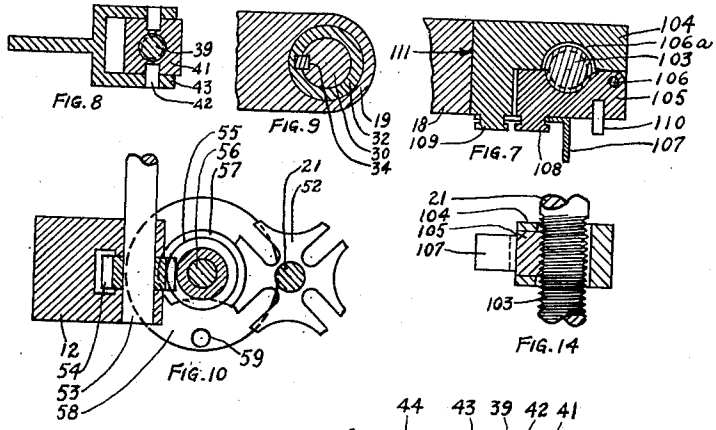
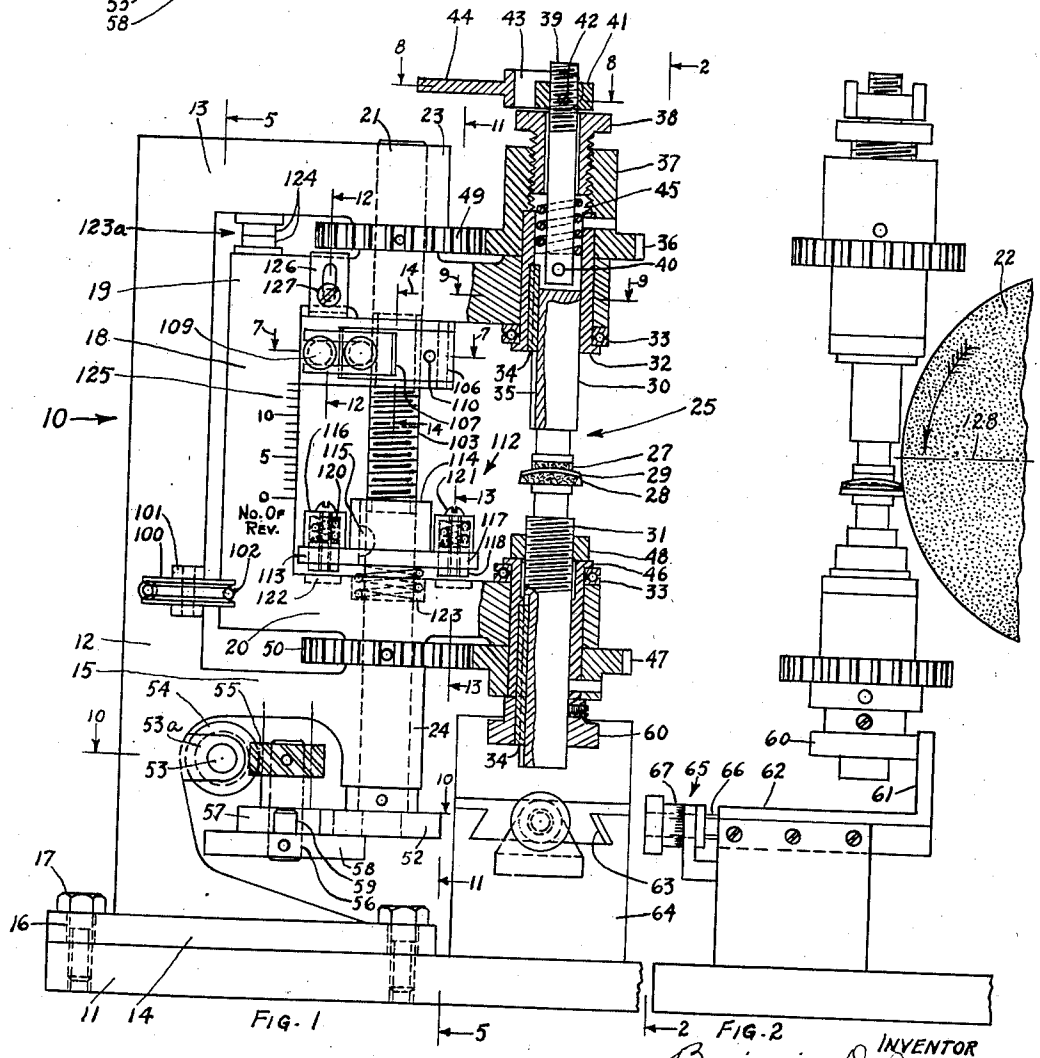
Dec. 31, 1940. B. D. BROWN 2,227,243

IRREGULAR CONTOUR GRINDING MACHINE

Filed Sept. 30, 1936 3 Sheets-Sheet 1





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IRREGULAR CONTOUR GRINDING MACHINE

Filed Sept. 30, 1936 3 Sheets-Sheet 2

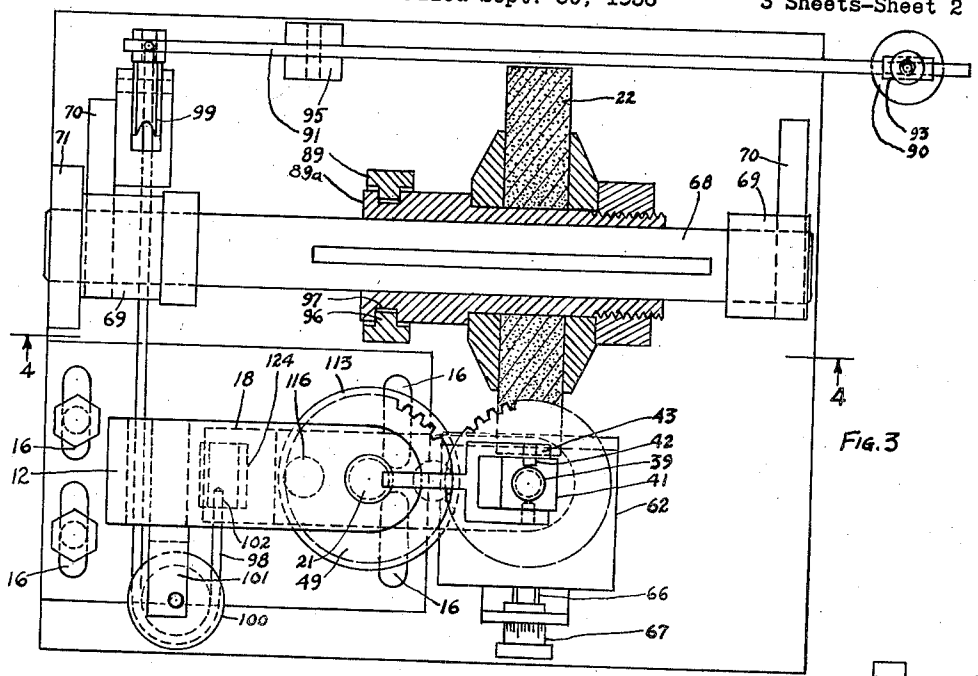


FIG. 3

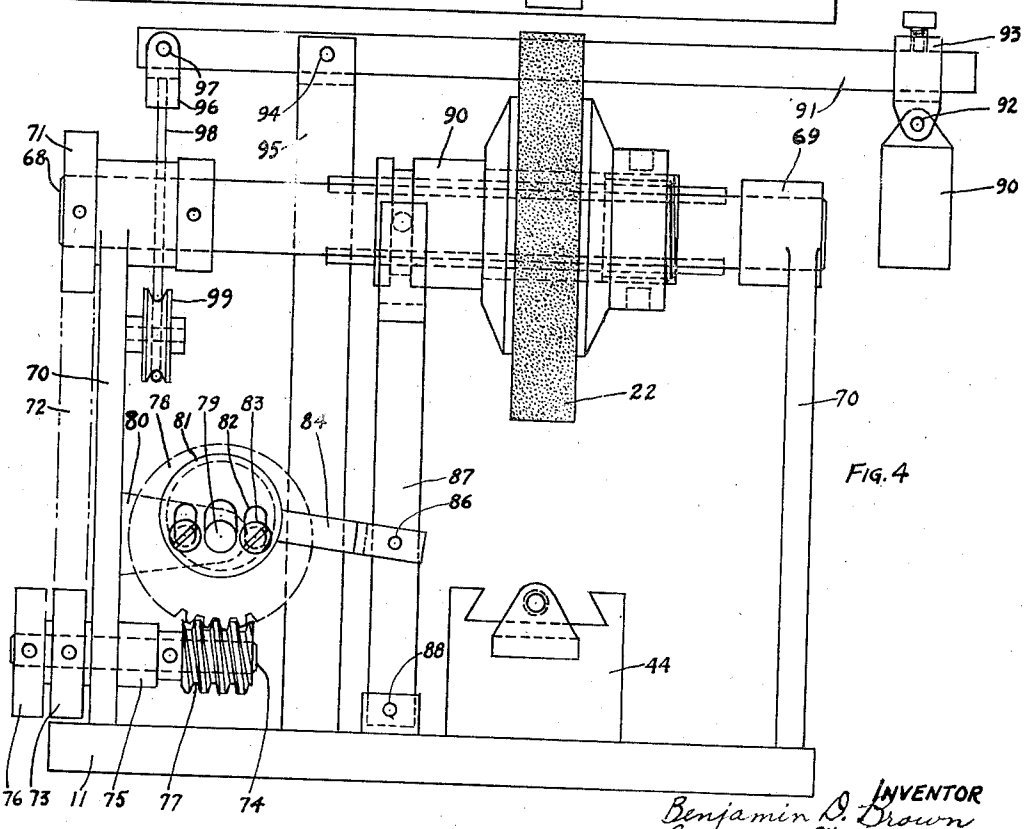


FIG. 4

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Dec. 31, 1940. B. D. BROWN 2,227,243

IRREGULAR CONTOUR GRINDING MACHINE

Filed Sept. 30, 1936 3 Sheets-Sheet 3

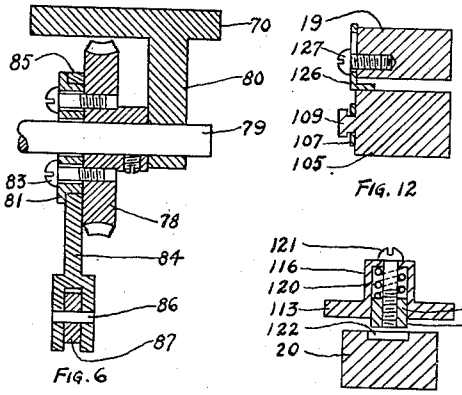


FIG. 6

FIG. 12

FIG. 13

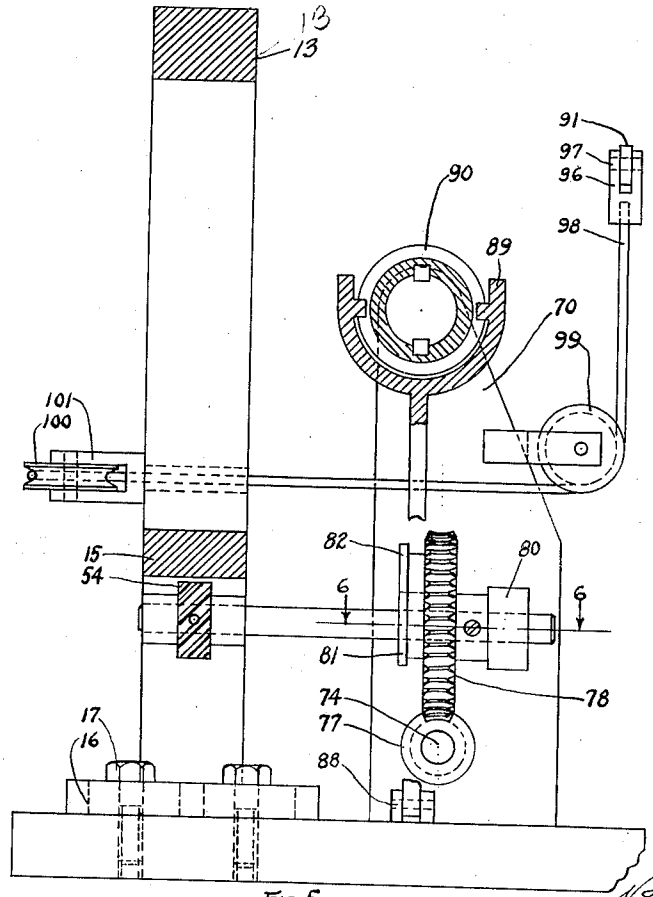


FIG. 5

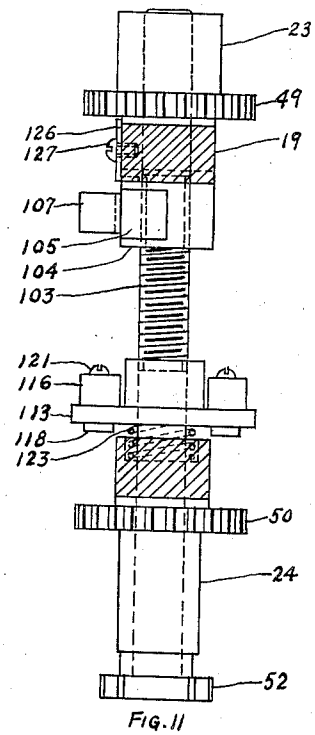


FIG. 11

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UNITED STATES PATENT OFFICE

2,227,243

IRREGULAR CONTOUR GRINDING MACHINE

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Application September 30, 1936, Serial No. 103,241

12 Claims. (Cl. 51—101)

This invention relates to machines and methods for the grinding or cutting of articles of irregular contour and with particular reference to the micrometric duplication of the articles to correspond in size or shape with a master.

One object of the invention is to provide a device for the micrometric duplication of articles of irregular contour by grinding blanks according to a pattern which is disposed parallel to a straight line or plane of the grinding face, in an improved manner, for true micrometric duplication.

Another object of the invention is to cause the irregular work to be movably urged toward the grinding surface with uniform pressure, according to an improved arrangement; and desirably also to so dispose the work holding head as to prevent its weight from variably influencing the grinding pressure, so that the latter may be uniform at all points of the irregular contour of the work.

Another object of the invention is to provide an improved crystal or lens grinding device according to the principle that the grinding surface moves transversely of the plane of the crystal to avoid "climb" or "back-thrust" of the crystal in course of its rotation, especially if the crystal be of irregular contour, so as to permit maintenance of the uniform grinding pressure hereinbefore mentioned; this "climb" and "back-thrust," while generally immaterial, may be undesirable, as in grinding a lens or crystal having concavities in its peripheral contour; and further, to permit the use of a simplified gage for the pattern.

It is therefore a further object of the invention to provide a device of the character described possessing the foregoing advantages and having relatively few and simple parts, and which is capable of inexpensive manufacture, and which is adapted for simple and convenient operation and observation, and which is accurate, durable, reliable, rapid and efficient in use to a high degree, and capable of grinding articles such as watch crystals with a straight or a beveled edge.

Other objects and advantages of the invention will become apparent as the specification proceeds.

With the aforesaid objects in view, the invention consists in the novel combinations and arrangements of parts hereinafter described in their preferred embodiments, pointed out in the subjoined claims, and illustrated in the annexed drawings, wherein like parts are designated by the same reference characters throughout the several views.

In the drawings:

Figure 1 is a view in front elevation with parts in section, showing a device embodying the invention.

Fig. 2 is a fragmentary view in side elevation of the device as indicated by the line 2—2 of Fig. 1.

Fig. 3 is a top plan view of the device.

Fig. 4 is a vertical view taken approximately on the line 4—4 of Fig. 3.

Fig. 5 is a vertical sectional view taken on the irregular line 5—5 of Fig. 1.

Fig. 6 is a horizontal sectional view taken on line 6—6 of Fig. 5.

Fig. 7 is a horizontal sectional view taken on the line 7—7 of Fig. 1.

Fig. 8 is a horizontal sectional view taken on the irregular line 8—8 of Fig. 1.

Fig. 9 is a horizontal sectional view taken on the line 9—9 of Fig. 1.

Fig. 10 is a horizontal sectional view taken on the irregular line 10—10 of Fig. 1.

Fig. 11 is a view in vertical section taken on the line 11—11 of Fig. 1.

Figs. 12, 13 and 14 are vertical sectional views taken on the respective lines 12—12, 13—13 and 14—14 of Fig. 1.

It will be obvious to those skilled in the art to which the invention appertains, that the same may be incorporated in several different constructions. The accompanying drawings, therefore, are submitted merely as showing the preferred exemplification of the invention.

Referring in detail to the drawings, 10 denotes a device embodying the invention. The same may include a base plate 11 on which may be mounted a frame 12, having upper, lower and intermediate laterally extending arms 13, 14, and 15, respectively. The arm 14 may constitute a base and may be slotted at 16 so as to be slidably secured to the base plate 11 by the bolts 17 that are threaded into the latter.

Pivotally mounted within the frame 12 is a U shaped frame 18 which comprises the upper and lower laterally extending arms 19 and 20 respectively. An upright, preferably vertical shaft 21 extends through the different arms 19, 20 and 13 and 15 so as to mount the frame 18 for swinging movement about a vertical axis toward and away from a shaping member, such as a cutting or grinding wheel 22. Any suitable bearing arrangements may be used, for instance, the frame 18 may be freely journaled on the shaft 21, the arm 13 may include a bearing hub or portion 23,

and the hub 24 of the arm 15 may be regarded as constituting a thrust bearing to hold the shaft 21 about its vertical axis and to sustain the weight of said shaft in a frictionless manner.

The frame 18 carries a work holding means 25 which is arranged for quick engagement and release of the work, and which is adjustable in the upright or vertical direction so as to permit any required bevel to be ground on the work below the center of the grinding wheel and to permit this angle to be maintained with different wheel diameters so as to allow for wear on the same. If the work were ground at a side of the wheel, such vertical adjustment might be dispensed with, but the most simple and advantageous construction requires that the grinding shall be performed in the manner herein disclosed.

The work holding means 25 may include a pair of pads 27, 28 of a pliable material, one of these pads being larger than the other so as to expose an edge portion of the work or watch crystal 29 that is held therebetween. Usually the edge of the work is beveled downward from the convex side of the crystal, and hence the pad 27 is of reduced size.

The work holding means may include vertically alined shafts, such as 30, 31 for rotatably holding the pads 27, 28 with the shaft 30 being axially movable to permit securement and release of the work by the pads. For operatively mounting the shaft 30, the arm 19 may have a sleeve 32 journaled therein, and supported against axial upward thrust by a thrust bearing 33. Said sleeve may carry a key 34 slidable along a keyway 35 of the shaft 30 to permit both axial and rotary movements of said shaft. At its upper end the sleeve 32 is connected to a drive gear 36 that is mounted thereon and is provided with a hub 37 in the end of which is threadedly secured a plug 38 having a central passage for receiving an actuator rod 39. The latter is pinned at 40 to a fork at the upper end of the shaft 30, and is threaded for adjustable engagement with an external nut or collar 41. The latter carries alined pins 42 for eccentric engagement with the fork arms 43 of a swing arm 44. In the position shown in Fig. 1, the expansion coil spring 45, which lies within the drive sleeve 32 and acts between the member 38 and the upper end of the shaft 30, tends to press the latter downward into work holding position, the shaft being rotatable by the gear 36 while in the position mentioned. After the machine has stopped, upon completion of the work, the arm 44 may be swung toward the vertical, the fork 43 acting as a cam bearing down on the member 38 to cause the shaft to be quickly elevated into work releasing position, against the action of the spring 45.

The mounting for the shaft 31 is somewhat similar to that of the shaft 30. For instance, a drive sleeve 46 is journaled in the arm 20, and has suitably affixed thereto a drive gear 47. Coacting with an annular shoulder of the sleeve 46 is a thrust bearing 33. The shaft 31 is keyed at 34 to the drive sleeve for axial adjustment as by a nut 48 threaded to the upper end of the shaft and bearing on the drive sleeve 46 to thus adjust the elevation of the shaft 31, and hence of the work holder 25. This permits the regulation of the bevel ground on the edge of the work, and also facilitates the vertical setting of the work holder to allow for wearing down in the diameter of the grinding wheel.

The gears 36 and 47 are respectively engaged by upper and lower gears 49, 50 which are fixed on the vertical shaft 21 that is journaled in the arms 13, 15. The gear 50 may support the swing frame 18 against axial movement relative to the shaft 21, and said gear may have suitable thrust bearing engagement with the swing frame. Thus the central portion of the gear may be regarded as a thrust bearing. These gears 49, 50 may lie for compactness between the respective arms 13, 19 and 20, 15. Fixed on the shaft 21 is a drive element for causing any desired actuation, intermittent or otherwise, of the work holder. Preferably said element is in the nature of a Geneva drive gear 52, disposed at the lower end of the shaft 21. For actuation of said element a shaft 53 is journaled in a hub portion 53a of the main frame 12 and carries a worm 54 for engagement with a worm wheel 55 on a shaft 56 that is mounted on the frame arm 15. Also mounted on the shaft 56 is a cam disc 57 and a disc 58 carrying a pin 59, in the usual manner of a Geneva drive, so as to cause intermittent angular motion of the shaft 21, and hence of the work holder 25. Such motion may be particularly useful in the grinding of square, rectangular and other shapes.

By causing precisely corresponding motion of a master 60, the work 29 may be produced to have the same size as the master or to have the same proportions in a different size. Preferably the master 60 may be directly mounted on the shaft 31, and locked against rotation relative thereto as by an extension of the adjacent key 34. The master may be movable along a plate 61, which lies in a vertical plane, and includes a section 62 having dovetail horizontal slide engagement at 63 with a base member 64 that is mounted on the base plate 11. Any suitable micrometric means 65 may be used for setting the stop plate 61, and may comprise a screw 66, and graduations 67 therefor, whereby the member 62 may be shifted, for the purposes hereinafter more in detail described.

The grinding wheel may be mounted on a shaft 68 having a horizontal axis, said shaft being journaled in bearings 69 mounted on statndards 70 carried by the base plate 11. The shaft 68 may have a pulley 71 driven by a belt 72 engaged by a pulley 73 mounted on the countershaft 74. The latter may be journaled in a bearing 75 carried by the standard 70, and may have at one end a drive element such as a motor or pulley 76, and at the other end a worm 77.

For causing axial reciprocation of the grinding wheel 22, to maintain true the surface thereof, the worm 77 may engage a worm wheel 78 mounted on a stub shaft 79 carried by arm 80 of the standard 70. A variable eccentric disc 81 may be slotted at 82 and secured to the member 78 by set screws 83 engaged through the slots. A connecting rod 84 may have a ring portion 85 engaged around the eccentric, and may be pivotally connected at 86 to an oscillating rod 87, pivotally mounted at 88 on the base plate. The rod 97 may include a yoke 89 engaging a sleeve 89a slidable along the shaft 68, which sleeve suitably carries the grinding wheel 22.

The shaft 53 may be direct connected to the shaft 79 or may be a continuation thereof. For different speed conditions, these shafts may be intergeared for constant or variable speed relations, as may be desired.

For obtaining a constant actuation of the swing frame 18 and hence the work holding means 25

toward the grinding wheel, a gravity member 90 may be employed. The latter may be slidably settably mounted on a lever arm 91, as by being pivotally suspended at 92 from a slide clamp 93 movable along said arm. The arm 91 may be pivotally mounted at 94 on a standard 95 affixed to the base plate 11. A motion transmitting means may include a yoke member 96 pivotally connected to the arm 91 at 97, and having a cable 98 passing around an upright idler pulley 99 and a horizontal idler pulley 100, mounted respectively on the standard 70, and on a bracket 101 affixed to the main frame 12. The end of the cable may be suitably attached as at 102 to the swing frame 18 so that the weight of the member 90 tends to swing the frame 18 to move the work holder 25 against the peripheral face of the grinding wheel 22.

For automatically controlling the machine, means is provided to stop the machine when the grinding of an article has been completed. This result is most readily accomplished by causing automatic stopping of the machine after the periphery of the article has been ground a predetermined number of times. The number of grindings required may be determined by actual test. The control means referred to may include a screw element 103 forming a part of the rotary shaft 21, and which may extend along a block 104 that is movable relative to the frame arm 19 in the plane thereof. Mounted on the block 104 is a half-nut 105 which cooperates with a smooth walled recess 106a in the retainer block to receive the screw element 103. The half nut 105, which has screw engagement with the threaded part 103, is pivotally connected at 106 to the retainer block 104, so as to be swingable toward and away from the latter. To releasably lock the half nut 105 against the retainer block 104, the former may carry a bolt 107 forked or slotted to slidably engage a headed retainer pin 108, the forked free end of the bolt being adapted to receive a headed pin 109 on the retainer block 104. Thus when the bolt is moved toward the left, as in Fig. 7, the bolt engages under the head of the pin 109, for locking the half nut, and permits release of the latter when the bolt is slid toward the right against the stop 110.

It will be noted that the retainer block 104 is of rectangular form to provide for ample surface contact at 111 with the adjacent plane vertical surface of the swing frame 18. Relative rotation as between the split nut assembly 104, 105 and the swing frame 18 is thus prevented. As shown, the block 104 is formed with a cut out or recess to guidingly receive the swingable member 105.

In course of rotation of the shaft 21, the split nut assembly is actuated by the screw portion 103 to move downward therealong into engagement with an actuator means 112. The latter may comprise a disc 113 having a hub 114 keyed at 115 to the shaft 21 so as to be rotatable therewith and axially slidable therealong. The disc 113 may carry casings 116 alined with holes 117 through which project buttons 118 mounted in the casings and downwardly actuated by respective expansion coil springs 120. The latter may take around the central retaining screws 121 which may be screwed into the buttons and may be centrally guided in holes in the upper ends of the casings 116.

Adapted to aline with the buttons 118 are a plurality of recesses 122 formed in the upper surface of the lower frame arm 20. To maintain the disc 113 and hence the buttons in spaced relation to the arm 20, an expansion coil spring 123 may act between said arm and the lower face of the disk 113, preferably without assistance to relative rotation of adjacent parts.

In action, when the split nut assembly 104, 105 descends and strikes the plate 113 or the hub thereof, as the case may be, the plate 113 is moved downward to cause the buttons 118 to bear down on the arm 20, and then to snap into the recesses 122 under actuation of the springs 120. In this manner, the swing frame 18 becomes locked to actuator 113, which is keyed to the shaft 21, and hence the latter swings the frame 18 so as to move the work holder 25 away from the grinding wheel 22. When this occurs, the transmission of power to the shaft 21 may be automatically stopped, as by an opening switch 123a, which may include switch elements 124 mounted respectively on the frame arms 13 and 19. In this manner, the source of power for the drive, whether an electric motor, or the like (not shown), may be cut off.

After the finished work 29 has been replaced by another article, the operator releases and opens the half nut 105 to permit the assembly to be moved upward to initial position, and then to be locked again in engagement with the shaft 21. The elevation or setting of the assembly 104, 105 may be determined with the aid of graduations 125 along the frame 18. An adjustable stop 126 clamped to the arm 19 by a releasable set screw 127 may be in alinement with the device 104, 105, and may be set to limit the upward movement of the said device, to facilitate the rapid return of the latter to operative position.

The manner of using the invention will now be briefly described. The frame 12 having been moved into suitable proximity to the grinding wheel 22, and secured by the bolts 17, the master 60 is secured to the shaft 31. Then an article 29 is placed on the pad 28 and the lever 44 swung to a side to release the shaft 30 to permit downward movement thereof so that the article 29 is secured between the pads 27, 28 of the work holder 25. Now the article 29 is ground down, with the master 60 following the guide or stop 61. The article 29 is of course below the center line 128 of the grinding wheel, if a bevel is desired. Adjustment in this respect is obtainable by the nut 48 to permit the shaft 31 to be raised or lowered.

After the first article has been ground, it is carefully checked, and if the work is found to be micrometrically of the same size as the master, and the bevel correct, the machine may be regarded as sufficiently adjusted for these purposes. Otherwise micrometric adjustment may be obtained by means of the graduated member 67. If the article is to be ground to a size different than that of the master, but micrometrically of the same proportions, then the stop plate 61 for the master is similarly adjusted. To produce a smaller article, the stop 61 is moved toward the right in Fig. 2, permitting the work holder to approach the grinding wheel more closely. The reverse is true if the work is to be larger. By providing a master that is larger than the average work, structural benefits are derived.

The required number of rotations or peripheral grindings having beeen obtained, the operator sets the device 104, 105 according to the gradua-

tions 125 to cause the machine to automatically stop accordingly. The main drive, which may rotate and axially reciprocate the grinding wheel 22 by means of the members 77, 78, 84 and 87, may also rotate the shaft 21, and hence the gears 49, 50 and 36, 47 so as to rotate the shafts 30, 31 in synchronism. The frame 18 which carries said shafts and hence the work holder 25 is actuated by the weight 90 toward the grinding wheel 22, to cause an even grinding pressure on the work. The frame 18, though mounted on the shaft 21, is free thereof except when the device 104, 105 actuated by the screw portion 103 of the shaft, travels downward to lock with the device 112 that is keyed to said shaft and hence to cause the frame 18 to be swung away from the grinding wheel, and the drive control switch 123a to be thereby opened.

It will now be seen that the grinding pressure is controlled solely by the adjustable weight 90, so that the article may be produced micrometrically accurate, with a perfectly smooth peripheral surface free of chattering, and with any possibility of chipping of the work eliminated. For like reasons the grinding can be performed with relatively high speed.

Likewise the grinding pressure is not influenced to any material degree by the weight of the actuator frame such as 18, since the latter is movable about a vertical axis, so that there is no variable weight and leverage as the frame 18 moves toward and away from the grinding wheel in course of grinding an object of irregular contour.

Similarly the factor of friction will be immaterial or relatively constant because the frame 18 moves about a vertical axis.

Since the weight 90 has a large leverage and is in suspended position, it is immaterial for the grinding pressure whether a low or a high point of the work is being ground. The pressure will always be constant, and therefore the amount of grinding will be uniform for micrometric duplication.

With the work 29 held crosswise to the grinding wheel 22, there can be no binding or climb or back thrust of the work at raised points thereof, so that the grinding pressure cannot vary, and the master can readily remain in uniform contact with the stop 61 for correct duplication.

The master may be a simple plane plate and need not be concentric with the grinding wheel as where the master lies parallel to the wheel where the work is in the plane of the wheel. Hence the plate 61, which is easily adjusted, takes the place of relatively complicated means that are necessary with concentric guide for the master where proportional micrometric duplication is desired.

While the wheel 22 moves axially for a smooth grinding surface, different parts of the article may be ground on widely different points of the wheel, with the work held crosswise of the wheel, and hence the further general desirability of a perfectly constant grinding pressure.

The arrangement of the mounting means for the work holder permits the latter to closely approach the grinding wheel, and yet quick release of the work is possible. Likewise, the machine is automatically stopped after a predetermined number of rotations of the work, in a simple and reliable manner.

The direction of rotation of the grinding wheel is such that the direction of grinding is downward where the work is held below the axial plane of the wheel.

Various degrees of bevel are obtainable by moving the work toward and away from the center line 128 of the grinding wheel, and as the latter wears down, adjustment for the angle of the bevel can be readily made.

The speed of grinding may be accelerated by the use of the Geneva drive shown in Fig. 10. Thus if an oblong article is considered, the grinding along a flat side will consume more time than at a point thereof. The Geneva drive will cause a relatively rapid rotation when the region of the point is reached, and thus save time in the production of the article.

The invention thus fulfills all the objects in the provision of improved machines and methods for the making of articles such as watch crystals, and the like. By the term "transverse cutting path of the grinding wheel" is meant the straight line path of contact between rotating work of irregular contour and the peripheral face of the grinding wheel, regardless whether the latter reciprocates or not along its axis, it being understood that the axis or rotation of the work is at an angle to the grinding wheel axis. Said path may be parallel to the grinding wheel axis or may lie along a flat side face of the grinding wheel.

I claim:

1. A machine for the micrometric proportional duplication of the contour of a master on articles, including a main frame, a drive shaft journaled therein, a secondary swing frame journaled on the drive shaft, rotary work holding means journaled on the swing frame, drive means for interconnecting the holding means and the said shaft to cause an article to be variably presented to a tool according to the degree that the secondary frame swings toward the tool, and means responsive to a predetermined number of rotations of the drive shaft for interconnecting theh secondary frame with the drive shaft so that the latter can cause the secondary frame to swing away from said tool.

2. A machine including a U shaped main and secondary frame disposed one within the other, a shaft journaled in the arms of the frames so that the secondary frame is swingable relative to the main frame, rotary work holding means mounted on the secondary frame to present the periphery of an article to a tool toward which the secondary frame is swingable, means for driving said shaft and for causing the latter to rotate the work holding means, said shaft having a screw portion, actuator means releasably engaged with the screw portion for traveling therealong upon rotation of the shaft, and locking means non-rotatably movable along the shaft for engagement with the secondary frame to cause the latter to be swung by said shaft, the locking means being actuable by the actuator means at a predetermined point in the travel of the latter, whereby the secondary frame can be swung after a required number of rotations of the work holding means.

3. A machine for the micrometric proportional duplication of the contour of a master on articles, including a main frame, a drive shaft journaled therein, a secondary swing frame journaled on the drive shaft, rotary work holding means journaled on the swing frame, drive means for interconnecting the holding means and the said shaft to cause an article to be variably presented to a tool according to the degree that the second-

ary frame swings toward the tool, and means responsive to a predetermined number of rotations of the drive shaft for interconnecting the secondary frame with the drive shaft so that the latter can cause the secondary frame to swing away from said tool, said shaft being substantially vertical, adjustable tension means, and means connecting the latter to the secondary frame to move the latter toward the tool to exert a constant working pressure less than the force that can be exerted by said shaft to swing the secondary frame away from the tool.

4. A machine for the micrometric duplication of articles including guide means comprising a master having straight sides, a plane member against which said master is adapted to ride, rotary means for holding an article and said master so that like peripheral parts of the master and article successively pass a predetermined point so that the article can be acted upon by a tool at said point, drive means for actuating the rotary means, including automatic means for causing the rate of rotation of the rotary means to be increased or decreased at regularly recurring intervals according as a projection or a relatively flat portion of the master passes said point.

5. A machine of the class described including a main frame, a drive shaft therein, a secondary frame journaled on the shaft, work holding means rotatably mounted on the secondary frame, drive means interconnecting said shaft and the work holding means, means settable along the shaft and coacting with the latter and the secondary frame to non rotatably positively move along the shaft upon rotation of the latter, and means responsive to a predetermined movement of the settable means to interconnect the secondary frame with said shaft so as to swing the secondary shaft to permit the latter to change the relation of the work holding means to a tool positioned to act upon the work.

6. A machine for the micrometric duplication of the shape-defining contour of a master on relatively flat articles including a rotary grinding wheel rotatable on and reciprocable along a horizontal axis, means for reciprocating said wheel along said axis, a main frame fixed relative thereto, a master, a secondary frame, rotary means on the latter for holding the master and an article in alignment therewith to rotate about an axis which is substantially parallel to the plane of rotation of the grinding wheel to provide a straight-line path of contact between the rotating work and the peripheral surface of the grinding wheel, a plan guide for the master, said guide being parallel to said straight-line path, normally fixed micrometric means for adjusting the guide, said secondary frame being mounted on the main frame for swinging movement about an axis which is substantially parallel to the plane of rotation of the grinding wheel and being so related to the grinding wheel and guide as to be adapted to move the holding means to bring the edge of said article into the said path of the grinding wheel and the master against the guide, and an actuator or weight connected to the secondary frame, said guide being of such dimensions as to limit the movement of said secondary frame so that no point on the shape-defining contour of the master in its rotation may pass the plane of the guide.

7. A machine for shaping articles including a rotating shaping tool, a main frame fixed relative thereto, a work holding frame mounted on the main frame for movement in a fixed path toward and away from said tool so as to move an article that is to be shaped into and out of contact with said tool, means mounted on the work holding frame for holding and rotating the article about an axis which is parallel to the plane of rotation of the tool to provide a straight-line path of contact between the rotating article and the rotating periphery of the tool, a weight, means for variably adjusting the effective weight relative to the work holding frame for actuating the latter with a constant force toward the tool for a uniform working pressure of the tool, a pattern element and a gage element, one of said elements being mounted on the work holding frame, and the other element being fixed relatively thereto, means for rotating the pattern in timed angular relation to the rotation of the article, the gage element having a plane gage face cooperating with the pattern element, the said plane face being parallel to said straight-line path, the work holding frame presenting the periphery of the article to the tool along said path, the pattern and gage elements cooperating with each other for micrometric proportional duplication of the shape-defining contour of the master on the article, and normally fixed micrometric means for adjusting the relation between the pattern and gage elements, said guide being of such dimensions as to limit the movement of the work holding frame so that no point on the shape-defining contour of the master in its rotation may pass the plane of the guide.

8. In a contour shaping machine, the combination of a pattern, a rotary work holder operable therewith and having means for holding the work in fixed relation and alignment with the pattern, said work holder being rotatable on an axis substantially parallel to the plane of rotation of the grinding wheel, a rotary grinding wheel having a normally fixed axis coordinated with the work holder so that the work is presented to provide a straight-line path of contact between the rotating work and the circular periphery of the grinding wheel, a gage arranged so that said cutting path is parallel to the gage, the pattern having a face operatively engageable with the gage, said work holder being movable along a fixed path toward and away from the grinding wheel as determined by the gage, and normally fixed micrometric means for setting the gage to control the extent to which the work is ground down in the micrometric proportional duplication of the master, said gage being of such extent as to limit the movement of the work holder so that no point on the shape-defining contour of the master in its rotation may pass the plane of the guide.

9. A contour shaping machine according to claim 8 wherein a weight is provided for actuating the work holder along its fixed path toward the grinding wheel, and the weight being substantially the sole means for controlling the resulting grinding pressure for a uniform cutting action.

10. A machine for micrometric proportional duplication of the shape-defining contour of a master on articles, including a master and a grinding wheel, means for holding the master and for holding an article to be worked upon, along a common axis at an angle to the straight-line path of contact between the rotating work and the circular periphery of the grinding wheel, means for rotating the master and the article in timed angular relation to each other, a plane guide against which the master may ride, the

plane of said guide being parallel to said path of contact, said guide being of such dimensions as to limit the movement of the master so that no point on its shape-defining contour during its rotation, may pass the plane of the guide, and normally fixed micrometric means for setting the guide.

11. In a machine for micrometric proportional duplication of the shape-defining contour of a master on articles, wherein the work is swung toward and away from the peripheral surface of the grinding wheel on an axis which is parallel to the plane of rotation of the grinding wheel and in which the plane of rotation of the work is at right angles to the plane of rotation of the grinding wheel to provide a straight-line path of contact between the rotating work and the circular periphery of the grinding wheel, a master mounted coaxially with the work, the work and master rotating as a unit, a gage, the surface of said gage having a line parallel to said path of contact, said master serving as a cam against the gage to control the swing of the work and operating against said gage line, said gage being of such extent as to keep every point on the shape-defining contour of the master on the same side of said gage line in the plane of rotation of the master.

12. In a machine of the character described having a rotating grinding wheel and a rotating master pattern, means for micrometrically proportionately duplicating on an article the shape-defining contour of the pattern, said means including mechanism for rotating the article and the pattern as a unit, on an axis which is substantially parallel to the plane of rotation of the grinding wheel to provide a straight-line path of contact between the rotating work and the circular periphery of the grinding wheel, means for moving the unit toward and away from the grinding wheel, means for limiting the said movement of the unit so that every point on the shape-defining contour of the pattern in its rotation will remain on one side of the line which is parallel to said path of contact.

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