April 15, 1947. I. S. PRIMUS 2,419,033

APPARATUS FOR LAPPING QUARTZ OSCILLATOR PLATES

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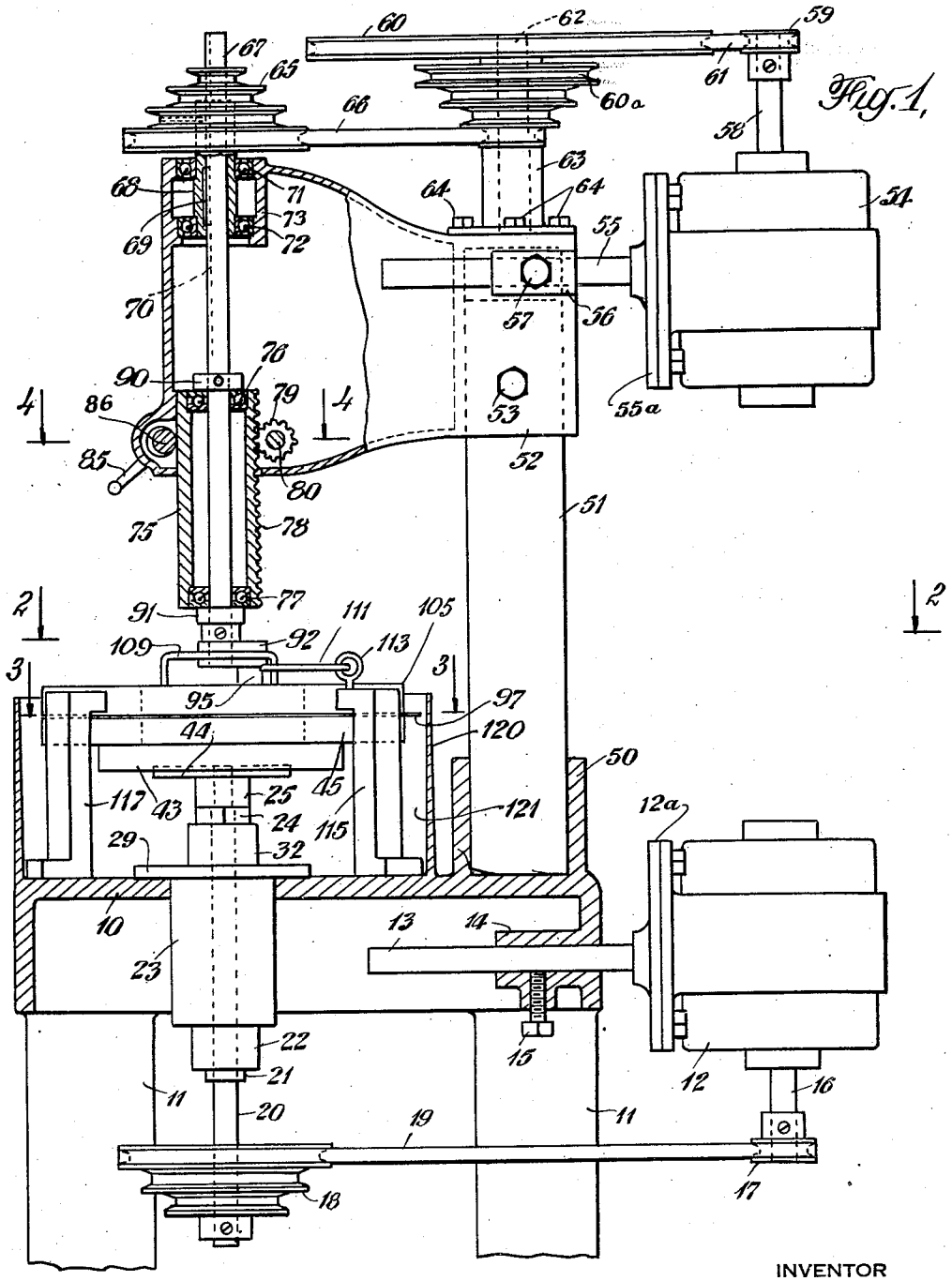


Fig. 1.

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Fig. 2,

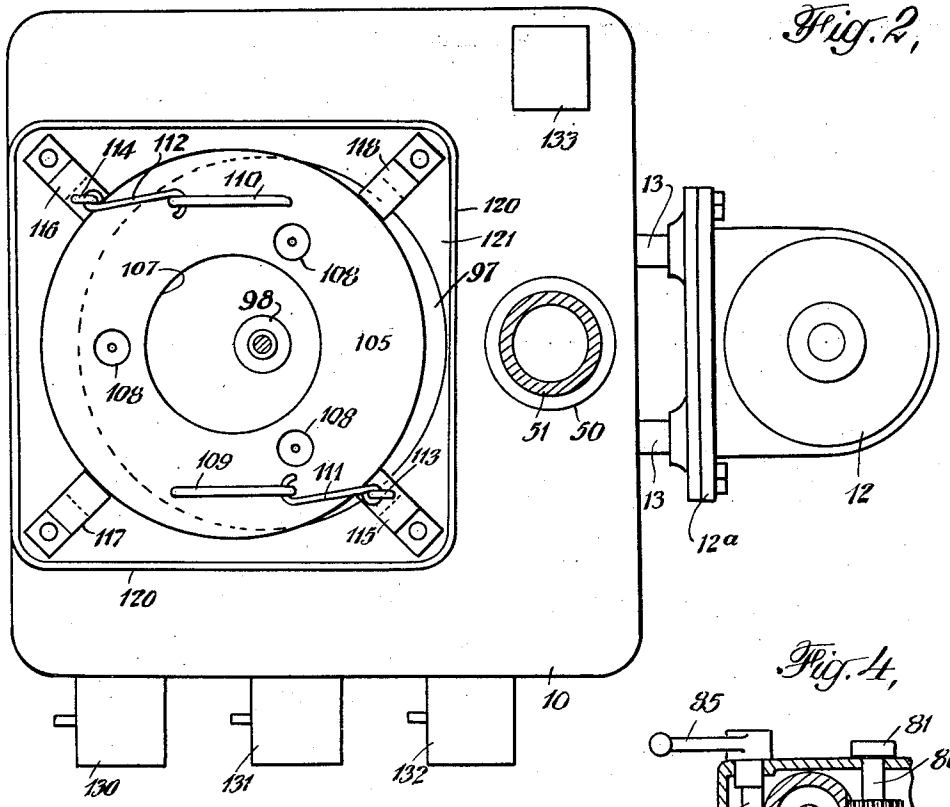


Fig. 4,

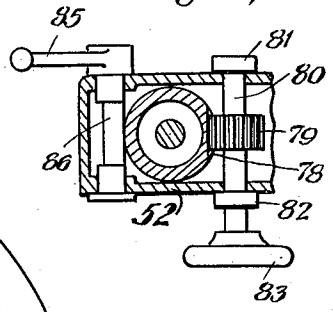
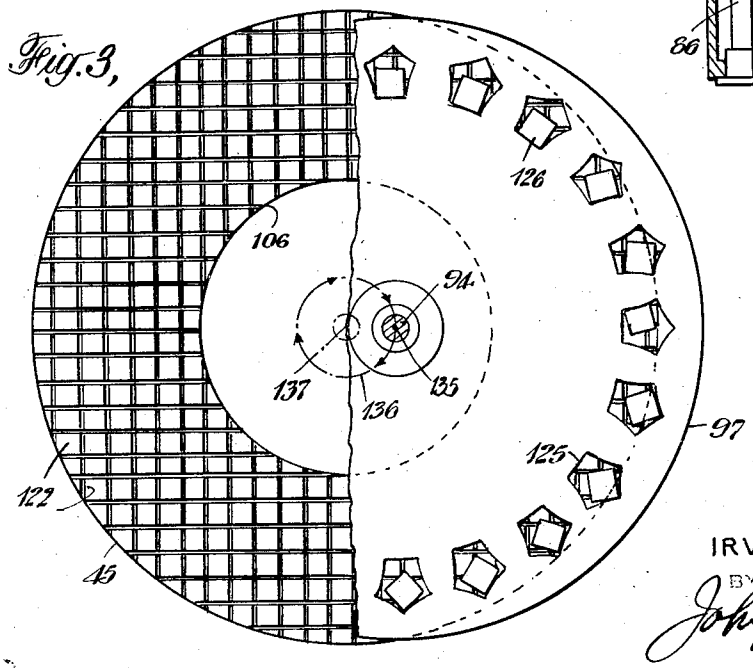


Fig. 3,



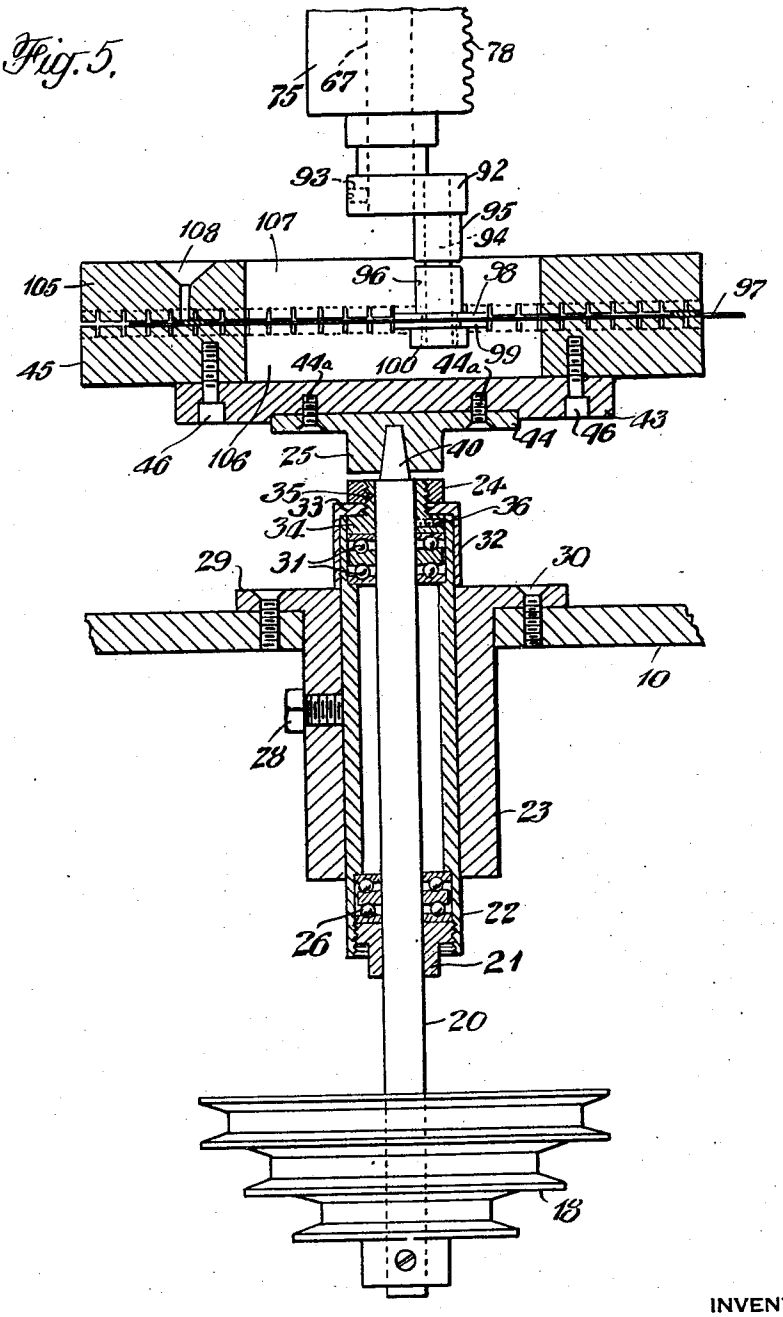
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Fig. 5.



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2,419,033

APPARATUS FOR LAPPING QUARTZ OSCILLATOR PLATES

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Application April 6, 1945, Serial No. 586,952

4 Claims. (Cl. 51—118)

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This invention relates to new and useful improvements in the manufacture of quartz oscillator plates and has particular relation to improvements in the method of and apparatus for lapping such plates.

Various methods and constructions of apparatus have been suggested for use in the lapping of blank quartz oscillator plates to bring them safely to a thickness from which they can be hand-finished with a minimum of effort. While highly useful in many cases, these previous proposals have certain inherent disadvantages. When using them the plates may be lapped unevenly on their major faces so that such faces are not brought into substantially true paral'elism; and/or their major faces and edges are not lapped smooth; and/or the amount of lapping is not accurately controlled; and/or an undue amount of time is required; and/or plates are damaged in large numbers during the lapping operation, etc.

As a result of my investigations, I have discovered certain improvements in the lapping of blank quartz oscillator plates which substantially eliminate disadvantages of the character enumerated. Using my invention quartz oscillator plates may be easily, smoothly, quickly and accurately lapped a predetermined amount; and after the plates are lapped, they may be hand-finished with a minimum of effort.

In accordance with the invention a number of blank quartz oscillator plates are simultaneously lapped by moving them in spaced relationship to one another between two lapping surfaces in a suspension of abrasive grit. About a fixed-stationary point one of the lapping surfaces is rotated in contact with a major face of each blank plate while the other lapping surface is maintained substantially stationary and in contact with the other major face of each blank plate.

While maintained in spaced relationship to one another the blank plates are moved in an undulating satellite path of relatively large convolutions. Such path is around the above mentioned fixed-stationary point and is relatively far removed from the center of each blank plate. The direction of movement of the blanks is generally opposite to that of the rotating lapping surface, so that the major faces of the blank plates are lapped as they are repeatedly passed completely around and across the effective lapping surfaces. In addition, while still maintained in spaced relationship with one another, the blank plates are moved in an undulating path of relatively small

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convolutions about a moving point relatively near their respective centers.

To this end, the invention contemplates apparatus including a pair of juxtaposed lapping heads, means for rotating one of the lapping heads about a fixed-stationary point, and means for holding the other lapping head substantially stationary. A carrier-disc is disposed between the lapping heads, the disc being provided with a plurality of spaced openings each of which is adapted freely to receive a blank oscillator plate. Means are provided for moving the carrier-disc in a satellite path about the fixed-stationary point and about a fixed-moving point that is relatively far removed from the centers of the disc openings and moves in a circular path about the fixed-stationary point, so that blank oscillator plates in the spaced openings of the carrier are made to follow a tortuous path around and across the lapping surfaces of the lapping heads.

In a presently preferred practice of the invention, the lapping heads are horizontally disposed, one above the other, and the carrier-disc is positioned between the two lapping heads. The lower lapping head is rotated around a fixed-stationary point while the upper lapping head is maintained substantially stationary. Means is provided for rotating the carrier-disc about a fixed-point that in turn moves in a circular path around the above mentioned fixed-stationary point. The openings in the disc are generally polygonal, and preferably pentagonal, in shape, with their sides curved inwardly.

As a result of the construction employed, blank oscillator plates confined within the openings in the carrier-disc are made to follow an exceedingly tortuous path between the grinding surfaces of the lower and upper lapping heads. This causes substantially even, smooth grinding or lapping of all the blank plates. By the time the operation is over, all of the plates are lapped to substantially the same thickness and, in addition, their major faces are in substantial parallelism. Due to the inwardly-curving sides of the openings in the disc, the side or edge portions of the oscillator plates tend to make only a point-to-point contact with the disc.

This method of operation greatly facilitates turning of each blank plate in its disc opening, resulting in a relatively free and independent movement of each plate separate and distinct from the general movement of the plate caused by the movement of the entire disc around the fixed point around which the lower lapping head is rotated as well as around its own moving

point. Lapping of each plate within its disc opening is not only facilitated by this series of compound movements but the point-to-point contact of each plate with the inwardly-curving sides of its disc opening tends greatly to reduce chipping or breaking of edge and corner portions of the plate.

Other features of the invention will become apparent from a consideration of the following detailed description taken in connection with the accompanying drawings wherein a satisfactory embodiment of the invention is shown. However, it is to be understood that the invention is not limited to the details disclosed but includes all such variations and modifications as fall within the spirit of the invention and the scope of the appended claims.

In the drawings:

Fig. 1 is a side elevational view with the upper portion partly in section, of an apparatus illustrative of a practice of the invention;

Fig. 2 is a sectional view on the line 2—2 of Fig. 1;

Fig. 3 is a sectional view on the line 3—3 of Fig. 1;

Fig. 4 is a sectional view on the line 4—4 of Fig. 1; and

Fig. 5 is an enlarged view showing the lapping head and lower portion of the apparatus in section.

Referring first to Fig. 1, the apparatus shown comprises a base 10 integrally formed with a plurality of vertical supports 11. A lower drive motor 12 is secured to the base by a motor support 12a including two parallel bar-like portions 13 adjustable inwardly and outwardly of a bearing 14 at one side of the base. Following any adjustment the position of the motor is fixed on tightening of a set screw 15. The motor is provided with a drive shaft 16 on the outer end of which is secured a motor pulley 17 connected to a variable speed pulley 18 by a belt 19. The variable speed pulley is secured to the lower end of a lower spindle 20 extending vertically (see Figs. 1 and 5) through a bearing securing collar 21, bearing sleeve 22, sleeve support 23, lock nut 24, and support collar 25.

Bearing securing collar 21 is threaded into the lower end of sleeve 22. A thrust bearing 26 is mounted about spindle 20 within the lower portion of bearing sleeve 22. Sleeve support 23 is secured to bearing sleeve 22 by a set screw 28. The upper portion of the sleeve support 23 includes an annular flange 29 secured against the top side of base 10 by a plurality of set screws 30. An upper thrust bearing 31 is mounted about the spindle 20 within the upper end portion of bearing sleeve 22.

To prevent ingress of abrasive material or other foreign particles, the upper portion of sleeve 22 is covered with a bearing-shield 32 fitting loosely about the sleeve. The upper portion of the bearing-shield is carried inwardly providing an internally threaded annulus 33 disposed on the upper surface of a horizontal shoulder or enlargement 34 of a threaded bushing 35 fixed to spindle 20 by a set-screw 36. The nut 24 is screwed onto the threaded bushing and bears downwardly on annulus 33 to assure a tight fit. This construction is more fully described and claimed in my co-pending application Serial No. 586,953, filed April 6, 1945.

At its upper end spindle 20 includes a tapered portion 40 having a wedge fit in the internally tapered collar 25. The lower portion of the support collar stops directly above nut 24, threaded bushing 35 and the reduced portion of spindle 20. Support collar 25 includes a radial flange 44 mounting a horizontally disposed support 43. These parts are secured together by means of a plurality of screws 44a. A lower rotating lapping block 45 is secured against the upper side of the horizontal support 43 by means of a plurality of screws 46 passing through the horizontal support and entering the lapping block from its under side.

Referring again to Fig. 1, base 10 is provided at one side with a vertical hollow socket 50 in which is securely fitted the lower end portion of a vertical column 51. A bracket-housing 52 is secured to the upper end of the column by means of a set screw 53. An upper drive motor 54 is secured to the bracket-housing by a motor support 55a having a laterally extending bar-like part 55 fitting in an outwardly extending bearing 56 at one side of the bracket-housing. Part 55 is shiftable longitudinally in the bearing 56 whereby the position of the motor is laterally adjustable. A set screw 57 is provided to secure part 55 and thus the motor 54 in adjusted position. On the outer end of shaft 58 of motor 54 is secured a motor pulley 59, adapted to drive a pulley 60 through a belt 61. The pulley 60 is mounted on an idler shaft 62, the lower end portion of which fits into a vertical bearing 63 secured to the bracket-housing as by bolts 64. Also on shaft 62 to be driven therewith is a variable speed pulley 60a.

Variable speed pulley 60a is connected by a belt 66 to drive a variable speed spindle pulley 65 secured to the outer end portion of an upper spindle 67, in axial alignment with the lower spindle 20. Spindle 67 passes through a sleeve 68 operatively connected to the spindle by a key 69 secured to the sleeve and slidably positioned within a spline 70 extending a substantial distance up and down the spindle. A pair of bearings 71 and 72 is disposed between the sleeve 68 and a built-in bearing 73 within the upper portion of the bracket-housing 52. About the lower section of the spindle 67 is a quill 75 extending through an opening in the lower portion of the bracket-housing. Bearings 76 and 77 are disposed between the upper and lower ends of the quill, respectively, and the spindle 67.

The quill 75 is provided with a vertical rack section 78 meshing with a pinion 79 secured to a shaft 80 extending completely through the bracket-housing 52 (see Fig. 4). Collars 81 and 82 are secured to the shaft 80 at the respective outer sides of the bracket-housing 52, to keep the shaft from longitudinal movement while a knob 83 provides for hand-turning of the shaft to rotate pinion 79 and thereby raise or lower the quill 75 to adjust it to the desired positions. As shown in Figs. 1 and 4, a small clamp handle 85 is secured to one end of an eccentric shaft 86, extending completely through the bracket-housing 52. Shaft 86 is so mounted that when turned to one position it is free of quill 75 and when turned to the opposite position binds against said quill to lock the same in any desired position of adjustment.

Returning to Fig. 1, collars 90 and 91 are secured to upper spindle 67 immediately above and below the respective ends of the quill 75. Therefore, as the quill is adjusted upwardly or downwardly on turning of the knob 83 upper spindle 67 is moved upwardly or downwardly, the key 69 remaining in the spline or keyway 70. The

lower end of spindle 67 is provided with a crank arm 92 secured thereto by a set screw 93 (see Fig. 5). A pin 94 is secured to the far end of the crank arm and immediately below the latter is received in a hub 95.

The lower end of pin 94 fits loosely in a hub 96 secured to the central portion of a carrier-disc 97. Hub 96 has a reduced diameter lower end portion which extends through one or more upper washers 98, the center hole of the disc 97, one or more lower washers 99 and is threaded to a lock nut 100.

As more particularly shown in Fig. 5, carrier-disc 97 is located between the lower lapping head 45 and an upper lapping head 105. Each lapping head is in the form of an annulus the lower head having a central circular opening 106 and the upper head having a similar opening 107. The head openings are in alignment and are sufficiently large to accommodate pin 94 and hubs 95 and 96 as they are moved around by the crank arm 92.

Upper lapping head 105 is provided with a plurality of spaced wells 108 (see Figs. 2 and 5), which are funnel-shaped to receive abrasive mixtures, grinding compounds, cleaning fluids, etc. Lift handles 109 and 110 are secured to the upper lapping head and are adapted to be engaged by a pair of hooks 111 and 112 pivotally connected to eyebolts 113 and 114 carried by alignment brackets 115 and 116 secured to the top of base 10. An additional pair of opposite alignment brackets 117 and 118 are secured to the top of base 10. The brackets are so arranged as to keep lapping head 105 in substantial alignment with lapping head 45, and yet permit the former to float freely within relatively narrow limits.

An apron 120 extends completely around the lapping heads, as more particularly shown in Figs. 1 and 2. The apron may be cast with the base 10 and is sufficiently high to form a receptacle 121 for catching used abrasive mixtures and cleaning fluids laterally discharged from between the lapping heads.

Each lapping head is provided with a grinding surface, the surfaces facing but not being in contact with one another when in operation due to the carrier-disc 97 being located between them. The grinding surface portion of each head is provided with a plurality of spaced criss-cross grooves 122 (see Figs. 3 and 5) extending through the peripheral edges of the respective heads. These grooves are sufficiently wide and deep to receive and ultimately discharge abrasive mixtures employed in lapping the blank oscillator plates.

The carrier-disc is more fully shown in Fig 3. It is preferably made of thin sheet metal, aluminum for example, and has a diameter substantially the same as that of the lapping heads and is somewhat thinner than the thickness to which the quartz oscillator plates are to be lapped. Carrier-disc 97 is imperforate except for a plurality of spaced openings 125 extending completely around the disc and located toward the outer edge thereof. In the instant construction each opening is generally pentagon in shape and has its sides or edges curved inwardly as shown.

Additionally each opening is of such size as to accommodate but a single blank quartz oscillator plate 126 and yet permit of turning of the plate on its major faces. Openings 125 are so spaced from the perimeter of the disc with respect to the pin 94 and crank arm 92 that portions of a number of successive openings extend beyond the perimeter of the lapping heads in any position of the disc. The portion of each opening so extending is regulated in amount so that the main portion of each blank plate continues to rest between the lapping heads and cannot drop through the opening into receptacle 121.

This is illustrated in some detail in Fig. 3, which shows five (5) of the openings extending in varying amounts beyond the perimeter of the lower lapping head 45. This permits abrasive mixture from each opening to be discharged laterally and outwardly of the perimeter of the lower lapping head into receptacle 121 as movement of the carrier-disc exposes a portion of the opening beyond the perimeter of the lapping head 45. To this extent each opening is self-cleaning.

Referring to Fig. 2, the apparatus is shown diagrammatically with a manually operated rheostat switch 130 for drive motor 12, a similar manual operating rheostat switch 131 for drive motor 54, a 3-pole safety switch 132 and an automatic timing switch 133 for controlling automatically the time period during which a set of oscillator plates is lapped when the apparatus is in operation. Since the electrical circuits are more or less standard or conventional, they are not shown in the drawings.

The safety switch connects with electrical current service lines as well as with the timing switch and the two relay switches. During normal operations, current for the two drive motors passes through the timing switch and the two relay switches. When the apparatus has been operated a predetermined length of time, the timing switch automatically stops the flow of current, through the relay switches, to their respective drive motors. Further movement of the lower lapping head and the carrier-disc is then terminated.

The apparatus may be operated as follows:

A small amount of a suspension of abrasive grit mixture is placed on top of the lower lapping head 45 and spread substantially evenly over its lapping surface as well as filling the grooves 122. Carrier-disc 97 is then placed on the lower lapping head, a portion of the disc extending beyond the perimeter of the head, as shown in Fig. 3, for example, so that the hub 96 is approximately in a position to receive the pin 94 when crank arm 92 is moved over the hub. A blank oscillator plate 126 is placed in each pentagon opening 125 in the disc. The blank plates are placed in successive disc openings in random positions as in Fig. 3.

A further amount of abrasive grit suspension is placed on the disc 97 and oscillator plate blanks. Upper lapping head 105 is then placed carefully on top of the disc and oscillator plate blanks, hooks 111 and 112 being engaged with lift handles 109 and 110. Knob 83 is suitably turned to operate pinion 79 and the latter meshing with rack 78 the quill 75 is moved downwardly, so that pin 94 is dropped into the hub 96 of the disc 97. Handle 85 is brought down to have shaft 86 engaged and clamp the quill in the desired position.

Upper spindle 67 is then turned slowly by hand to move the disc 97 and give the operator an opportunity to observe whether the blank plates are correctly positioned in the pentagon openings as the protruding portion of the disc moves around the perimeter of the lapping heads. Abrasive grit suspension is poured into wells 108 in order to provide a generous supply between the lapping surfaces of the lapping beads.

Timing switch 133 is set and current passed to

drive motors 12 and 54. Lower lapping head 45 and carrier-disc 97 are then suitably moved or rotated to obtain the desired lapping action on the major faces of the oscillator plates. A few trial runs may be made to determine a definite relationship between the lapping time and the amount of quartz removed from each oscillator plate. After this period of time has been determined for oscillator plate blanks of a certain general size and thickness, timing switch 133 may be adjusted accordingly. When the time interval expires, current flow to the motors is automatically stopped by the timing switch 133 and this, in turn, stops movement or rotation of the lower lapping head 45 and the carrier-disc 97.

During the lapping operation, further amounts of abrasive grit suspension are fed into wells 108. Due to the depth and criss-cross arrangement of grooves 122, spent or partially spent abrasive grit suspension finds its way to the perimeters of the two lapping heads and is dropped into receptacle 121. A certain amount of the abrasive grit suspension in disc openings 125 is also dropped into the receptacle when a portion of each opening is advanced to the point where it extends over and beyond the perimeter of the lapping heads.

It is better practice to rotate the lower lapping head much more rapidly than the carrier-disc. The invention has been satisfactorily practiced by rotating the lower lapping head at the rate of about 1100 R. P. M. and upper spindle 67 which turns crank arm 92 and hence moves pin 94 as well as the carrier-disc, at the rate of about 90 R. P. M. With drive motors of adequate speed, the desired speed relationship between head 45 and disc 97 may be obtained by using belts 19, 61 and 66 on the proper pulleys of variable speed pulley 18, 60 and 65, respectively.

If the course of each blank plate 126 is followed in its movements generally toward and away from as well as around the axis of lower spindle 20, (referred to as a fixed-stationary point, about which lower lapping head 45 rotates, and about which carrier-disc 97 is moved) and around the axis of eccentrc pin 94 (referred to as a fixed-moving point) about which carrier-disc 97 rotates, as well as its movements generally in its disc opening 125, it will be seen that the blank plate follows an exceedingly tortuous path, which brings it into repeated sliding and turning contact with substantially all effective lapping portions of the lapping surfaces of the two lapping heads.

Referring again to Fig. 3, it will be seen that as pin 94 moves in a clockwise direction, indicated by arrows, its fixed-moving point 135 follows a circular path 136 about the fixed-stationary point 137 of lower lapping head 45. This causes each blank plate to move inwardly and outwardly across the lapping surfaces of both lapping heads while it progresses in an undulating counter-clockwise satellite path completely around fixed-stationary point 137 and counter-clockwise completely around fixed-moving point 136.

The clockwise movement of the carrier-disc is, of course, due to the clockwise direction of movement of the eccentric pin and the combined counter-clockwise direction of the carrier-disc (and hence of the blank plates) is due to the dragging action of the lower lapping head against the bottom of each blank plate as it, the lapping head 45 rotates, in a counter-clockwise direction. This counter-clockwise movement of the carrier-disc is possible since the pin 94 has only a loose fit in the hub 96. The effect, therefore, is to move each blank plate generally in the same direction of travel as that of the rotating lapping surface in a path of relatively large convolutions about a fixed-moving point that is relatively far removed from the center of the blank plate and that moves in a generally circular path about the fixed-stationary point of the rotating lapping surface.

In addition to the counter-clockwise movements just described, each blank oscillator plate 126 is simultaneously moved within the zone defined by its carrier-disc opening 125. Since the confined zone is somewhat larger in cross-sectional area than the cross-sectional area of the blank plate, the plate is free to move or rotate within the disc opening. Due to the number of sides of each opening and the manner in which they are curved inwardly, it is difficult to define accurately the precise course followed by the plate as the carrier-disc simultaneously pursues its clockwise and counter-clockwise courses.

Because of the rapidity with which lower lapping head 45 is rotated compared with the rate of rotation of carrier-disc 97 and the further fact that the carrier-disc has a counter-clockwise movement, the dragging counter-clockwise action of the lapping surface of the lower lapping head against the bottom of each blank plate tends to impart a generally similar counter-clockwise movement of the plate in its disc opening. The effect, therefore, is simultaneously to move each blank plate generally in the same direction of travel as that of the rotating lapping surface in a path of relatively small convolutions about a moving point relatively near the center of the blank plate as the plate advances around the orbits of the larger paths described above.

Unusually good results have been obtained. The blank plates are lapped to an exceedingly smooth finish. This applies to the edge portions of the plates as well as to their major faces. Also the present invention provides for the rapid reducing of the quartz oscillator plates to a thickness from which they are to be finished by hand. For example, using 220 grit and rotating the head 45 at 1100 R. P. M. and shaft 70 at the rate of approximately 90 R. P. M. the quartz crystal plates have been reduced in thickness at the rate of approximately .010 inch per minute. The rate of removal of stock varies depending on the size, etc., of the grit used. Much better results are obtained according to the present method than can be obtained, for example, by the method of moving the blank plates solely by a carrier-disc of conventional construction between two stationary lapping heads. It is believed that the superior results of the present practice may be in part due to an enhanced reciprocal effect between the lapping surfaces of the lapping blocks and the surfaces of the major faces of the blank plates. Because of the exceedingly tortuous, constantly shifting, path repeatedly followed by each blank plate, the effective lapping surfaces of the lapping blocks are maintained uniformly smooth and flat. The smooth and flat surfaces are in turn adapted to lap the major faces of the blank plates to a smooth and flat finish.

Having thus set forth the nature of my invention, what I claim is:

1. In apparatus for the manufacture of quartz oscillator plates, a base, a lower vertical spindle extending above said base, a motor on said base, means to drive said spindle from said motor, a lower lapping head concentric with and driven by said spindle, a carrier disc disposed on the upper side of said lower lapping head, an upper

annulus shaped lapping head disposed over said carrier disc, means for holding said upper lapping head substantially stationary, an upright supported from said base at one side of said spindle, a head on said upright and extending radially therefrom over said lower vertical spindle, an upper vertical spindle having bearing in said head and arranged in alignment with the lower vertical spindle, a motor supported from said head, a drive between the second mentioned motor and the upper vertical spindle, a crank on the lower end of said upper vertical spindle and including a pin located eccentrically with respect to said upper vertical spindle and entering the central opening of said annulus shaped upper lapping head, and a hub centrally located on said carrier disc and receiving the lower end portion of said eccentrically located pin whereby as said upper vertical spindle is rotated said carrier disc is given a satellite movement about the axes of said upper and lower vertical spindles.

2. In apparatus for the manufacture of quartz oscillator plates, a base, a lower vertical spindle extending above said base, a motor supported on said base, means to drive said spindle from said motor, a lower lapping head concentric with and driven by said spindle, a carrier disc disposed on the upper side of said lower lapping head, an upper annulus shaped lapping head disposed over said carrier disc, means for holding said upper lapping head substantially stationary, an upright supported from said base at one side of said spindle, a head and a motor supported from said upright, said head extending radially from said upright over said lower spindle, a vertical spindle having bearing in said head and arranged in alignment with the lower vertical spindle, a drive between the second mentioned motor and the upper vertical spindle, a crank on the lower end of said upper vertical spindle and including an eccentrically located part entering the central opening of said annulus shaped upper lapping head, a hub centrally located on said carrier disc and receiving the lower end portion of said eccentrically located part, whereby as said upper vertical spindle is rotated said carrier disc is given a satellite movement about the axes of said upper and lower vertical spindles.

3. In an apparatus for the manufacture of quartz oscillator plates, a base, a lower vertical spindle extending above said base, a motor on said base, a pulley and belt drive between said motor and said lower vertical spindle, a lower lapping head concentric with and driven by said lower vertical spindle, a carrier disc disposed on the upper side of said lower lapping head, an upper annulus shaped lapping head disposed on said carrier disc, means for holding said upper lapping head substantially stationary, an upright supported from said base at one side of said lower vertical spindle, a head and a motor supported on said upright, said head extending radially of said upright to a position over said lower vertical spindle, an upper vertical spindle having bearing in said head and arranged in alignment with the lower vertical spindle, a counter shaft supported in said head, a belt drive from said motor to said counter shaft, a variable speed belt drive between said counter shaft and said upper vertical spindle, a crank on the lower portion of said upper vertical spindle and including a part located eccentrically with respect to said upper vertical spindle and entering the opening of said annulus shaped upper lapping head, and a hub centrally located on said carrier disc and receiving the lower end portion of said eccentrically located part whereby as said upper vertical spindle is rotated said carrier disc is given a satellite movement about the axes of said upper and lower vertical spindles.

4. The apparatus as in claim 3 including a quill about and forming a bearing means for a lower portion of said upper vertical spindle, means for shifting said quill and thus said spindle vertically to carry said eccentric part into and out of the central opening of said annulus shaped upper lapping head, and means for locking said quill and thus said upper vertical spindle in the desired position of adjustment.

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