

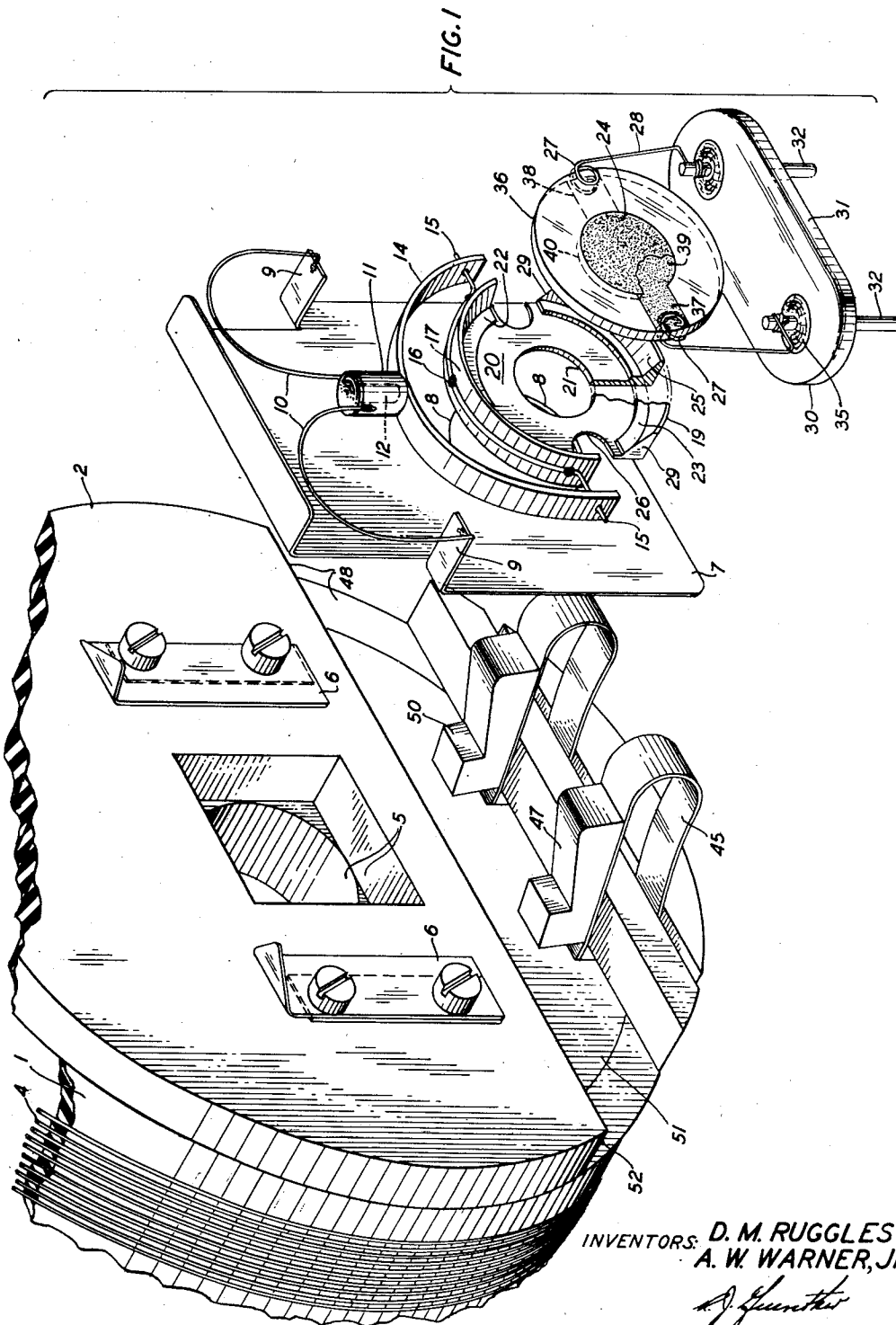
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D. M. RUGGLES ET AL
MASKING DEVICE FOR CRYSTALS

2,571,167

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2 Sheets-Sheet 1



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2 Sheets-Sheet 2

FIG. 2

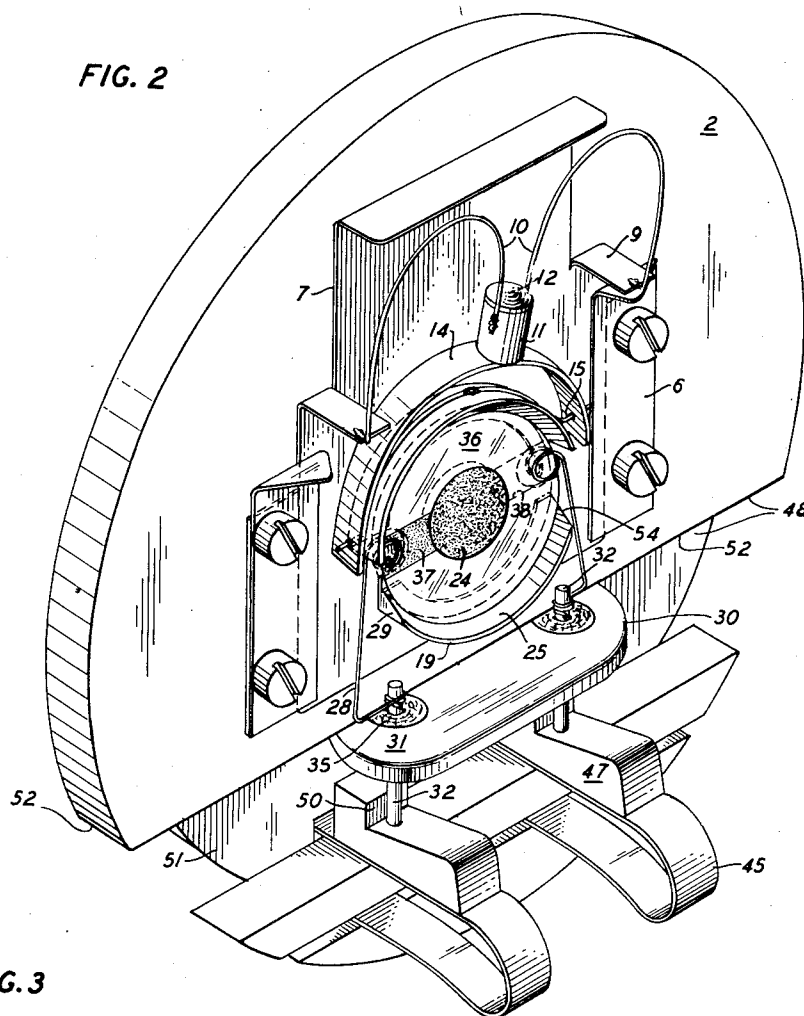
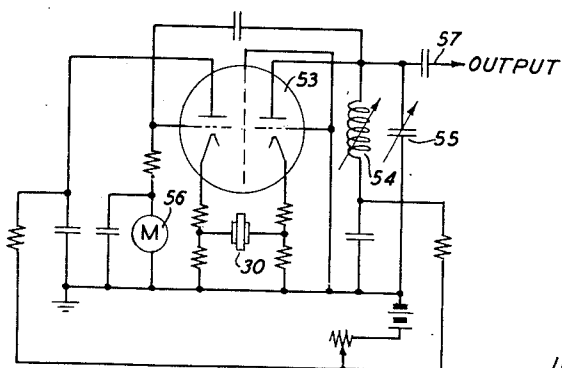


FIG. 3



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[Signature]

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UNITED STATES PATENT OFFICE

2,571,167

MASKING DEVICE FOR CRYSTALS

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10 Claims. (Cl. 171-327)

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This invention relates to masking devices, and more particularly to means for masking a piezoelectric crystal during coating thereof to frequency.

It is a common practice in the manufacture of piezoelectric crystals to provide a thin coating or plating of gold or similar material which acts as a conducting layer to transmit the potentials developed during piezoelectric action to and from the circuit in which the crystal is connected. At the higher frequencies it is very difficult to secure an absolutely accurate adjustment to frequency during the preliminary stages of manufacture inasmuch as the final frequency is affected perceptibly by the addition or removal of a mass which may be in some cases as small as one microgram. To correct inaccuracies in manufacture, and to permit the use of a single size of crystal blank for a number of frequencies in the same general region, it is customary to "load" the crystal, that is, to apply a sufficient additional coating over the conducting coating to bring the crystal to the intended frequency. The coating is conventionally applied in an evacuated chamber, thermostatically controlled to maintain the temperature of the chamber and crystals being coated at a constant value. The coating, which is usually of gold, may be conveniently applied by energizing a heating filament to cause evaporation of gold applied thereto in the form of a heavy coating or discrete globules. It is desirable to apply this loading to the crystal while the latter is oscillating, so that continuous frequency measurements may be made and the application stopped at the proper instant.

Various methods of masking the crystal during such coating to frequency have been used, which have in general been subject to certain limitations in operation. If the alignment of the mask with the crystal is not exactly determined, the coating will not be deposited on precisely the area desired. If the loading coating is deposited on an area of the crystal plate outside the conducting coating area, improper adherence of the loading coating may result, because of the more rapid technique and less complete evacuation utilized. This is likely to be followed by separation and eventual flaking off of the loading coating, with a consequent change in frequency. Furthermore, if the loading coating does not coincide in position with the conducting coating, boundary conditions may be set up which will interfere with the proper operation of the crystal unit, and the static capacitance of the crystal may be increased beyond tolerances permissible

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in interchangeable units. If in an effort to minimize misalignment of coatings, the mask were to be brought into immediate contact with other than the quiescent portions of an oscillating crystal, the frequency would be shifted away from the natural period of vibration to an unpredictable degree, and oscillation might cease entirely. On the other hand, if the mask were not disposed close enough to the crystal surface, irregular spreading of the coating material might occur around the edges of the intended area with consequences similar to those discussed above in connection with improper alignment.

The present invention provides a crystal masking and supporting device, so constructed that the crystal on its application to the device, is automatically aligned with the mask, and held in proper relation to a coating chamber while evaporation coating is in progress. The masking unit is arranged for removable mounting on a coating chamber so that different shapes of masks may be inserted for different shapes of crystals, and includes a resilient support for a gimbal-type, freely rotatable mask carrier. The masking and supporting device is preferably formed of metal, but other materials resistant to heat and susceptible of precise machining or forming to the desired shape and dimensions may be utilized.

The construction of the mask and gimbal mounting is such that they cooperate to receive a crystal presented to the machine by an operator without particular attention to the correct position and automatically align the crystal and mask properly with the plating chamber and hold them securely in position relative thereto during the coating operation. This has the advantage that the single step by the operator inserts the crystal in the coating machine and aligns the mask with the crystal.

In a particular embodiment to be described hereafter for use with round crystals, the mask, which is universally rotatable on its gimbal mounting, includes a conically-recessed seating portion surrounding the intended position of the crystal, which acts as a guide in bringing it into its final position. The crystal seats against segmental annular shoulder portions, which engage its periphery, and space the crystal face away from the masking plate by a distance of the order of .003 inch to .006 inch, so that the coated conducting area does not come in direct contact with the mask face. The central portion of the mask face is apertured to define the area to which the loading coating is to be applied, and proper align-

ment of that coating with its intended position on the crystal is obtained automatically by virtue of the fact that the crystal itself determines the position of the mask. The invention has been illustrated as applied to the production of round flat AT-cut quartz crystals having a natural period of vibration in the region between 15 and 100 megacycles and mounted by means such as those shown in the United States Patent No. 2,392,429 to R. A. Sykes. The invention is equally applicable to crystals of plano-convex or double-convex curvatures, and the mask may be shaped to follow contours of crystals of a variety of different shapes and conducting coatings.

In the illustrated crystal unit a round central conducting coating is applied to each side of the crystal, and a conducting tab extends from each coating to the edge of the crystal, the tabs on opposite sides extending to the diametrically opposite crystal edges. At the crystal periphery, the tabs are engaged by separated resilient turns of helically formed portions terminating resilient mounting wire supports. The helical turns are preferably cemented, by means such as the well-known Bakelite-silver cementing technique, to the coating tabs for permanent connections of constant resistance. The mask is cut out at diagonally opposite portions of its periphery to provide clearance for the helical turns, which are about one-eighth inch in diameter when used with crystals of the order of 1.2 centimeters in diameter. It is not required that the helical portions be prevented from engaging the mask entirely, but it is sufficient if the cut-out portions and lateral clearance are so adjusted that contact, if it occurs, is limited to one side of the crystal circuit and does not extend to both at the same time. The crystal unit is normally mounted in a sealed metal container, which is evacuated or filled with an inert gas to prevent deleterious changes resulting from external climatic conditions. No cover portion is shown on the unit as illustrated in the drawings for the sake of clarity, and only the conventional base portion is illustrated. The base portion includes mounting pins, to which resilient support wires for the crystal are permanently secured, disposed through the base for external connection. The coating unit is designed to cooperate with the base of the crystal unit and has resilient connecting members arranged to hold the crystal unit in proper position relative to the mask and the coating chamber during this stage of the manufacture process.

It is thus a general object of the invention to improve the technique of producing coated crystal units having desired natural frequencies of oscillation.

Another object is to provide a masking device for use in the manufacture of crystal units having desired natural frequencies which reduces the number of operations and handling time necessary.

Still another object is to provide a self-aligning masking device for crystal coating by evaporation.

A further object is to provide a mask so designed that the crystal itself will determine the position of the loading coating to be applied therethrough.

A still further object is to provide a masking device in which the mask may engage the crystal directly and closely during oscillation without affecting the natural frequency of vibration.

Yet another object is to provide a simply operable masking device which will retain the crystal

in proper relation to the source of coating material, by direct engagement therewith, while allowing continuous measurements of crystal frequency to be made during the coating.

5 An additional object is to make possible the production of accurately calibrated crystals of very high frequencies.

A further object is the improvement in the manufacture of high frequency crystals of specified frequencies in which the ultimate frequency desired is directly measured during the coating process.

The details of the invention may be better understood by reference to the drawings, in 15 which:

Fig. 1 is an exploded view showing a portion of the coating chamber and head, with the masking device and the crystal unit spaced therefrom;

Fig. 2 is a perspective view of the head of the 20 coating chamber, with the crystal to be coated held in proper position in the mask; and

Fig. 3 is a schematic diagram illustrating a circuit for measuring the frequency of the crystal during the application of the coating thereto.

25 It is to be understood that the embodiment illustrated is exemplary only of the invention, and that the principles may be incorporated in embodiments involving changes in the shapes and relations of the various elements and that such changes, and substitutions of materials, are within the scope of the invention.

Referring now to Fig. 1 of the drawings, there is shown a constant temperature coating chamber 1, having a head plate 2 which serves to support the masking unit. The coating chamber 1 is of conventional design, and is intended to operate in a turret-type coating machine in which the coating chamber is evacuated and its temperature thermostatically controlled to within narrow limits by means which include heating windings 4, seen fragmentarily in Fig. 1. The chamber and head plate are preferably formed of heat-resistant insulating material. The head plate 2 is set snugly in the end of the coating chamber 1, and is centrally apertured as shown at 5, to permit the evaporated metal from the interior of the coating chamber to pass through for deposition on the crystal. Guide ways 6 are mounted on the front of head plate 2 to receive the mounting plate 7, centrally apertured at 8. Yoke support tabs 9 are bent from plate 7, and to them are welded resilient supporting arms 10 which terminate in a collar 11. Collar 11 holds rotatably therethrough a yoke pin 12, to which is secured the gimbal yoke 14. The gimbal yoke 14, in turn, receives mask supporting pins 15 rotatable about an axis normal to that of yoke pin 12. Pins 15 may be formed by a single wire member 16 spot welded or otherwise secured to the upper peripheral portion 17 of the mask 19. Mask 19, which is formed of metal or other heat-resistant material susceptible of careful dimensioning, is shown in a form convenient for use with thin round flat AT-cut 15-100 megacycle and 2-15 megacycle AT and BT cut plano-convex crystals, as mentioned above, has a masking plate portion 20 provided with a central bore 21 defining exactly the area to be loaded by evaporation coating. Upper and lower peripheral shoulder portions 22 and 23 are provided to engage the peripheral portion of the crystal and hold the central loading coatings 24 out of contact with the masking plate. Masking plate 20 and shoulders 22 and 23 are surrounded by a 75 tapered or inclined receiving portion 25 which

assists in guiding the crystal into proper seating position relative to the central bore 21. The periphery of the masking plate 20 is cut away to provide clearance channels 26 for the helical portions 27 of the supporting wires 28. Similarly, the receiving portion 25 is cut away at outer clearance channel 29 to avoid engaging supporting wires 28. The portion of the crystal unit shown in Fig. 1, generally designated as 30, includes the base 31, which has the connecting pins 32 fixed therein by insulating seals 35 of vitreous material or equivalent. Supporting wires 28 are permanently secured to the connecting pins 32. Connecting tabs 37 and 38 extend in diametrically opposite directions from the central conducting coatings 39 and 40 on opposite sides of blank 36. The tabs 37 and 38 are engaged near the periphery of the crystal 36 by the helical portions 27 to which they are cemented by conventional methods, such as those disclosed in the Sykes patent referred to above.

Retroverted spring arms 45 mounted in and extending through the head plate 2 provide for electrical connection to the crystal, and assist in mechanically maintaining it in proper position during plating. Pin receiving blocks 47 are fixed on the spring arms 45, and are so positioned that they may be readily engaged by connecting pins 32. When the crystal unit 30 is placed in position by the operator the connecting pins 32 slide along the pin receiving blocks 47 until stopped by shoulders 50. The springs 45 are depressed sufficiently to permit base 31 of the crystal unit to fit within the recessed portion 51 formed in the head plate 2 and to hold it against the upper edge 52 of this recess; recessed portion 51 and upper edge 52 thus constitute a seat 48 for the reception of the crystal unit 30. At the same time, the crystal face is held in proper alignment with the central masking bore 21 by the pressure of the resilient supporting wires 28, and the reaction thereagainst of the resilient supporting arms 10, through the gimbal yoke and mask 19.

Thus, when the operator applies the crystal unit to the assembly described so that the contact pins engage the blocks 47, the crystal and mask automatically correctly position themselves relative to each other, and are resiliently retained in the proper position relative to the coating chamber by the spring mounting through which contact is made for the measurement of frequency during the coating.

While the invention has been described with particular reference to use with crystals having quiescent peripheral portions, it is also intended that the principles may be applied to use with others, such as the CT cut, for example, in which the nodal point is at the crystal center. For such use, the shoulder portions which determine the spacing of the mask from the crystal face would be located at the center of the masking plate, and the loading coating apertures would be disposed at the periphery of the mask.

In Fig. 3 there is illustrated a schematic cathode-coupled oscillator circuit of conventional type, exemplary of that with which the apparatus described is to be used. The circuit, which involves a dual triode 53 with the crystal 30 connected between the cathodes, is well adapted to measuring the frequency of the crystal in series resonance. Reactive elements 54 and 55 are used to adjust the circuit for maximum oscillation, as indicated by meter 56, and the output is applied through lead 57 to a frequency-indicating circuit

of conventional design, not shown, where it may be continuously observed so that the plating operation may be stopped when the desired frequency is reached.

The invention as described above makes possible an increased rate of production of coated crystal units of specified frequencies, and is suited to mass production use. Its use substantially reduces the number of crystal units which must be rejected for defects in manufacturing, and makes possible successful mass production of very high frequency crystal units.

Reference is made of the application Serial No. 136,070, filed December 30, 1949, wherein a related invention is disclosed.

What is claimed is:

1. A mask for use in loading coating crystal units having a crystal supported by resilient wires connected to conducting coatings thereon, comprising a masking plate apertured to define an area to be coated therethrough, inclined guiding portions on said plate and positioned to assist in the seating of a crystal to be coated, and spacing shoulders extending from said plate for engagement with quiescent portions of the crystal, and said plate and shoulders having clearance channels therein to avoid contact with the resilient wires and conducting coatings of the crystal units.

2. The combination, with a chamber for the coating to frequency of crystals, having an apertured head plate, of means for supporting, masking and providing electrical connection to a crystal unit to be processed, comprising a yoke associated with said apertured head plate, a mask apertured to define an area to be coated, rotatably mounted by said yoke and arranged to receive a crystal to be coated, means associated with said head plate for receiving a crystal unit to be processed, and resilient means associated with said head plate, and cooperating with said means for receiving a crystal unit to be processed, for maintaining a crystal to be coated in proper relation to said mask while providing electrical connection to said crystal.

3. The combination, with a chamber for crystal coating to frequency having an apertured head plate through which coating material may flow, of means for supporting and masking a crystal unit to be processed, comprising a gimbal yoke resiliently mounted on said apertured head plate, a mask, apertured to define an area to be coated, rotatably mounted within said gimbal yoke, a crystal unit seat associated with said head plate, and resilient means associated with said head plate for maintaining a crystal unit to be processed in position in said seat and in engagement with said mask.

4. The combination, with a chamber for crystal coating to frequency having an apertured head plate through which coating material may flow, of means for supporting, masking and providing electrical connection to a crystal unit to be processed, comprising a gimbal yoke resiliently mounted on said apertured head plate, a mask, apertured to define an area to be coated, rotatably mounted within said gimbal yoke, a crystal unit seat associated with said head plate, resilient means associated with said head plate for maintaining a crystal unit to be processed in position in said seat and in engagement with said mask, and means for providing electrical connections to said unit.

5. The combination, with a chamber for crystal coating to frequency having an apertured

head plate through which coating material may flow, of means for supporting, masking and providing electrical connection to a crystal unit to be processed, comprising a gimbal yoke resiliently mounted on said apertured head plate, a mask, apertured to define an area to be coated, rotatably mounted within said gimbal yoke, means in said mask for guiding crystals to be coated into seating position therein, means in said mask for limiting seating position contact of said mask to quiescent area of a crystal to be coated, a crystal unit seat associated with said head plate, and resilient means associated with said head plate for providing electrical connections to a crystal unit to be processed, while maintaining said unit in said crystal unit seat and in engagement with said mask.

6. The combination, with a chamber for crystal coating to frequency having an apertured head plate through which coating material may flow, of means for supporting, masking and providing electrical connection to a crystal unit to be processed, a gimbal yoke resiliently mounted on said apertured head plate, a mask rotatably mounted with said yoke and having a masking plate apertured to define an area to be coated, tapered surfaces associated with said plate and arranged to act as guides into proper seating position for a crystal applied thereto, shoulder portions extending from said masking plate and arranged to prevent contact between said plate and coatings on a crystal to be inserted thereagainst in said mask, a crystal unit seat associated with said head plate, and resilient means associated with said head plate for providing electrical connections to a crystal unit to be processed, while maintaining said unit in said crystal unit seat and in engagement with said mask.

7. The combination, with a chamber for crystal coating to frequency having an apertured head plate through which coating material may flow, of means for supporting, masking and providing electrical connection to a crystal unit to be processed having a base, contact pins insulated from and disposed through said base, resilient and connecting means extending from said pins, and a crystal fixed to said connecting means, a gimbal yoke resiliently mounted on said apertured head plate, a mask rotatably mounted within said yoke and having a masking plate apertured to define an area to be coated, tapered surfaces associated with said plate and arranged to act as guides into proper seating position for a crystal applied thereto, shoulder portions extending from said masking plate, clearance channels formed in said masking plate adjacent the positions in which said connecting means engage said crystal, and outer clearance channels formed in said mask adjacent said connecting means, a crystal unit seat associated with said head plate, and resilient means associated with said head plate for providing electrical connections to a crystal unit to be processed, while maintaining said unit in said crystal unit seat and in engagement with said mask.

8. The combination, with a device for use in the adjusting to frequency of a crystal unit having a base, contact pins extending therethrough and a coated piezoelectric crystal mounted thereon, by the application thereto of a loading coating from a coating chamber while making continuous frequency measurements thereon, of crystal aligning and masking means, comprising an apertured head plate closing said chamber, a uni-

versally rotatable mask resiliently positioned on said head plate, a crystal unit receiving portion formed in said head plate, and resilient contact members mounted in said head plate and arranged to engage said contact pins of a crystal unit to be adjusted for electrical connection to said crystal and to hold said unit against said crystal unit receiving portion.

9. The combination, with a device for use in the adjusting to frequency of a crystal unit having a base, contact pins fixed through said base, and a coated piezoelectric crystal connected by resilient supports to said contact pins, which utilizes a coating chamber and means for making continuous measurements of the frequency of oscillation of said crystal, of an apertured head plate forming a closure for said chamber, a gimbal-type mask support, resilient supporting arms fixed to said head plate and pivotally connected to said mask support, a mask, apertured to define a crystal area to be coated, carried by said mask support, tapered crystal-receiving portions in said mask, segmental spacing shoulders within the periphery of said mask, said mask having indented portions to provide clearance for said crystal resilient supports, crystal unit receiving portions in said head plate, and resilient members fixed to said head plate and arranged to hold said crystal in contact with said mask and to hold said crystal unit against said crystal unit receiving portions of said head plate.

10. A device for use in the evaporation coating to frequency of a unit having a piezoelectric crystal secured by helical portions to resilient mounting wires attached to connecting pins, which comprises the combination, with a coating chamber having a head plate closing one end of said chamber and having a passage therethrough for evaporated coating material, of an apertured mounting plate disposed on said head plate, resilient supporting arms extending from said mounting plate, a gimbal yoke pivotally supported by said supporting arms, a mask, incorporating an apertured masking plate, supported by said gimbal yoke pivotally about an axis normal to that about which said gimbal yoke is pivotally connected to said resilient mounting arms, a tapered recess formed in said mask, upper and lower segmental annular shoulder portions formed in said mask and arranged to engage peripherally and space a crystal to be received thereagainst from said masking plate, diametrically opposed receiving portions formed in said masking plate and arranged to provide clearance for said resilient wires and helical portions, and means comprising a seating recess formed in said head plate and resilient spring arms arranged to be engaged by said connecting pins for holding said unit in position against said head plate, and for providing electrical connection thereto.

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