July 1, 1958 W. J. WARDEN ET AL 2,840,957

LAPPING DEVICE

Filed June 7, 1957 4 Sheets-Sheet 1

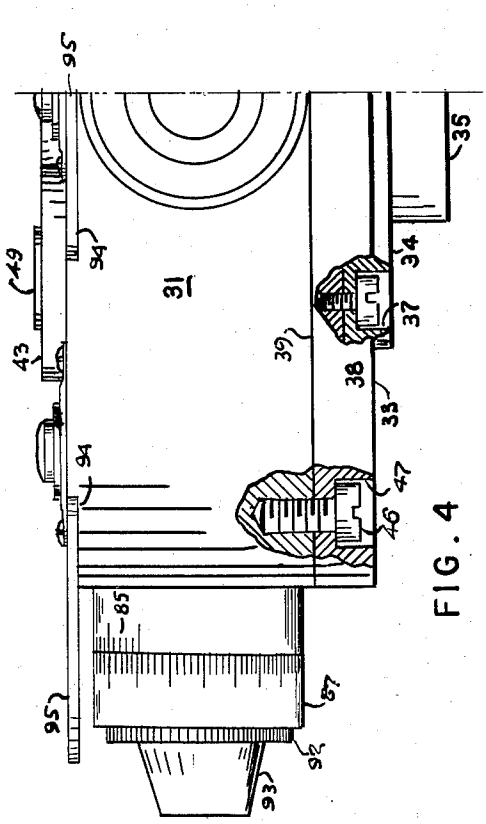


FIG. 4

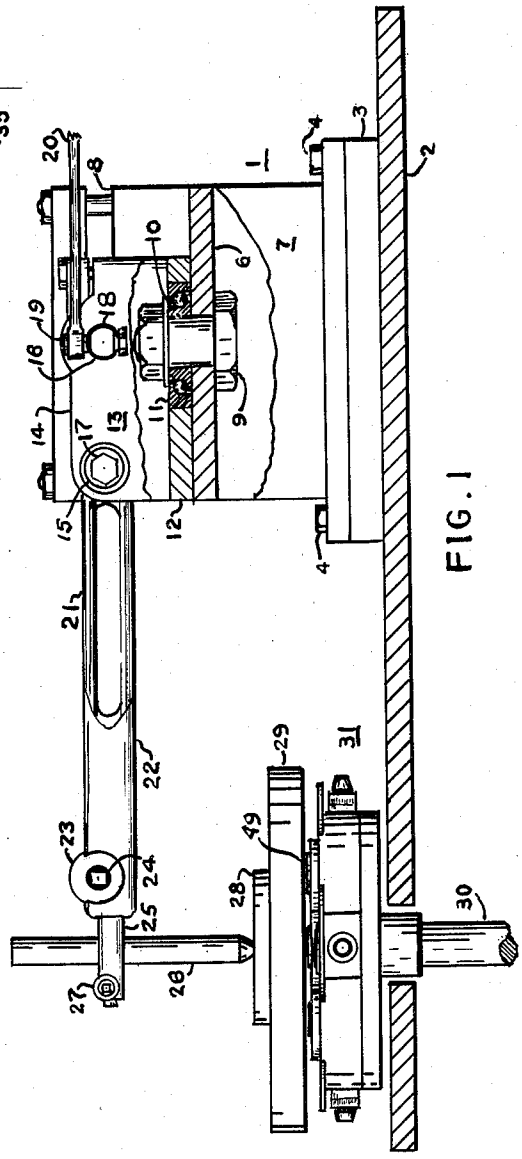


FIG. 1

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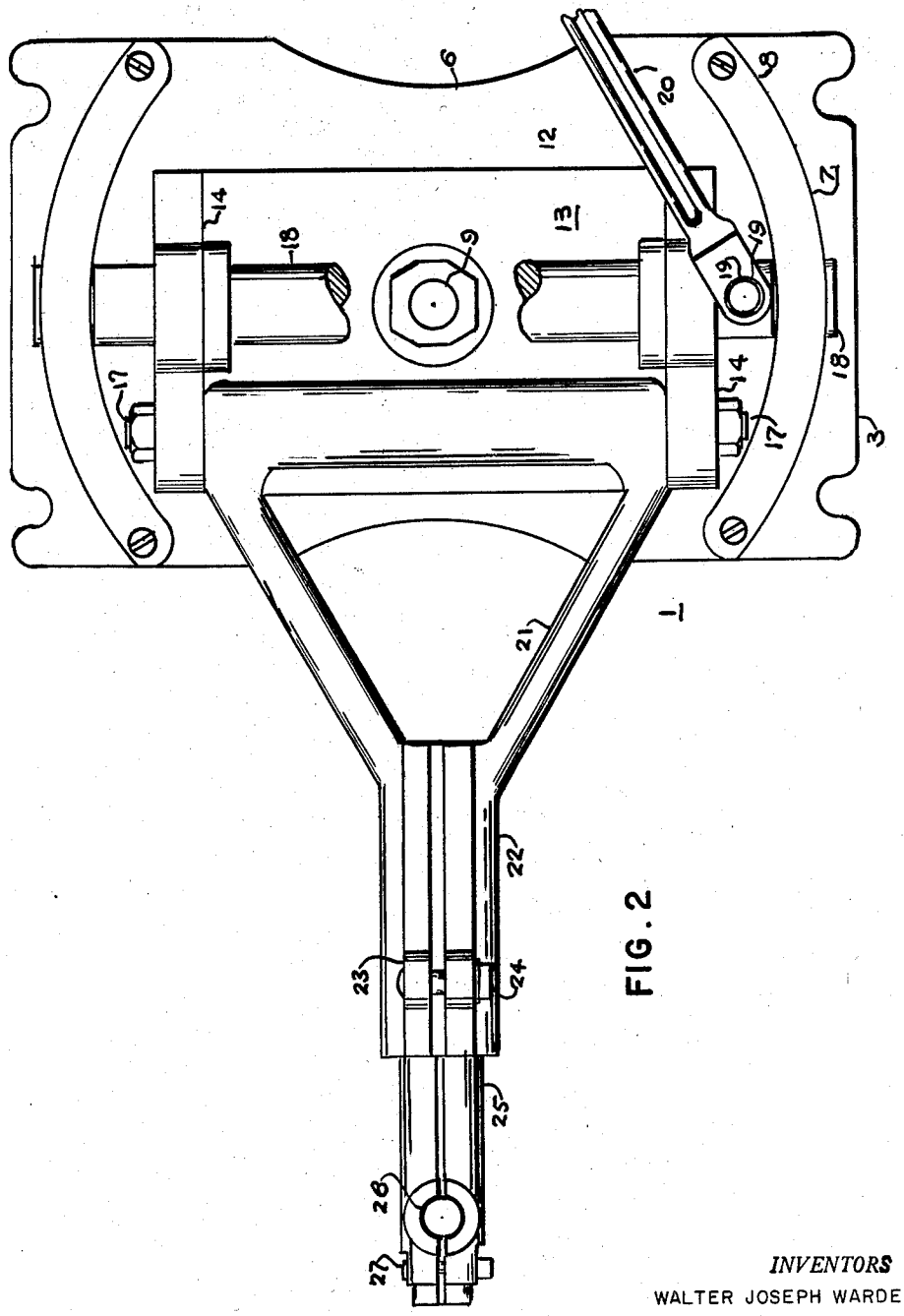


FIG. 2

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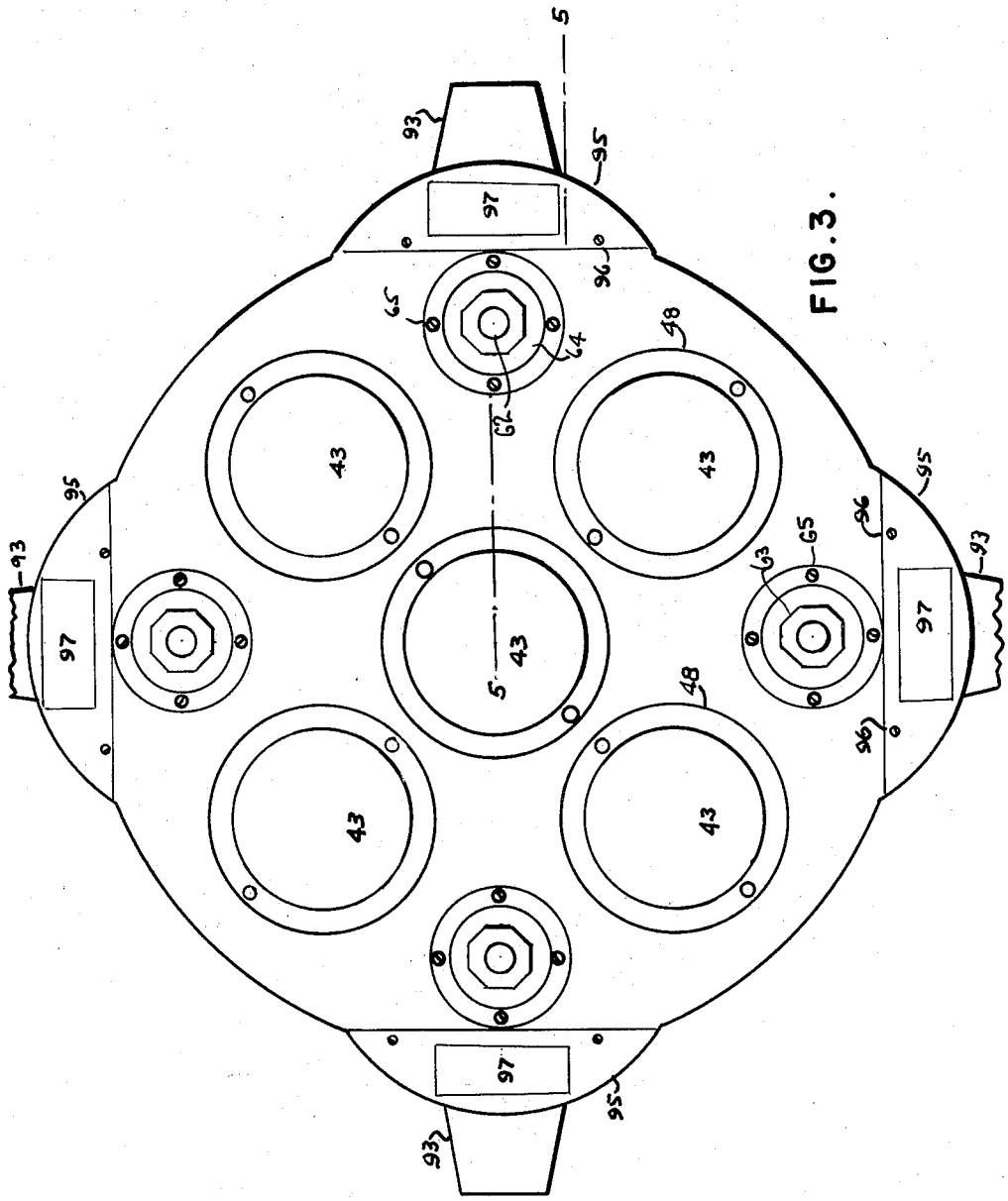


FIG. 3.

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Filed June 7, 1957 4 Sheets-Sheet 4

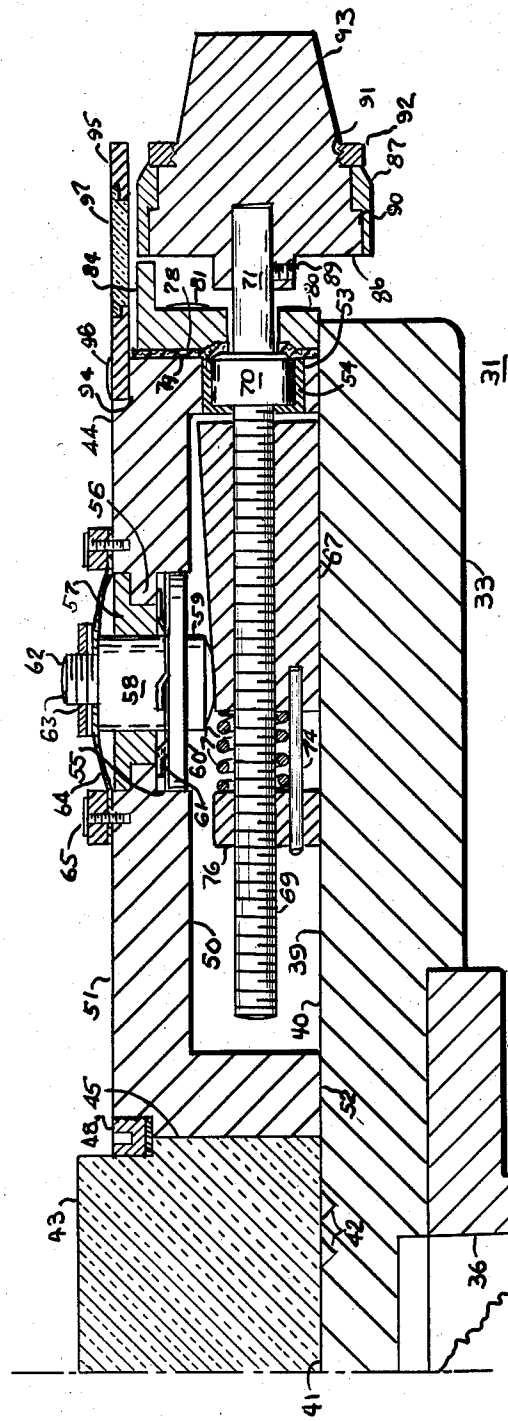


FIG. 5

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LAPPING DEVICE

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Application June 7, 1957, Serial No. 664,446

4 Claims. (Cl. 51—58)

(Granted under Title 35, U. S. Code (1952), sec. 266)

This invention may be manufactured and used by and for the United States Government for governmental purposes, without the payment to me of any royalty thereon.

Quartz crystals vibrating in their thickness shear modes are in wide use for the control of high frequencies. Since the frequency response of a crystal is inversely proportional to the thickness, the crystal becomes extremely thin at the higher end of the frequency range. With the increased thinness of the crystals, imperfections in the surface have an increased deleterious influence upon the functional quality of the crystals. For this reason, crystals produced for use in the high frequency range of the frequency spectrum have in the past been polished or finished to provide a perfect surface finish. Experience has proven that flat optically polished crystals are superior in characteristics and function to crystals finished in any other manner.

In prior art methods of finishing crystals and with the apparatus available, the crystal blanks are ground to a thickness in excess of the finished product in the usual manner. One side is then polished to perfect flatness and high degree of polish. The crystal is then mounted upon an optically flat surface of a work holder and the opposite side is polished down to perfect flatness, parallelism and proper thickness required for the frequency desired. To accomplish this requires that the polishing operation be interrupted with increasing frequency as the final dimensional limits are approached to assure against removal of excessive material. The crystal is required to be removed from the holding surface to be reoriented relative to the polishing surface to obtain the degree of perfection that is requisite in high frequency crystals. The removal of the crystals and reorientation is attended by a great consumption of time and a high percentage of spoilage of crystals at a time in their production when the crystal represents a considerable expenditure of money. The measurement of the dimensions, the degree of polish, flatness and parallelism and the high degree of care required in the final finishing of crystals having a thickness of the order of one thousandth of an inch call for the use of highly skilled workers such as are found in the laboratory and operate to prevent quantity production and a reduction of the cost of production.

To obtain the production of crystals of the order of a thousandth of an inch thickness and less at a rate necessary to meet the demands for such crystals, and to reduce the cost of the crystals may be accomplished by construction of apparatus which makes for less frequent interruption of the polishing operation, which enables the use of less skilled workers in their production, which makes the removal of the crystals from the supporting surface unnecessary to reorient the crystals and which shortens the time in the production. The present invention serves by its very nature to accomplish these purposes and others, that make provision for the greater production of crystals of the character mentioned.

The improvement according to the present invention

resides in the structure of the work holder means of a crystal grinding machine. The prior work holders were made in one piece comprising a large glass disk having one face providing an optically flat surface upon which is secured the crystal blanks, which are previously prepared with optically ground and polished flat surface. The blanks are "wrung-on," i. e., the optically flat surfaces of the crystals are pressed tightly to the optically flat surface of the holder in such a manner as to force all air from between the surfaces so that the pressure of the air on the opposite surface acts to hold the crystal blanks firmly to the surface of the work holder.

The work holder according to the present invention, provides a plurality of work holders, each separately mounted in a carrier, and each presenting optically flat surfaces all in the same plane upon which the crystal blanks may be secured in the same manner. The separate work holders are secured in such a manner that they may be released and rotated in their mounting and interchanged with other work holders. This structure enables the reorientation of the crystal blanks relative to the grinding or polishing surface without requiring the removal of the blanks from the holding surface, and serves to remove one cause of the high percentage of spoilage prevalent with prior art structures and methods.

The work holders are further provided with a stop means, four in number, circumferentially spaced, and projecting from the carrier surface to limit the amount of material that can be removed in a grinding or polishing operation. The extent to which the stop means project from the carrier is adjustable by a means which enables adjustment in increments of the order of one millionth of an inch. As the grinding or polishing continues, the grinding or polishing surface approaches and contacts the stop means preventing further removal of material from the crystal and enabling the operator to know when to discontinue the operation and make further adjustments or to substitute different grinding or polishing means to approach the final dimensions of the crystal. This provides for less frequent operational interruption since the limits of each grinding or polishing operation can be preselected and the reaching of the limit is indicated by contact between the polishing or grinding means and the stop means. This built-in feature enables the use of less skilled workers in the production and finishing of crystals and makes it possible to increase the rate at which crystals can be ground and polished to final dimensions.

It is an object of the invention to provide for quantity production of crystals of very thin dimensions for use in high frequency apparatus.

It is another object of the invention to provide a means which will enable the production of highly polished, thin and exactly dimensioned crystals at a rate greater than presently possible, with less spoilage than presently prevalent and with the use of workers having less skill than the workers presently required.

It is another object of the invention to provide built-in features of work holder means for limiting the extent of removal of material between adjustments and for enabling the reorientation of the crystals relative to the grinding or polishing surface without the necessity of removing the crystals from the holding surface.

Other objects of the invention will become obvious from a consideration of the specification, the claims and the drawings in which:

Fig. 1 is an elevational view of a crystal lapping and polishing machine in which the invention has been incorporated;

Fig. 2 is a plan view of a portion of the machine illustrated in Fig. 1;

Fig. 3 is a plan view of the work holder means;

Fig. 4 is a partial elevational view of the work holder means showing the manner in which the parts are secured together, and

Fig. 5 is a sectional view of a fragmentary portion of the work holder means taken on line 5—5 of Fig. 3.

The lapping and polishing machine shown in Figs. 1 and 2 is of the conventional design except that the lapping or polishing plate and the work holder means have been interchanged in position and the work holder in the present disclosure is of the improved type in accordance with the present invention.

The machine provides for two concurrent motions, one rotational and the other oscillational. It includes an oscillating mechanism **1** mounted on a table **2** having a base portion **3** secured to the table as by bolts **4**. The base portion **3** has a raised deck portion **6** supported by end walls **7**. The end walls having cylindrical shape are provided adjacent their top portions with horizontally disposed slots **8** operable as guides. The deck portion **6** which extends between the walls **7** contains a pivot bolt **9** located such as to be at the center of the curvature of the end walls. The pivot bolt **9** carries one raceway **10** of a ball bearing.

The other raceway **11** of the ball bearing is carried by a floor portion **12** of an oscillatable frame structure **13** which pivots about the pivot bolt **9**. The oscillatable frame structure **13** has two end walls **14** supported on and connected to the floor portion **12**. The end walls **14** contain two pairs of oppositely arranged bores **15** and **16** operable as journals for rods **17** and **18**. The rod **18** is provided with flattened ends engageable in the slots **8** in the side walls **7** and operable to guide the oscillatable frame structure in a horizontal plane. One end of the rod **18** is provided with a transverse bore in which is tightly fitted a pin **19**. The pin **19** serves as a pivot for connecting the connecting rod **20** to the oscillatable frame structure **13**. The other end of the connecting rod **20** is connected to a crank driven by a rotatable shaft (not shown) for driving the oscillatable frame structure.

The other rod **17** forms a pivot for the arm having an A-frame portion **21** and a split cylindrical portion **22** having a longitudinal bore. Near the outer end of the arm the cylindrical portion **22** is provided with a pair of ears **23** through which passes a bolt **24** that threads in one ear for drawing the split portions together and thus reducing the inner dimensions of the longitudinal bore, and clamping a rod **25** therein. The connection between the rod **25** and the cylindrical portion **22** of the arm makes provision for the adjustment of the length of the arm. The rod **25** is similarly split longitudinally thereof and provided with a bolt **27** extending between the portions for drawing them together. The rod **25** is further provided near the bolt **27** with a transverse bore for receiving a spindle **26** and which is clamped therein by the tightening of the bolt **27**. The spindle **26** is provided with a conical point for engagement in conical detents in a metallic plate **28** secured to the abrasive plate **29** which may be a polishing or lapping plate as desired.

Extending through the table **2** is a shaft **30** rotatably driven by means not shown and having a tapered upper end. The upper end of the shaft **30** receives a work holder means **31** thereon. The shaft **30** is driven at any preselected speed and drives the work holder means in a horizontal plane parallel to and adjacent to the horizontal plane of motion of the abrasive plate **29**.

Referring to Figs. 3 to 5 inclusive, a work holder means acording to the present invention comprises a base plate **33** having in one face a concentric bore extending approximately one-fourth of the thickness of the plate and a smaller concentric bore extending another one-fourth of the thickness thereof. In the larger bore is fitted the flange **34** of a flanged sleeve **35**. The flanged sleeve **35** is provided with a tapered bore **36**, the inner end being of substantially the same size as the smaller bore and is designed for the reception of the upper end of the rotatable shaft **30**. The flange **34** is provided with a plurality of circumferentially spaced countersunk bores **37** aligning with threaded bores in the bottom of the larger bore of the base plate **33**, for the reception of machine screws by which the base plate **33** and the flanged sleeve **35** are connected securely together. The tapered bore in the flanged sleeve **35** is in alignment with the smaller bore in the bottom of the base plate **33** to allow for the extension of the shaft **30** thereinto.

The opposite face **39** of the base plate is provided with an optically flat surface **40** having five areas **41** symmetrically spaced about the central axis thereof and ringed by a plurality of V-shaped grooves **42**. The five areas provide a seating surface for five work holders **43** having corresponding optical flat surfaces. The V-shaped grooves operate as free spaces for the reception of any foreign matter that may be present on the ringed surface and moved therefrom during the seating operation of the work holders on said surfaces.

A retainer plate **44** having a thickness comparable to that of the base plate **33** is provided with five countersunk bores **45** symmetrically spaced in the same manner as the areas **41** on said base plate to communicate therewith. The retainer plate **44** has a surface **52** mounted against the optically flat surface **40** of the base plate **33**. The retainer plate **44** is secured to the base plate **33** by a plurality of circumferentially spaced machine screws **46**. The machine screws **46** pass through countersunk bores **47** in the base plate **33** into threaded bores in the retainer plate **44**. The countersunk portions of the through bores **45** are threaded for the reception of a threaded annular ring **48**, which when assembled, engages a shoulder on the work holder **43** as pointed out below. The threaded rings **48** provide a means for releasably securing the work holders **43** in place. The work holders **43** comprise a cylindrical plate of precision ground glass having parallel top and bottom surfaces, ground to optical flatness with the upper surface reduced in diameter to form a shoulder. The shoulder is arranged to be engaged by the ring **48** whereby the work holder **43** is held tightly in seated relation to the ringed surfaces **41**. With the plates **33** and **44** in assembled relation and the work holders **43** firmly seated against the areas **41**, the upper surfaces of the work holders **43** occupy a common plane perpendicular to the axis of the plates and above the upper surface of the retainer plate **44**. Upon the upper surface of the work holders **43** crystal blanks may be "wrung-on" whereby they may be secured for grinding and polishing.

The retainer plate **44** is further provided with a means for limiting the motion of the polishing plate toward the work holders **43**. For this purpose the retainer plate **44** is further provided with four radially extending bores or cavities **50** extending from the outer periphery of the plate **44** and opening through the bottom surface **52** of the plate **44** whereby the top surface **40** of the base plate **33** forms one wall of the bore or cavity **50**. The outer ends of the bores **50** are reduced as at **53** in which is located a bushing **54** having a flanged portion that provides a thrust bearing and a sleeve portion that provides a journal. The cavity or bore **50** may be formed by any known machine operation such as milling or drilling.

Approximately midway between the ends of the bore or cavity **50** is a transverse bore **55** opening from the bore or cavity **50** through the upper surface **51** of the retainer plate **44**. Said bore **55** is formed with an internal flange **56** approximately midway between its ends which provides a reduced bore. A flanged bushing **57** is inserted from the face **51** and has a sleeve portion engaging the reduced bore and a flange portion engaging the upper enlarged portion of the bore **55**. The bushing **57** provides a cylindrical guide surface for a pin **58**. The

pin 58 is provided with an upper reduced threaded portion 62 which is hardened on the end and an intermediate flanged portion 60. The shank portion 59 fits the reduced bore and the flange portion 60 fits in the lower part of the bore 55. A spring washer 61 surrounds the shank portion 59 and engages the under side of the inwardly directed flange 56 and the end of the bushing 57 and the top of the flange 60. As so located the spring 61 exerts a downward thrust upon the pin 58 tending to move the pins inwardly toward the cavity or bore 50.

On the upper end of the pin 58 seated against the shoulder formed by the reduced portion 62 is a membrane 64 of suitable material having a diameter suitable to overlap the boundary of the bore 55. A nut 63 is threaded upon the reduced threaded end of the pin 58 against the membrane for securing the membrane to the pin. The outer periphery of the membrane 64 is secured to the face 51 of the plate 44 by machine screws 65 engaging threaded bores in the face 51 around the bore 55.

For adjusting and maintaining the pins in a preselected position a wedge 67 is interposed between the lower end of the pin 58 and the upper face 39 of the base plate 33. The wedge 67 is so formed and related to the pin 58 that movement thereof radially inwardly of the plate 44 will cause an upward displacement of the pin 58 against the thrust of the spring washer 61.

For moving the wedge in a radial direction a threaded rod 69 engages in a threaded bore in the wedge 67 and extends throughout substantially the radial length of the bore 50. The threaded rod 69 is provided with an enlarged head 70 journaled in the bushing 54 and has a shoulder engaging the inwardly directed flange.

The wedge 67 is further provided with a back-lash eliminator comprising a rod 74 projecting from the inward end of the wedge 67 and received in a bore in a traveling nut 76 that is threaded on the threaded rod 69. A spring 77 is interposed between the traveling nut and the inward end of the wedge 67 for the purpose of exerting a thrust therebetween. In this manner the wedge is compelled to bear always against one side of the threads of the rod 69 and back-lash is eliminated.

The other shoulder of the enlarged portion 70 of the threaded rod 69 is engaged by a neoprene seal 78 which also engages the flattened portion 79 of the periphery of the retainer plate 44 in the region of the bore 50. The outer face of the seal 78 is engaged by an end wall of the vernier dial 80 affixed to the plate 44 by machine screws 81 passing through the end wall of the dial 80 and the neoprene seal 78 into threaded bores in the plate 44.

The end wall of the vernier dial is provided with a bore through which the reduced end 71 of the threaded shaft 69 extends and forms a shoulder backing up the neoprene seal 78 and forming a thrust bearing on the other side of the enlarged portion 70. The cylindrical portion 84 of the vernier dial 80 is provided with markings 85 thereon which are engraved or etched and filled with a permanent black enamel.

The end of the reduced portion 71 of the threaded shaft 69 is secured to a drum 86 by a set screw 89. The drum 86 is provided with a stepped cylindrical portion 90 over which fits a drum dial 87. The cylindrical surface of the dial 87 is suitably engraved and filled with a black enamel similar to the vernier dial. The drum 86 is further provided with a reduced threaded portion for receiving a threaded knurled ring 92, which when threaded thereon engages the end of the dial 87 and secures it in a preselected adjusted position. The outer end of the drum 86 has a knurled tapered knob 93 integral therewith which may be grasped for rotating the shaft 69. The plate 44 is milled as at 94 on its peripheral edge in the regions adjacent the dial and a splash plate 95 is fixed thereto by screws 96 and arranged to be flush with the surface 51 of the plate 44. The splash plate is further provided with a window 97 of clear plastic material through which the markings on the dials may be observed.

The work holder means of the present invention operates in the following manner. With the work holder means assembled in the manner shown in Fig. 1 on the end of the shaft 30, the rings 48 may be removed permitting the removal of the work holders 43 from the plate 44. The crystal blanks which have been previously prepared, by grinding and polishing of one face thereof, are "wrung-on" the work holders. The work holders 43 are then assembled in the bores 45 and seated on surfaces 41 and the rings 48 are then threaded in place to clamp the work holders against the surface 41. The polishing plate 29 is then placed upon the blanks, spindle 26 clamped in the rod 25 is lowered into engagement with a detent in the plate 28. The knobs 93 are rotated to the proper position to set the wedges 67 and the pins 58 to the proper position determining the limit of the first grinding operation. The shaft 30 is then set to rotating at the same time that the mechanism 1 is set to oscillating.

The grinding operation may then continue until the pins 58 engage the under side of the plate 29, at which time the grinding operation is halted to permit the change of the polishing plate, the reorientation of the holders 43, measurement of the thickness, flatness and polish of the surface and the readjustment of the pins 58.

The grinding or polishing operations may then be continued with the interruptions required for attaining the optimum results.

As has been hereinbefore pointed out, the reorientation of the crystal blanks relative to the grinding or polishing surface, a necessary operation to the attainment of a perfectly flat surface, is made possible by the releasable rings 48 which secure the holder 43 in place. This provision permits the reorientation without the need of removing the "wrung-on" crystals from the optical flat surfaces of the holder 43. In this manner the spoilage of crystals is reduced to a minimum.

The pins, providing as they do a built-in means for halting the grinding or polishing operation, provide for the less frequent interruptions in the grinding and polishing operation and less need for measuring of the thickness.

Having described our invention and the best mode of making and operating the same, what we claim as our invention is set forth in the following claims:

1. In a crystal polishing machine having a polishing disk, a means for oscillating said polishing disk through an arcuate path in a horizontal plane, and a shaft having a tapered end rotatable about a vertical axis which intercepts the horizontal plane in the region of motion of said polishing disk, a means carried by the tapered end of said shaft comprising a base plate having an optically flat surface parallel to the plane of motion of the polishing disk, a plurality of areas symmetrically arranged on said surface and encircled by a plurality of V-shaped grooves for catching foreign matter that may be moved along said surface, a precision ground glass workholder having optically flat parallel surfaces, a work holder seated upon each of said areas, a retaining plate embracing said work holders for releasably securing said work holders to said surfaces and means projecting from said retaining plate at symmetrically spaced positions engageable with said polishing disk to interrupt the movement of the polishing disk toward said work holders whereby the polishing operation may be interrupted beyond a predetermined point.

2. In a crystal polishing machine having a polishing disk, a means for oscillating said polishing disk through an arcuate path in a horizontal plane, and a shaft rotatable about a vertical axis which intercepts the horizontal plane in the region of motion of the polishing disk, a means carried on the end of said shaft for supporting the crystals to be polished comprising a base plate having a plurality of optically flat symmetrically positioned sur-

faces lying in the same plane perpendicular to the vertical axis, a precision ground glass work holder having optically flat parallel surfaces seated on each of said surfaces of said base plate, a retaining plate secured to said base plate having symmetrically positioned bores embracing work holders in their positions upon said surfaces, means associated with said retainer plate engaging said work holders for releasably securing said work holders in their seated positions, a plurality of hardened pins adjustably extending from the upper surface of the retainer plate at symmetrically placed positions and means for adjusting the extension of said pins from said retaining plate, said latter means operating upon engagement by said polishing plate to interrupt the polishing operation beyond a predetermined point.

3. In a crystal polishing machine having a polishing disk movable in an arcuate path in a horizontal plane and a means for supporting crystals and carrying them in a circular motion in said plane, said means comprising a base plate having an upper optically flat surface lying in a parallel horizontal plane, symmetrically positioned areas of said surface encircled by a plurality of V-shaped grooves, a retainer plate secured to the upper surface of said base plate having bores symmetrically arranged to match the symmetry of said areas, precision ground glass work holders mounted in each of said bores having optically flat parallel surfaces, one of said surfaces engaging the optically flat areas of said base plate, and the other surface of said work holders lying in a horizontal plane above the upper surface of the retainer plate, means carried by the retainer plate engaging said work holders for releasably securing said work holders in seated positions, adjustably extendable hardened pins projecting from the upper surface of said retainer plate for engaging said polishing disk and interrupting said polishing operation at a predetermined limit and means for adjusting the extension of said pins from said retainer plate relative to the upper surface of the work holders.

4. A crystal supporting means for a crystal polishing machine comprising a base plate having an optically flat surface on one side and a sleeved flange on the other side, symmetrically positioned areas of said surface being encircled by a plurality of V-shaped grooves, a retainer plate secured to said base plate having bores therethrough in positions to communicate with said encircled areas, a precision ground glass work holder having opposite sides parallel to each other and ground to optical flatness mounted in said bores seated with one surface against said encircled area and the other surfaces of each lying in a common plane above the upper surface of said retainer plate, means carried by the retainer plate engaging said work holders for releasably retaining said work holders in their seated positions, stop pins extending from the upper surface of the retainer plate in symmetrically arranged positions between said work holders, wedge shaped means engaging the lower ends of said stop pins to support said pins in a predetermined extendible position of said wedge means, and means for indicating the distance of the tops of said stop pins relative to the top surface of said work holders.

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