Oct. 9, 1945. F. C. JEARUM 2,386,687

GRINDING MACHINE

Filed May 25, 1943 3 Sheets-Sheet 1

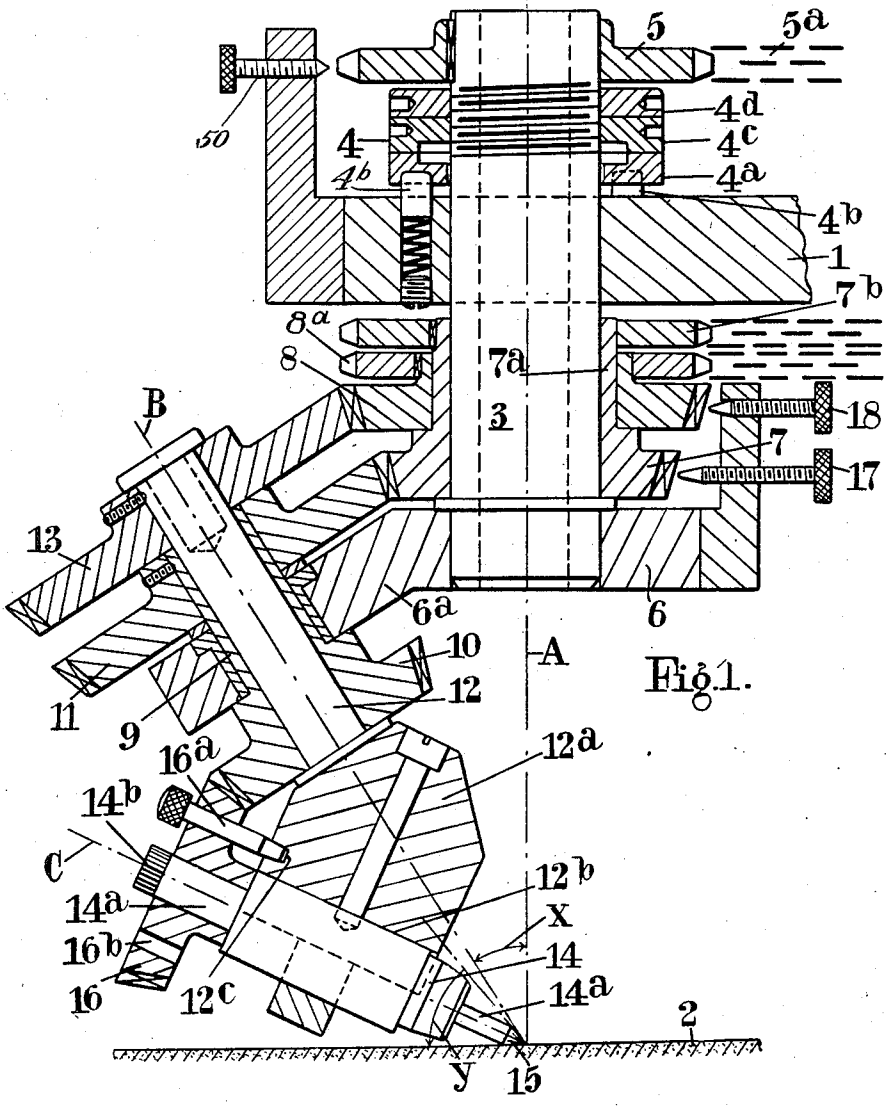


Fig. 1.

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Filed May 25, 1943 3 Sheets-Sheet 2

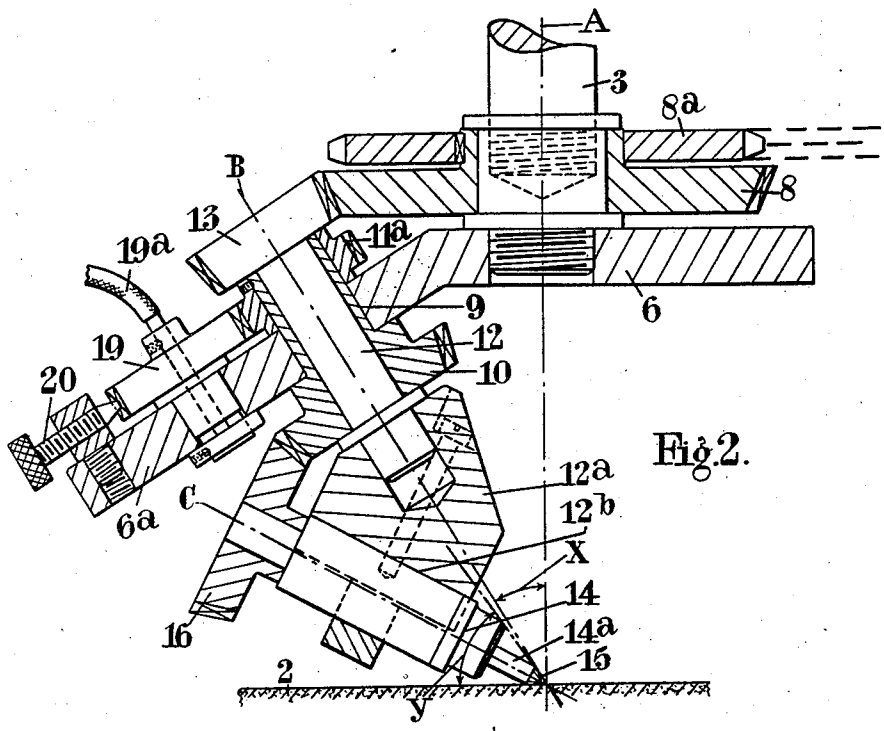


Fig. 2.

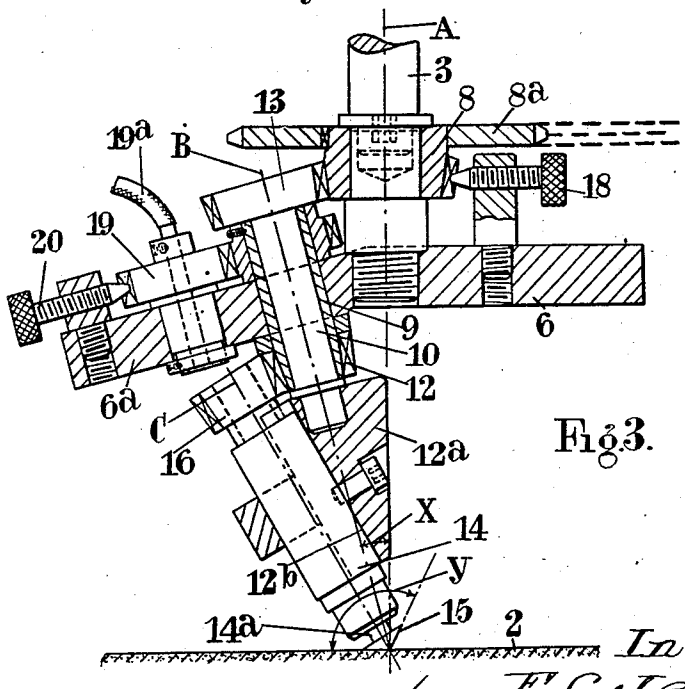


Fig. 3.

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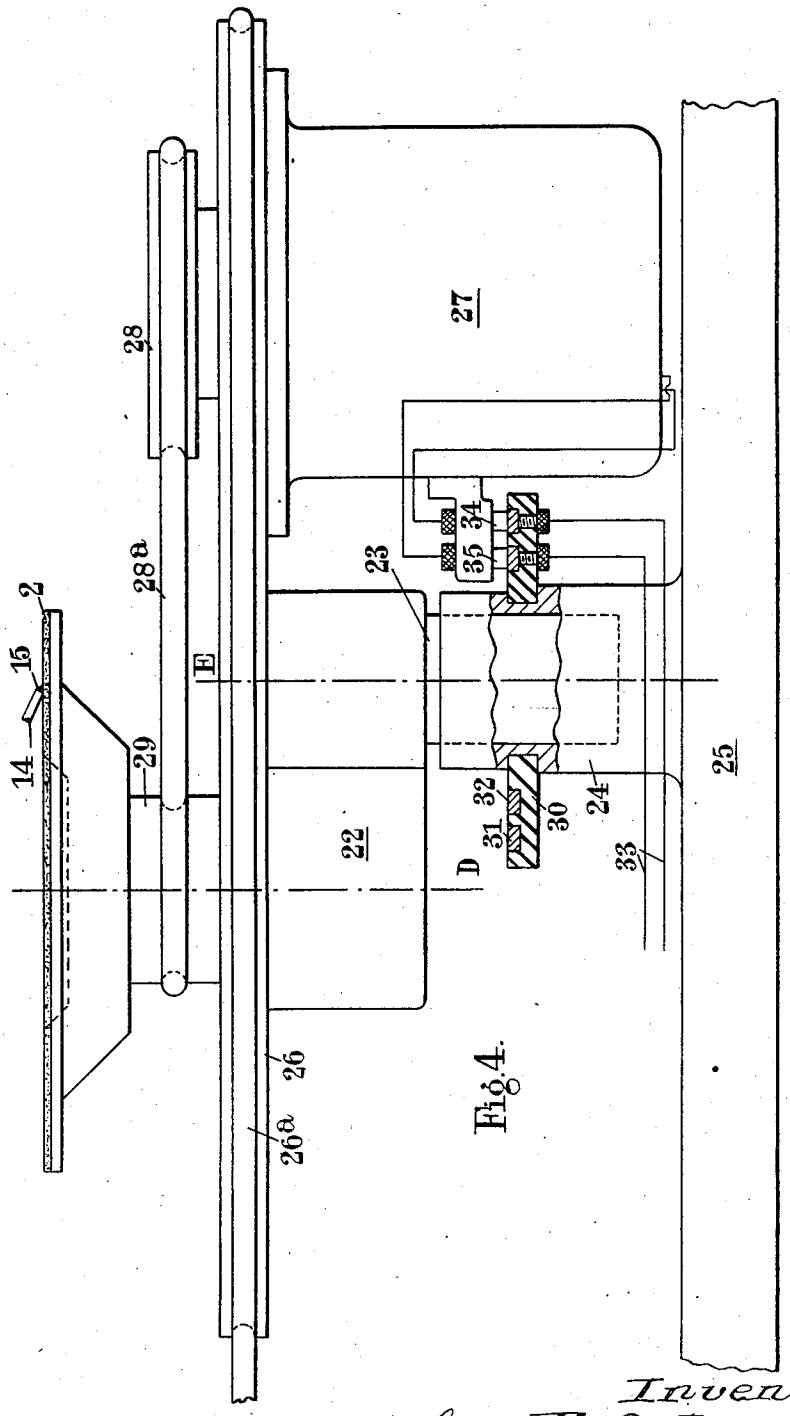


Fig. 4.

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UNITED STATES PATENT OFFICE

2,386,687

GRINDING MACHINE

Frederick Charles Jearum, Sutton, England

Application May 25, 1943, Serial No. 488,452
In Great Britain June 12, 1942

12 Claims. (Cl. 51—229)

This invention relates to the grinding, lapping, cutting or polishing upon a skaif or rotary disc (hereinafter referred to as cutting) of diamonds or of other stones, compositions or hard tool metals (hereinafter referred to as stones) to generate forms requiring the continuous or step rotation about the axis of the stone such as for example conical forms with or without radiussed points or (to generate) domed or convex forms or (to produce) pyramidal or domed faceted forms; these terms including not only complete forms but frustums and also forms having a facet or facets which if appropriately repeated would produce a pyramid or pyramidal frustum. The invention is applicable to the production of stone forms for industrial tool making or for the jewelry trade.

The object of the present invention is to provide a machine for automatically or semi-automatically generating or cutting forms of the kind indicated, which is adapted for repetition work or mass production of a selected form of stone or certain selected forms with a very high degree of accuracy.

The invention consists in a machine for cutting stones to generate forms of the kind indicated comprising means adapted to rotate a stone or enable it to be rotated from one cutting contact position to another about its axis and means adapted to enable the said stone axis to be revolved about an axis intersecting the stone axis in the plane of the skaif employed for cutting and in such a manner as to generate a conical figure which is tangent to a line normal to the skaif. This axis about which the stone axis may be revolved may be conveniently referred to hereinafter as the "tangent axis."

The angular position of the tangent axis may be expressed with respect to the normal to the skaif plane as

$$\frac{1}{2}\left(90-\frac{y}{2}\right)$$

where y is the apex or included angle of the form to be generated about the stone axis.

Locking or index setting means may be provided with respect to the rotation about the stone or tangent axis so that continuous or stepwise rotation may be effected about the stone axis, or so that the stone axis may be continuously revolved about the tangent axis or maintained stationary. Also means may be provided, in a machine adapted to revolve both axes about an axis normal to the skaif for automatically cutting diamonds, for locking the mounting so that said axes do not revolve about the normal axis when such machine is used for stones other than diamonds.

The structure of a diamond is such that it is capable of being cut only when the abrasive particles pass in a certain directional sense relative to the grain or crystalline structure of the diamond known as the cutting or polishing grain. The usual practice in the trade has been to determine the correct cutting grain or direction by the observation and skill of the operative. It is however known or it has been proposed to provide a machine adapted automatically to find the cutting grain of the diamond by employing a rotary skaif or cutting disc, the axis of which is revolved in a planetary or orbital path such that the cutting grain of the diamond operated upon is automatically found at least twice in each revolution of the skaif about the planetary axis. It will be appreciated, therefore, that when the invention is applied to a machine for cutting diamonds solely or in addition to other "stones" it must be used in conjunction with means for automatically finding the cutting grain of the diamond. To this end a skaif having a planetary or orbital path such as indicated above may be employed, although it is preferred according to a further feature of the invention to provide a novel self-contained grain-finding means by revolving the stone and tangent axes referred to above about an axis normal to the skaif and preferably intersecting the said axes in the plane of the skaif or cutting disc.

The accompanying drawings illustrate three examples of the invention showing the head of a machine for generating conical points of different angles or other forms based on such angles. The means for supporting the head over a skaif are not illustrated as such form no part of the invention and any appropriate arbor means of known character may be employed.

In the accompanying drawings:

Figure 1 is a sectional elevation of a machine head according to the invention for generating conical points or like forms where the apex or included angle is 50°.

Figures 2 and 3 are similar sectional elevations of heads for generating conical points and like forms where the apex or included angle is respectively 55° and 120°. Figures 2 and 3 also illustrate certain modifications of the manner in which the invention may be carried into effect.

Figures 1, 2 and 3 illustrate examples of self-contained means for revolving the stone and tangent axes about an axis normal to the skaif

for automatically finding the cutting grain of a diamond, while

Figure 4 is a side elevation of a skaif mounting in which a skaif rotatable about its axis is revolved about a planetary axis for automatically finding the cutting grain of a diamond.

Similar references are employed for similar or corresponding parts in the several figures of the drawings.

In carrying the invention into effect according to one mode as described with reference to Figure 1 for generating any of the forms above mentioned of which the included angle is 50° the end 1 of an arbor mounted over a horizontal skaif 2 has a main shaft 3 mounted in suitable bearings with its axis A normal to the horizontal skaif 2. The shaft 3 may be supported on a thrust bearing indicated by the general reference 4 comprising a thrust collar 4a resiliently supported on a plurality of equally spaced spring-pressed plungers 4b. The shaft is screw-threaded at its upper end to receive a nut member 4c which bears upon the thrust collar 4a and is provided with a lock nut 4d. A chain wheel 5 (or other gear) is provided on the end of the shaft and a chain 5a is adapted to cause its rotation at a suitable speed, power being supplied from any suitable source (not shown). At the lower end of the shaft an angle plate 6 is mounted so that it may be rotated with the shaft 3. The angle plate comprises a part at right-angles to the axis of the shaft and a part 6a at an angle thereto (in the instance under consideration) of 147° 30′ so that it lies normal to the tangent axis B (to be described below). Rotatable upon the shaft 3 is a bevelled wheel 7 having a sleeve 7a on which a chain wheel 7b (or other driving gear) is mounted. This bevel gear in the present instance has 48 teeth and is adapted to communicate a drive to the stone-holder or dop for revolving the stone about its own axis C. Upon the sleeve 7a another bevel gear 8, having 60 teeth (in this case), is rotatably mounted and driven by a chain wheel 8a (or other gear) so that rotation may be communicated by the bevel gear 8 for revolving the stone axis C in a path which generates a conical surface of revolution (to which the vertical axis A is tangent) about the tangent axis B.

In the angled portion 6a of the plate 6 in a suitable bearing bushing a sleeve 9 carrying at the underside of the plate a bevel gear 10 having 40 teeth is rotatably mounted. Fixed upon the sleeve 9 at the upper side of the angled plate 6a is a 64-toothed bevel gear 11 which meshes with the bevel gear 7. Within the sleeve 9, a spindle 12 is rotatably mounted having fixed at its upper end a 65-toothed bevel gear 13 meshing with the gear 8. At its lower end the spindle 12 carries a dop carrier or head 12a having an angularly disposed face or bed 12b for receiving the bushing or body of the stone-holder or dop 14. Any suitable means may be provided for securing the dop upon its bed. This bed is located at an angle to accord with the angle at which the stone axis is located. In this instance it will be appreciated that the angle included between the stone axis and the plane of the skaif will be 25°, that is to say half that of the included angle of the conical or other forms to be generated.

The axis of the spindle 12 (which is the tangent axis B previously mentioned) is located so that it intersects the stone axis C in the plane of the skaif 2 and also intersects the vertical axis A at the same point.

The angle x included between the tangent axis B and the vertical axis A and the angle between the axis B and the stone axis C is 32° 30′, the angle included between the stone axis and the vertical axis being twice this amount, which leaves the angle of 25° above mentioned as the included angle between the stone angle and the plane of the skaif, that is to say, half the included angle y of the stone form to be generated, which in this case is 50°.

It will be appreciated that to find the angle x for any form having an included angle y the formula

$$x=\tfrac{1}{2}\left(90-\frac{y}{2}\right)$$

may be employed, the angle

$$\frac{y}{2}$$

being the angle the stone axis C makes with the plane of the skaif 2.

The tool-holder or dop 14 may be of any known kind and has a spindle 14a for enabling the stone 15 to be rotated about its axis C and also means operated by a milled knob 14b for affording the stone an axial displacement for feed, retraction, setting or like purposes. Upon the rotatable spindle 14a a 36-toothed bevel gear 16 is fixed in mesh with the bevel 10 on the sleeve 9. Means for locking the gear 16 against rotation is provided, which may consist of a pin 16a adapted to be inserted in any selected bore of a series 16b with which the gear 16 is provided and engaged in a recess 12c on the block or head 12a. The series of bores 16b may be arranged according to a dividing index for setting the stone stepwise for cutting predetermined facets.

The plate 6 may be provided with set screws 17, 18 for respectively locking in any of the teeth of the gears 7 and 8. The lock upon the gear 7 may be used as a supplementary lock or as an alternative lock to the pin device 16a and may be used for facet cutting while the lock upon the gear 8 serves to anchor the spindle 12 and prevent rotation of the stone axis C about the tangent axis B when grinding facets.

Similar means 50 may be provided for locking the chain wheel 5 when revolution of the head 12a about the vertical axis is not required, as for example when grinding stones (other than diamonds) which have no particular cutting grain.

In association with the locking means for preventing rotation of the stone about its axis C or its revolution about the tangent axis B or the revolution of the head 12a about the vertical axis A, a slip friction clutch or a disengageable clutch is employed on each of the means for driving the chains of the wheels 5, 7 and 8.

From the above it will be appreciated that by driving the vertical spindle 3 the angle plate 6, 6a is caused to revolve about the vertical axis A together with the tangent axis spindle 12 and tool-holder head 12a so that the axis B of the spindle generates a cone of revolution the axis of which coincides with the vertical axis. This movement in conjunction with the rotation of the skaif 2 ensures that the cutting grain of the stone is found twice in each revolution. If while this is taking place the gear bevel 7 on the vertical shaft is driven, the dop spindle 14a and stone 15 are revolved about the stone axis C through the train comprising the bevel gear 11 and the toothed bevels 10 and 16 and the stone will be cut to generate a 50° conical point. When the

bevel gear 16 on the dop is locked a 50° pyramidal facet will be cut upon the stone and a series of pyramidal facets may be cut by turning spindle 14a and setting the stone about its axis through the appropriate angles by means of the pin 16a and the series of bores 16b, appropriate means being provided for preventing the revolution of the axis C about the tangent axis while cutting a facet or facets. For this purpose, if desired, a calibrated dividing head may be associated with the bores.

Assuming that it is desired to generate a radiussed point or dome shape form, in addition to the rotation of the stone about its own axis C and the revolution of the stone axis about the vertical axis A, a drive is communicated to the bevel gear 8 on the vertical spindle which drives the bevel gear 13 on the tangent axis spindle 12 which causes the head 12a in which the dop is mounted bodily to be revolved about the tangent axis B so that the axis C of the stone generates a cone of revolution to which a plane including the vertical axis A is tangent. The radiussed point or dome will be tangential to planes having an included angle of 50° and the diameter of the point or dome will depend upon the distance the apex of the cone of the stone is set back from the point of intersection of its axis with the tangent axis B, the setting back operation being accomplished by adjusting the axial feed means of the dop as by manipulating the knob 14b. The revolution of the stone axis C about the tangent axis B will progressively raise the stone axis from the position seen in the drawings to the vertical and as the revolution continues the stone axis will be progressively lower again. This motion in conjunction with the rotation of the stone on its own axis C will cause a true spherical point or dome to be generated by the cutting action of the skaif.

In carrying the invention into effect according to a modification, as exemplified in Figure 2 for generating forms having a 55° included angle, the vertical spindle 3 (the lower part only of which is illustrated) carrying an angled plate 6, 6a similar to that already described but set at an angle corresponding with the angle required for the tangent axis B (according to the basic included angle of the form to be cut) has mounted upon it a bevel gear 8 (of 83 teeth) which may be chain or otherwise driven, while the tangent axis spindle 12 carrying the tool-holding head 12a has a bevel gear 13 (with 28 teeth) fixed upon it for revolving the head and stone axis C so that the latter generates the conical surface which is tangent to the vertical axis A of the shaft. Locking means may be provided for preventing rotation about the tangent axis similar to the locking means provided for the gear 8 as described in reference to Figure 1 and as shown in Figure 3. Between the angled plate and the head 12a a 38-toothed bevel gear 10 carried on the sleeve 9 meshes with a 35-toothed bevel gear 16 on the dop spindle. In this modification, instead of driving the dop spindle from a gear (such as 7, Figure 1) on the main vertical spindle a drive is communicated through a pinion 11a on the sleeve. The pinion 11a has 25 teeth and meshes with a 28-toothed spur wheel 19 having a stub shaft mounted in the plate portion 6a. This gear is provided with a coupling or means adapted to receive an independent flexible or cable drive 19a receiving power from any suitable source. For the purpose of locking the dop spindle in any position afforded by the teeth of the 28-toothed spur gear 19 for facet cutting, a spring-pressed or screw-threaded plunger 20 is suitably mounted upon the angled plate so that the nose of the plunger may engage between any selected pair of teeth on the spur gear. The axis B is disposed so that the angle included between it and the vertical axis A is 31°15′ while the angle included between the dop axis C and the plane of the skaif 2 is 27°30′ for forming a cone or pyramid of an included angle of 55°.

In carrying the invention into effect (see Figure 3) for generating forms having a greater included angle such as, say, that of 120°, for example, the vertical spindle 3 carries, rotatably mounted upon it, a chain or otherwise driven bevel gear 8 having 25 teeth. A locking pin 18 for engaging the teeth of the bevel gear may be provided on the angled plate adjacent the vertical spindle. A bevel gear 13 of 22 teeth is mounted on the upper end of the head or tangent axis spindle 12 and is in mesh with the bevel gear 8. The dop spindle carries a 15-toothed bevel gear 16 meshing with a bevel gear 10 having the same number of teeth carried by the sleeve 9. Between the gear 13 and the angled plate, a spur gear 11a having 19 teeth is provided and meshes with a spur gear 19 of 20 teeth rotatable in a bushing in the angled plate, which also carries a locking pin or plunger 20 for engaging the spur teeth as described in the preceding modification. The spur gear 19 has a coupling for a flexible or cable drive 19a.

In the form of the invention shown in Figure 3 means may be provided (as in the cases described in reference to Figures 1 and 2) for locking the vertical shaft 3 to a fixture or otherwise preventing rotation of the head 12a about the vertical axis A.

It will be appreciated that in each of the forms of the invention described, the means for imparting the various operational movements concerned in generating the several forms is designed for shapes of the predetermined included angle specified, and that for shapes having other included angles the operating means are appropriately designed or redesigned to dispose the dop or stone axis C and the head spindle or tangent axis B at the appropriate angles, and to provide gears having the appropriate number of teeth for effecting the required relative rotations.

It will also be appreciated that although certain forms or means have been described specifically in reference to a particular figure of the drawings such may, circumstances permitting, be equally adopted in connection with a form or modification described in another figure of the drawings.

Instead of revolving the angled plate around the axis of the vertical shaft a similar effect may be obtained when the angled plate is maintained stationary, by employing in place of the skaif revolving about a fixed axis, a cutting disc or skaif mounted upon a crank or crank disc, giving the skaif axis a planetary motion around the axis of the crank or crank disc as well as a rotation about its own axis.

In Figure 4 a planetary skaif arrangement is illustrated. The skaif 2 is rotatably mounted upon a crank pin (having an axis D) of the crank 22. The crankshaft 23 is mounted in a footstep bearing 24 carried by a suitable base 25 which may be in one with the base on which the arbor 1 is mounted. The crank 22 carries a large pulley 26 mounted coaxially of the axis E of the crankshaft 23, the pulley being driven by a belt 26a from any suitable power source. The pulley 26 has sus-

pended from its underside an electric motor **27** the shaft of which carries a pulley **28** driving through the belt **28***a*, a pulley formation **29** on the crank pin mounting. The footstep bearing **24** carries externally an insulation annulus **30** having distributing rings **31**, **32** coupled by supply lines **33** to a suitable source of E. M. F. A bracket on the motor **27** carries brushes **34**, **35** which collect from the rings **31** and **32** respectively. According to this arrangement the skaif and skaif axis D are revolved planetwise by the pulley drive **26**, **26***a* about the crank axis E, while simultaneously the skaif is rotated about its own axis D by the motor **27** through the pulleys **28**, **29**. A fragment of the dop **14** and the stone **15** are shown in cutting contact with the skaif.

It will be appreciated that when stones other than diamonds are to be cut it is unnecessary to turn the stone or provide a relative motion between the skaif and the stone such that the cutting grains of the skaif pass in a diversity of directions with respect thereto in order to secure a cutting action and consequently in such cases it is unnecessary to provide any means such as had been described for automatically finding the cutting grain. In cutting stones other than diamonds the arrangements described in reference to Figures 1, 2 and 3 may be employed whilst maintaining the axes B and C stationary with respect to a vertical axis such as A and without employing a skaif planetary arrangement such as shown in Figure 4. It will however be understood that by providing for revolution about the axis A or providing the planetary arrangement shown in Figure 4 a machine may be adapted for universal purposes, that is to say for grinding diamonds in addition to any other stones.

I claim:

1. A machine for cutting stones to generate forms of the kind indicated comprising a skaif, means for rotating the skaif, means for continuously rotating a stone about its axis and means for continuously revolving said stone axis about a tangent axis intersecting the stone axis in the plane of the skaif in such a manner that the stone axis moves through a path describing a conical figure which is tangent to a line normal to the surface of the skaif.

2. A machine as claimed in claim 1 wherein a driving gear is mounted with its axis normal to the surface of the skaif and is meshed with a gear coaxial with the tangent axis for revolving the stone axis about the tangent axis.

3. A machine as claimed in claim 1 wherein means are provided for revolving the stone and tangent axes together about an axis normal to the surface of the skaif and intersecting the said axes in the plane of the skaif for enabling the machine automatically to cut diamonds in addition to other stones.

4. A machine as claimed in claim 1 in combination with a skaif rotatable about its axis and having means for revolving the skaif axis about a planetary axis as an alternative to revolving the stone and tangent axes together about the axis normal to the surface of the skaif, for enabling the machine automatically to cut diamonds in addition to other stones.

5. A machine as claimed in claim 1 and comprising a driving gear mounted with its axis normal to the surface of the skaif and meshed with a gear coaxial with the tangent axis for revolving the stone axis about the tangent axis, another driving gear mounted about the axis normal to the surface of the skaif in mesh with a further gear coaxial with the tangent axis about which a third gear is mounted which in turn meshes with a gear on a dop spindle on which the stone is mounted, for rotating the dop spindle and stone about the stone axis.

6. A machine as claimed in claim 1 wherein the stone is mounted on a dop spindle and means are provided for rotating the dop spindle about the stone axis by a flexible shaft.

7. A machine as claimed in claim 1 wherein the stone is mounted on a dop spindle and comprising a flexible shaft adapted to drive a gear meshing with a gear coaxial with the tangent axis, another gear coaxial with the tangent axis which in turn meshes with a gear on the dop spindle for rotating such about the stone axis.

8. A machine as claimed in claim 1 wherein the stone may be rotated about its axis from one cutting contact position to another and means are provided for temporarily locking the stone against rotation about its own axis in any selected contact position.

9. A machine as claimed in claim 1 wherein means are provided for temporarily locking the stone mounting against rotation of its axis about the tangent axis, in any selected position.

10. A machine as claimed in claim 1 wherein means are provided for revolving the stone and the tangent axis together about an axis normal to the surface of the skaif and comprising temporary locking means for preventing the revolution of the said axes about the axis normal to the surface of the skaif.

11. A machine as claimed in claim 1 wherein means are provided for revolving the stone and the tangent axis together about an axis normal to the surface of the skaif and comprising means for temporarily locking the stone mounting against revolution of its axis about the tangent axis in any selected position.

12. A machine as claimed in claim 1 wherein means are provided for adjusting the stone in the direction of its axis towards or away from the cutting plane of the skaif.

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