shown in Fig. 3 is used, the shape of the resulting extruded clamping contact members 8 and 9 will be of a contour as illustrated, in greatly enlarged scale, in Fig. 6 which illustrates an example of the form of extruded contour that may be provided for the clamping members 8 and 9 by means of the cavity 22 provided in the die 20 shown in Fig. 3. The springs 2 and 3 of Fig. 5 may be of the same form as those illustrated in Fig. 1, Figs. 1 and 5 showing edge views of such springs. As an example of a particular form which the springs 2 and 3 may take, reference is made to Figs. 7 and 8.

Fig. 7 is a perspective view and Fig. 8 is a side view of the spring mount illustrated in edge view in Fig. 5 and in Fig. 1 also. As illustrated in Figs. 7 and 8, the springs 2 and 3 may be oppositely disposed, upright and flat triangular-shaped metal plates secured to and individually electrically connected with the terminal pins 4 and 5, respectively, and embedded in the molded insulating base 1. A bent perforated flange provided in the bottom corner portion of each spring 2 and 3 as illustrated in Fig. 8, may be staked and welded or soldered to the top portion of the corresponding terminal pins 4 and 5 in order to provide a good connection. The top or free end portion 7 of the springs 2 and 3 may be arranged in the region along the longitudinal axis Y—Y and may be there provided at 7 with small circular openings if metal inserts 14 and 15 are to be used therein as illustrated in Figs. 1 and 2; or with slight inwardly depressed prominences if the crystal clamping members 8 and 9 are to be extruded directly from the spring material itself,

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as illustrated in Figs. 5 and 6. In either case, the crystal clamping pins 8 and 9 are formed by extruding metal into a suitable cavity opening 21 or 22 in a suitable die 20 held between the cantilever springs 2 and 3 by any suitable means such as an indexed holder using the base 1, the springs 2 or 3, or other fixed reference members as a guide for locating the die cavity along the longitudinal axis Y—Y of the clamping pins 8 and 9.

Figs. 9 and 10 are perspective views illustrating a die and punch arrangement which may be used for cold-pressing the extruded clamping members 8 and 9 of Figs. 1, 2, 5 and 6. Figs. 7, 9 and 10 may be taken together as representing, in disassembled or exploded form, a complete punch and die arrangement for extruding the clamping projections 8 and 9 of Figs. 1, 2, 5 and 6, wherein the die section 20 of Fig. 9 may comprise the die section 20 of Figs. 2, 3 and 4 and wherein the punch members 30 or 31 of Figs. 9 and 10 may comprise the compression punch members 30 and 31 of Fig. 2.

As illustrated in Fig. 9, means may be provided for aligning the cavity 21 or 22 of the die 20 with respect to the desired location for the longitudinal axis Y—Y of the contact projections 8 and 9 to be extruded. For this purpose, the steel die 20 may be provided on its lower surface with guides in the form of dowel pins 34 and 35 aligned along the axis X—X, the dowel pins 34 and 35 being insertable in fitting relation in suitably placed holes 36 and 37 respectively provided along the axis X—X referred to, in the upper surface of the supporting base 1 of the assembly, and the lower surfaces of the legs of the die contacting the base to provide a vertical stop so that when the extruded contact points 8 and 9 are cold-pressed into the cavity 21 or 22 of the die 20, they will be at the desired location on the springs 2 and 3 along the longitudinal axis Y—Y thereof.

A suitable compression punch arrangement may be provided for pressing the extruded metal contacts 8 and 9 into both open ends of the cavity 21 or 22 of the die 20. As illustrated in Figs. 9 and 10, a pair of similar punch members 30 and 31 of Fig. 2 may be carried by a pair of punch plates or bars 38 and 39 each provided with two holes 40 and 41 which cooperate with two dowel pins 42 and 43 located on each side of the die 20 as illustrated in Fig. 9. The dowel pins 42 and 43 are insertable along the axis Z—Z and the axis Z'—Z' respectively, in the corresponding holes 40 and 41 provided in the punch plates 38 and 39, and act as means for locating and aligning the punch members 30 or 31 along the desired location for the longitudinal axis Y—Y of the extruded contact points 8 and 9, whereby by applying a suitable compression pressure inwardly in the Y—Y axis direction, on the two punch plates 38 and 39 and on their respective punch members 30 and 31, part of the metal at 7 from the springs 2 and 3 may be pressed into the opposite open ends of the cavity 21 or 22 of the die 20 at both sides thereof simultaneously, thus forming the coaligned contact points 8 and 9 carried by the springs 2 and 3.

As shown in Figs. 7 to 11, it will be noted that the guide dowel pins 34 and 35 fit in the holes 36 and 37 in the upper surface of the supporting die holder base 1, and that the cavity 21 or 22 of the die 20 is accordingly aligned with the longitudinal axis Y—Y desired for the extruded contact members 8 and 9, so that when metal is forced into the ends of the cavity 22 of the die

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20, the resulting extruded contacts 8 and 9 are disposed along the longitudinal axis Y—Y. In order to remove the extruded contact points 8 and 9 from the die 20, the springs 2 and 3 may be bent outwardly by spreading them apart, thereby removing the integral contact points 8 and 9 from the cavity 22 in the die 20. Thereafter the die 20 may be removed from the die holder base 1 by lifting the dowel pins 34 and 35 from the holes 36 and 37 in the supporting base 1. The die 20 may be removed by spreading the springs 2 and 3 apart sufficiently to remove the die 20 without scraping or touching it against the fine tips of the extruded contact points 8 and 9.

The extrusion method provided in accordance with this invention for forming the contact members 8 and 9 insures the alignment of the contact projections 8 and 9 without any but rough tolerance consideration in the assembly of the component members carrying the contact points 8 and 9, since the two spring members 2 and 3 may be first assembled so as to be only very approximately aligned in the direction as indicated by the longitudinal axis Y—Y, and are fixed in such a position with reference to the base 1. The desired length, diameter and shape of the contact members 8 and 9 being known, the die 20 may be made with a cavity 21 or 22 to suit the shape and size of the contact points 8 and 9, and may be disposed between the two springs 2 and 3 with the extrusion cavity 21 or 22 of the die 20 aligned with the desired location of the longitudinal axis Y—Y for the contact points 8 and 9 on the springs 2 and 3.

The cavity 21 or 22 in the die 20 has an inner diameter made equal to the diameter desired for the end or tip portions of the contact members 8 and 9, and is made in the die 20 at the desired location with reference to the longitudinal axis Y—Y of the clamping points 8 and 9. The cavity 22 of the die 20 may be suitably contoured at both of its end openings, to conform with a broadened base portion for the broadened bell-shaped spacer base of the contacts 8 and 9 when they merge into the springs 2 and 3 as illustrated in Fig. 6.

It will be noted that the extrusion method of forming the opposite contacts 8 and 9 provides advantages of interest over prior art methods. For example, where the clamping pins are made individually and separately, and afterward are set by soldering or welding in the springs, it is very difficult and not a simple operation to set the contact pins accurately in the springs in precise alignment; whereas in the integral extruded operation provided in accordance with this invention, the simultaneously extruded pins 8 and 9 may be accurately and easily aligned in one operation, and moreover, the small pins 8 and 9 may be made relatively much shorter in length, as of the order of .006 inch to .002 inch in length, for example.

While one pair of oppositely extruded clamping points 8 and 9 have been particularly illustrated in Figs. 1 to 11, it will be understood that an additional pair of such oppositely extruded contact points may be provided from the same springs 2 and 3 by a similar cavity 21 or 22 in the die 20, in order that a suitable crystal element 10 may be clamped between two such pairs of oppositely disposed clamping points 8 and 9 as illustrated in Fig. 12. Moreover, the invention embraces the idea of the alignment of any number of sets of extruded contacts each consisting

of one or more pairs of contact points arranged in any predetermined direction or combination.

Fig. 12 is an enlarged sectional view, similar to that of Fig. 2, but illustrating two pairs of aligned contact elements 8 and 9 which have been extruded from four insulated metal plug inserts 14 and 15 carried by a single pair of springs 2 and 3. As illustrated in Fig. 12, one pair of the aligned extruded contact elements 8 and 9 may be located along the longitudinal axis Y—Y as in Fig. 2, and the other pair of aligned extruded contact elements 8 and 9 may be provided along another axis Y'—Y' which is parallel to the axis Y—Y. The extrusion of both pairs of contact elements 8 and 9 shown in Fig. 12 may be performed by methods as hereinbefore described, using oppositely disposed punch members 30 and 31 for pressing metal from the metal inserts 14 and 15 into the opposite end openings of a suitable die cavity 21 or 22. Where the springs 2 and 3 are composed of conductive material, the two contact elements 8 or 9 that are mounted on the same spring 2 or 3, respectively, may be electrically insulated from each other by providing suitable insulating bushings 19 inserted between each of the four metal plugs 14 and 15 and the corresponding conductive springs 2 and 3, as illustrated in Fig. 12. Individual electrical connections to the four electrically insulated contact elements 8 and 9 shown in Fig. 12 may then be established by means of four separate conductive wires 19a, individually soldered or otherwise electrically connected at 19b to the four corresponding metal plugs 14 and 15.

It will be noted that the arrangement illustrated in Fig. 12 may be utilized for mounting a crystal body, such as the crystal body 10 of Fig. 1, between the two pairs of aligned clamping contact elements 8 and 9, and that if the crystal body 10 is provided with integral electrodes 11 and 12 of the split or divided type, the four contact elements 8 and 9 illustrated in Fig. 12 may be utilized to establish individual electrical connections with the four electrodes so provided on the opposite major faces of the crystal body 10. Such divided type electrodes are well known in the art in connection with longitudinal mode type crystal elements for example where the two pairs of electrodes may be utilized to obtain from a single crystal element two separate circuits of equal frequency, and for other purposes.

While the invention has been described in connection with springs of the general type utilized in pressure type crystal mountings, it may be utilized in other types of contact springs, and although this invention has been described and illustrated in relation to specific arrangements, it is to be understood that it is capable of applica-

tion in other organizations and is therefore not to be limited to the particular embodiments disclosed.

What is claimed is:

1. Extrusion apparatus comprising a unitary die having a single cavity therein provided with oppositely disposed enlarged end openings positioned at opposite sides of said die and a substantially smaller opening positioned adjacent the central part of said cavity intermediate said enlarged end openings, the openings taken at consecutive points spaced along the length longitudinal axis of said cavity being increased in area from said smaller central part opening outwardly in opposite directions to each of said enlarged end openings, means including a work supporting base for detachably fastening said die temporarily in predetermined relation with respect to said base and constituting guide means for providing a fixed reference axis for said longitudinal axis of said die cavity with respect to the work, and punch means carried by said die and having punch member means disposed adjacent said die cavity and in alignment relation with respect to said longitudinal axis of said die cavity and the work.

2. Extrusion apparatus comprising a unitary die having a divided cavity therein provided with oppositely disposed enlarged end openings positioned at opposite sides of said die and a substantially smaller opening positioned adjacent the divided central part of said cavity intermediate said enlarged end openings, the openings taken at consecutive points spaced along the length longitudinal axis of said cavity being increased in area from said smaller central part opening outwardly in opposite directions to each of said enlarged end openings, and a partition in said die cavity forming a transverse dividing wall across said cavity at said smaller central part opening remote from said end openings, the thickness of said partition wall being substantially uniform across said cavity and made of a value corresponding to the value of the spacing desired between the inner extremities of said divided cavity and the work to be extruded therein.

JOSEPH F. BARRY.

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