# United States Patent [19]

**Hoffman**

[11] **3,797,177**

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[54] **GEM FACETING APPARATUS**


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[51] **Int. Cl.** .............................................. **B24b 9/16**
[58] **Field of Search** ................. 51/43, 90, 120, 229; 125/30



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*Attorney, Agent, or Firm*—Wells, St. John & Roberts



[57] **ABSTRACT**

A faceting apparatus capable of automatically cutting a predetermined pattern of facets on rough gems. The machine basically includes a gem holder and an angularly adjustable and movable grinding surface. The gem is held at a stationary location while the grinding surface is movable in orientation for cutting a series of pre-selected angular facets. The gem itself might also be angularly indexed and axially located relative to the grinding surface to control depth of cut during a grinding step.


**17 Claims, 19 Drawing Figures**

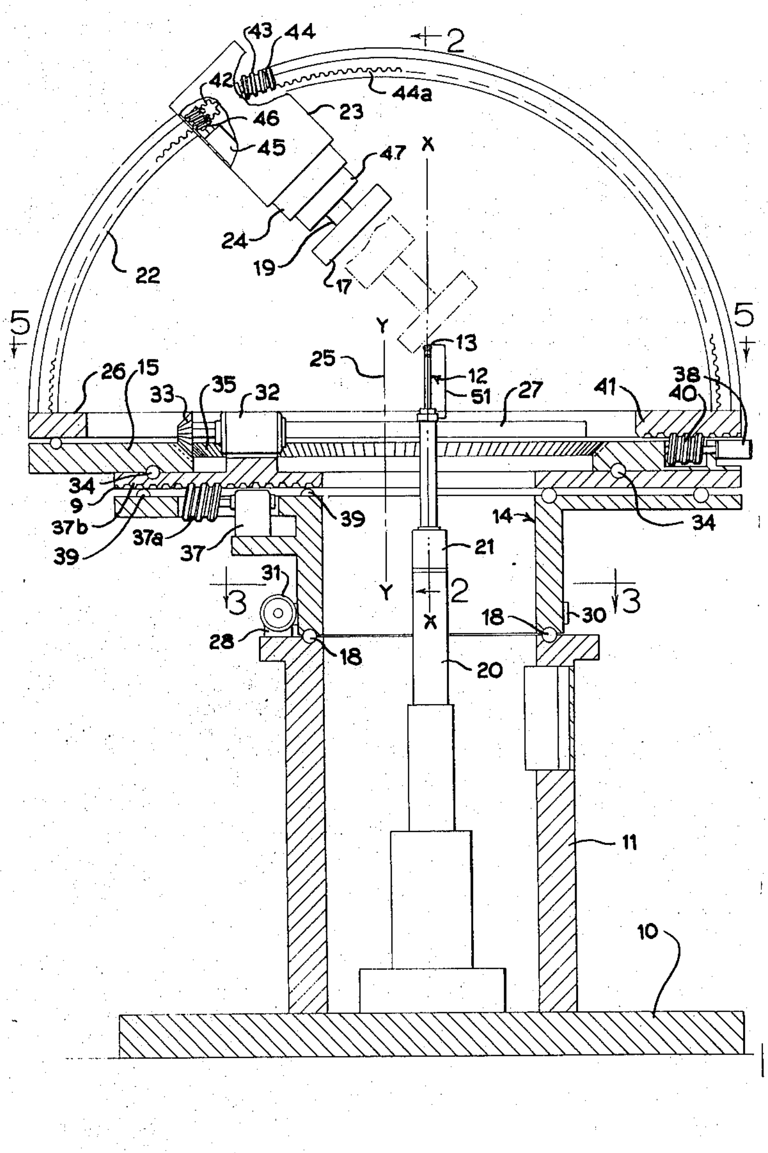
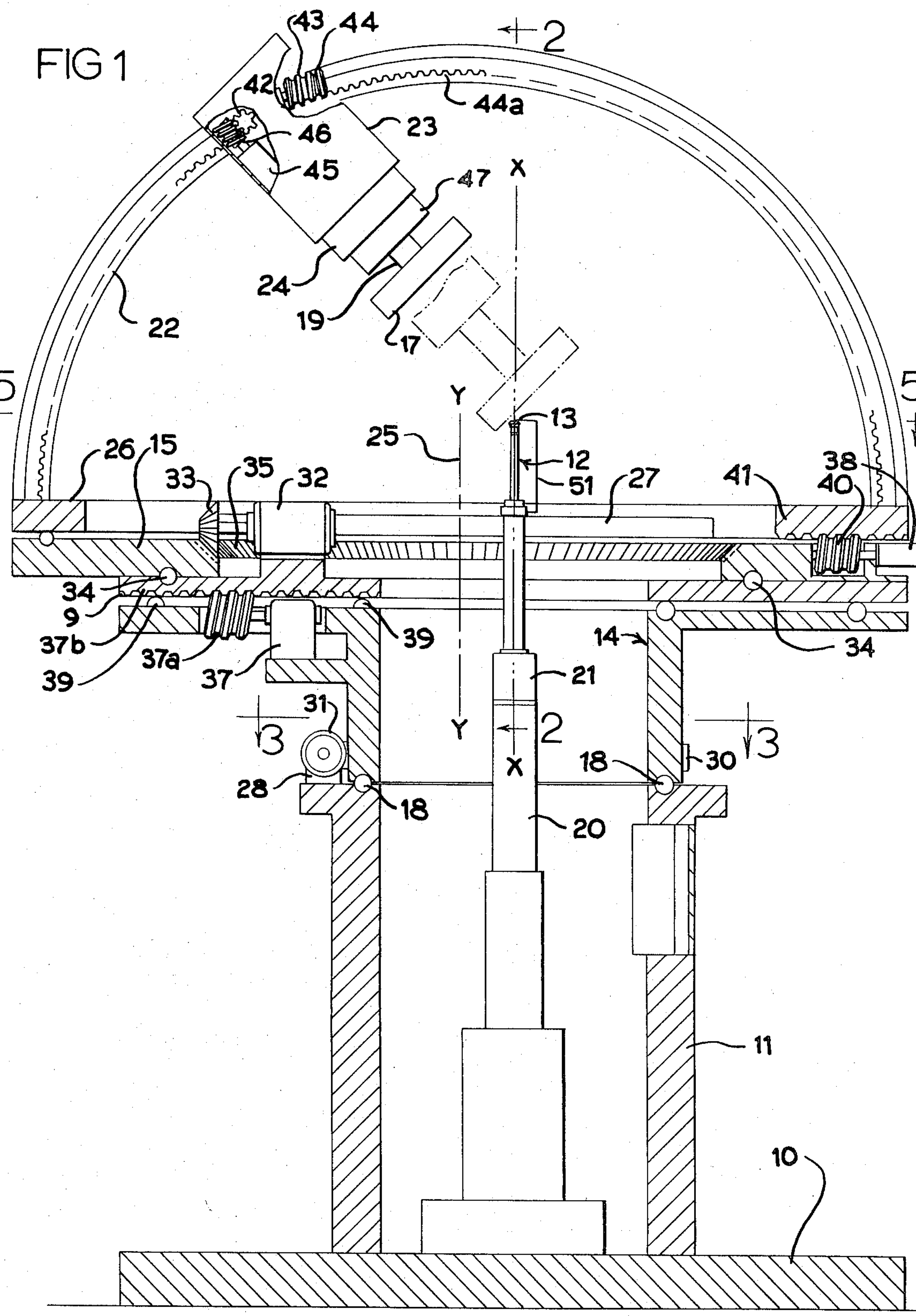


FIG 1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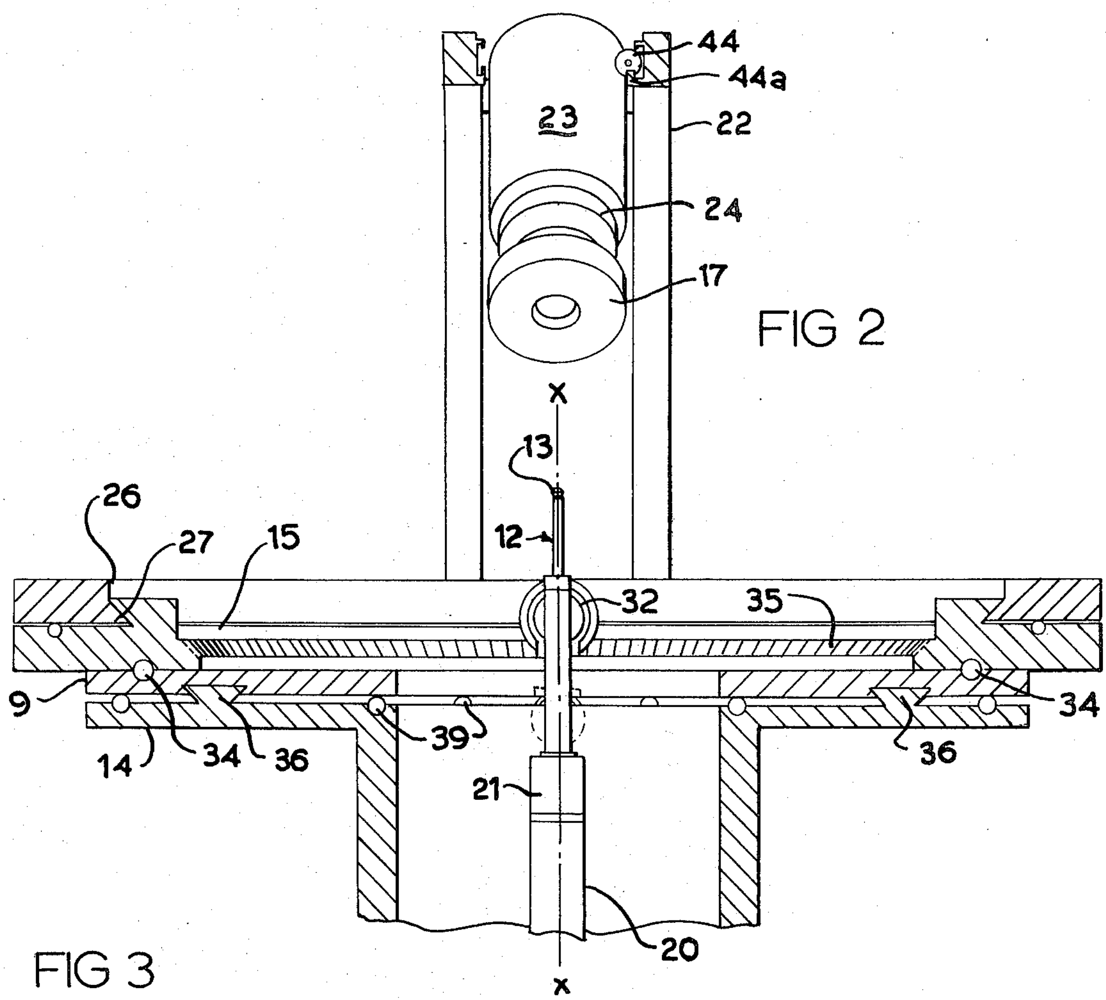



FIG 2

FIG 3

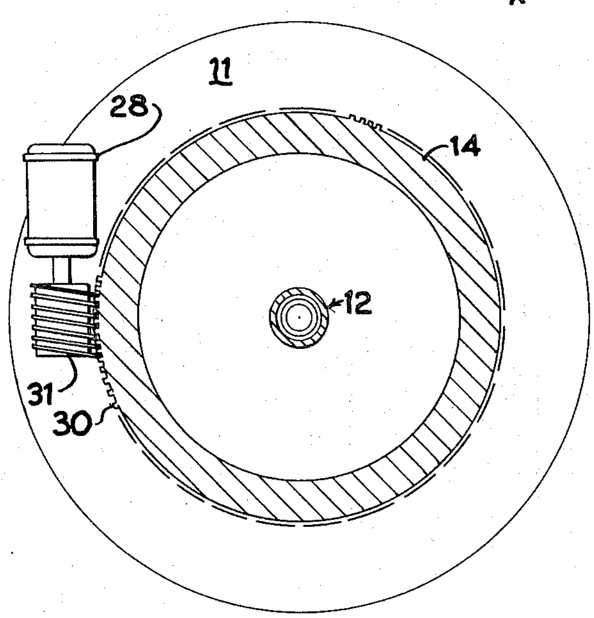



FIG 4

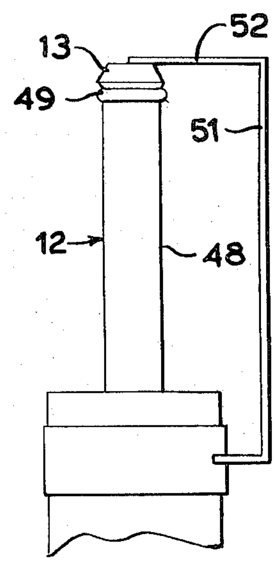


FIG 5

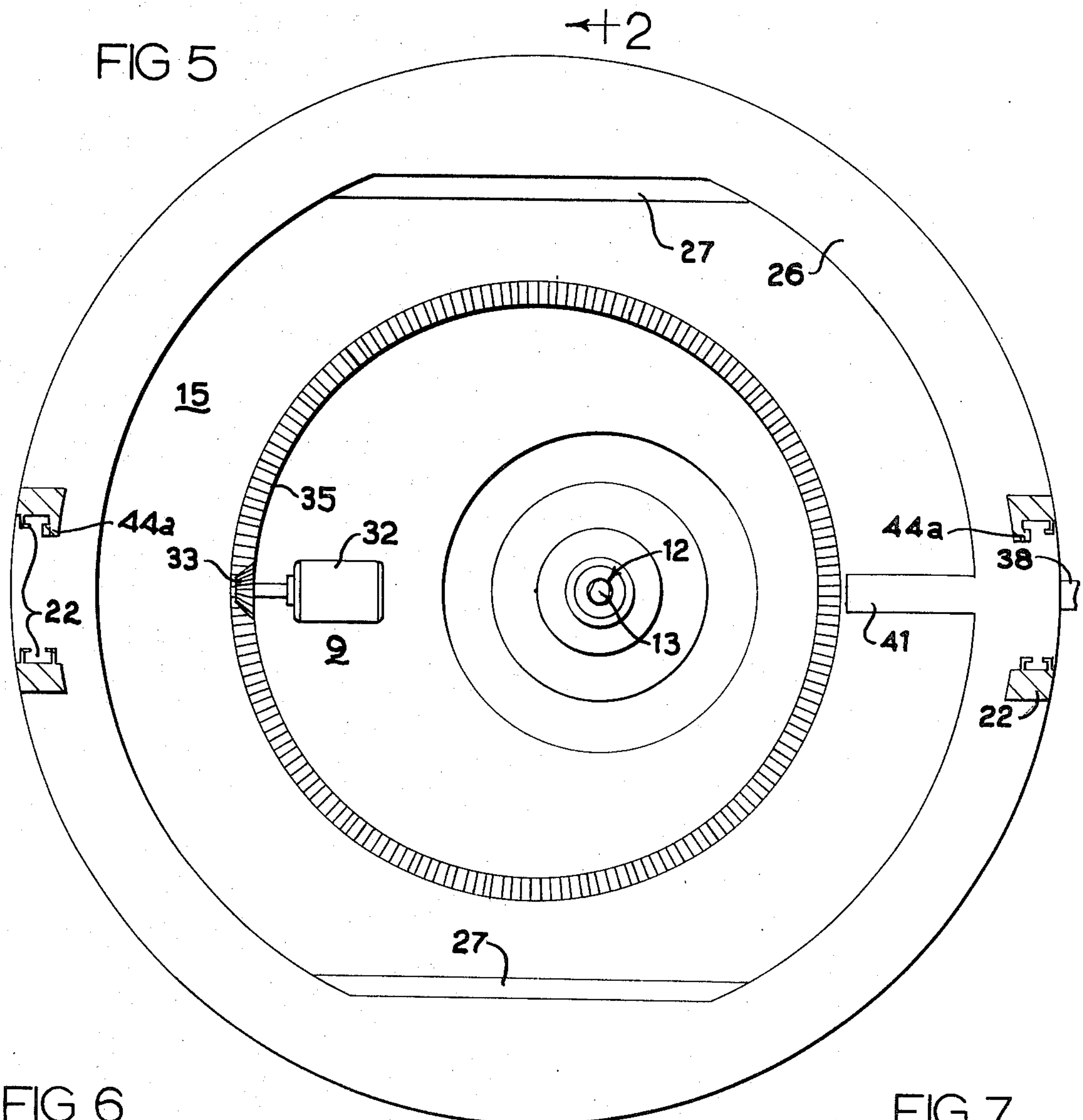



FIG 6

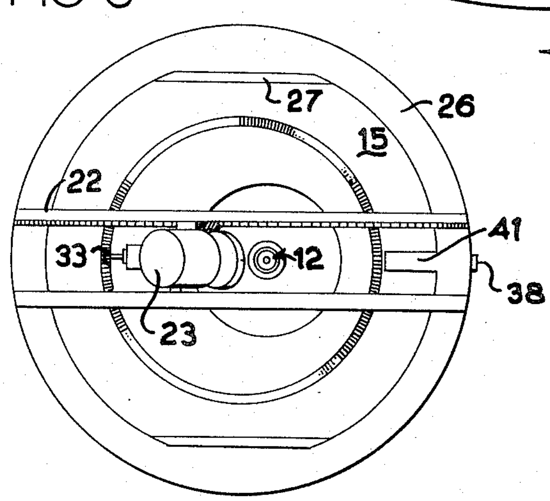



FIG 7

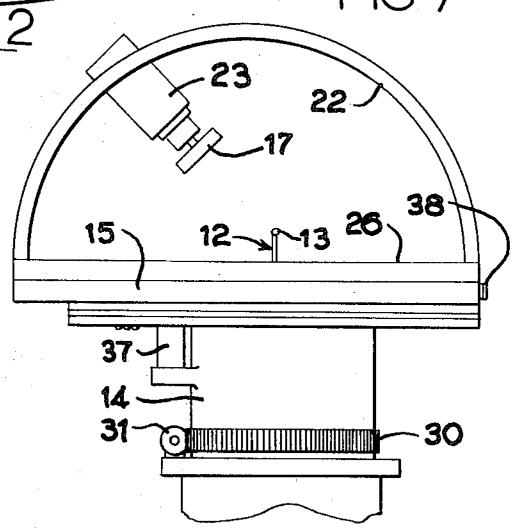


FIG 8

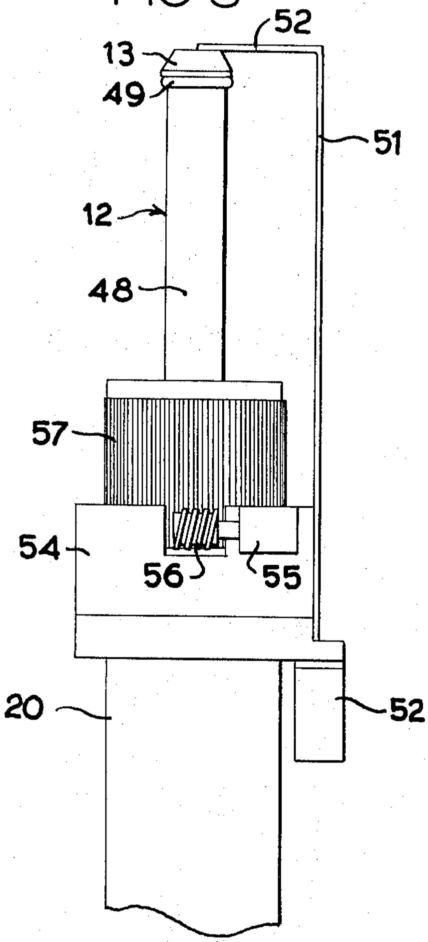



FIG 10

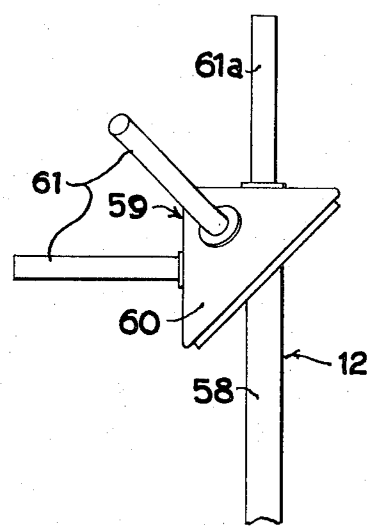
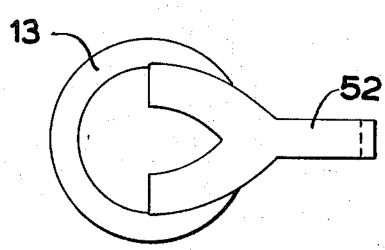



FIG 9



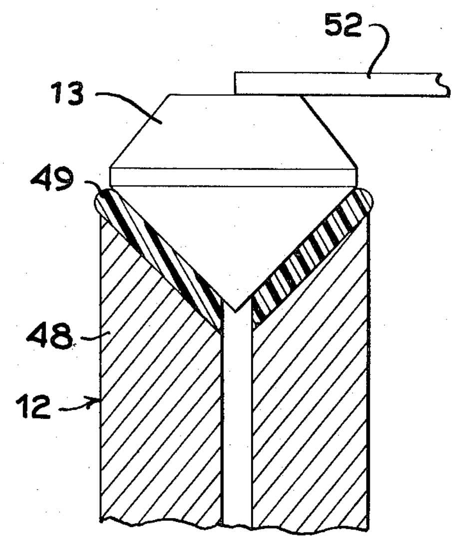




FIG 11

FIG 12

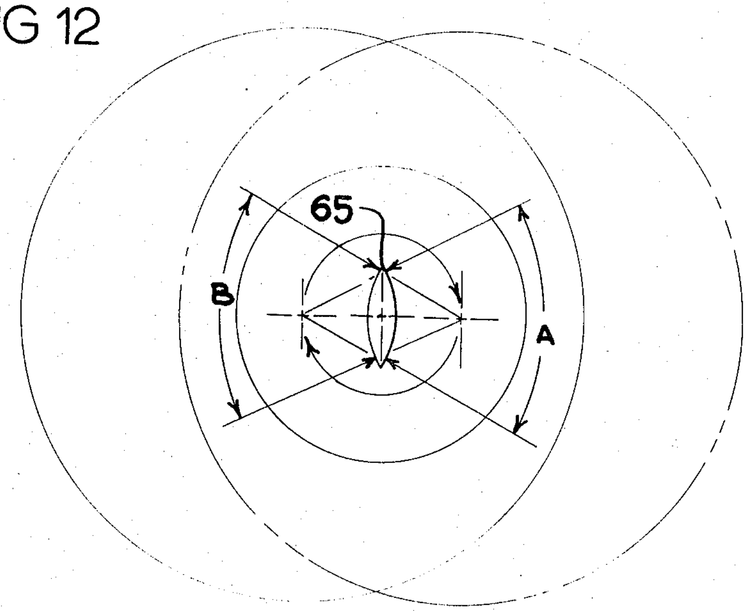



FIG 13

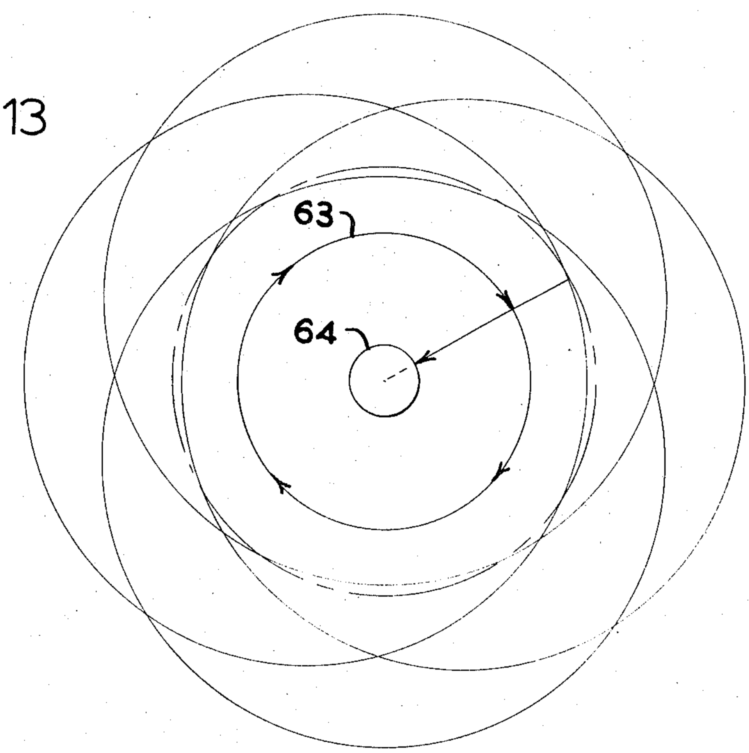



FIG 14

FIG 15

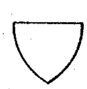


FIG 16

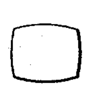


FIG 17

FIG 18

FIG 19

# GEM FACETING APPARATUS

## BACKGROUND OF THE INVENTION

Faceting machines in current use usually comprise a grinding wheel fixed to rotate in a selected plane (usually horizontal), and a gem holder or "dop arm" adjustably positioned above and extending angularly downward to the grinding surface. The dop arm usually provides an adjusting and locking means which allows the operator to pre-select a facet angle. Once the angle has been selected, the operator cuts the facet by angularly urging the stone at the outer end of the dop arm against the grinding wheel until the dop arm engages a stop. This process must be repeated for every cut. Some gem designs require hundreds of separate cuts. With several separate adjustments to be made for each cut, the possibility for human error becomes tremendous. Further, the value of a cut gem is dependent not only on the quality of the stone itself, but also on uniformity in the facet cuts. Eliminating human error is highly desirable.

The present invention comprises a faceting machine having the potential of being operated by computer, thereby eliminating possibilities of human error.

The present structure holds a gem stationary or moves it axially while an angularly grinding surface cuts each facet. The grinding surface is mounted for compound angular movement relative to the gem, including both horizontal and vertical adjustment capability. An upwardly projecting curved track adjustably supports the grinding surface for the vertical angular adjusting components. The track, in turn, is supported by a 360° horizontally rotatable disc, facilitating compound angular adjustment by adding the horizontal angular adjusting components.

Since all angular adjustments of the grinder can be motor-controlled it is possible to perform the gem cutting operations in a sequence controlled by a suitably programmed computer.

## SUMMARY OF THE INVENTION

The described invention relates to a gem faceting apparatus that essentially includes a stationary base and a dop mounted to the base for supporting a gem at a fixed location relative to the base. The gem is aligned along a first reference axis on the base. A powered grinding surface is movably supported on the base for angular adjustment in a plane containing the reference axis. The grinding surface intersects the reference axis during a faceting operation. Power devices are operatively connected between the base and the support means for the grinding surface and are operable to vary the angle of intersection of the grinding surface with respect to the reference axis through the gem. By repeated retraction of the gem and grinding surface relative to one another and reorientation of these two elements with respect to each other, one can cut a pre-selected facet pattern about the gem in a machine-controlled pattern.

It is a first object of this invention to provide an effective apparatus for repetitive faceting of gems in a production operation. This is to be contrasted with normal faceting machines which are substantially under manual control and which require considerable skill on the part of the human operator.



Another object of this invention is to provide a unique faceting apparatus which can be stepped in a pre-selected or programmed sequence by machine or computer controls.

Another object of this invention is to provide a faceting machine wherein the gem being faceted is held at a pre-selected location and the grinding surface for cutting the facets is moved about the gem in an angular pattern corresponding to the facet configuration desired on the finished gem.

Another object of the invention is to provide an extremely versatile faceting apparatus capable of forming a wide variety of facet patterns on various sized gems without requiring machine modifications or special design of the apparatus.

These and further objects and advantages of the invention will be evident from the following disclosure, taken together with the enclosed drawings, which illustrate a preferred form of the apparatus in schematic detail.

## BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. 1 is a sectioned side elevational view of my invention;

FIG. 2 is a side elevation view taken along line 2—2 in FIG. 1;

FIG. 3 is a sectioned plan view taken along line 3—3 in FIG. 1;

FIG. 4 is a detailed elevation view of the gem holding apparatus of my invention;

FIG. 5 is a sectional plan view taken along line 5—5 in FIG. 1;

FIG. 6 is a reduced plan view of my machine;

FIG. 7 is a fragmentary side elevation of the object of FIG. 6;

FIG. 8 is an elevation view showing the gem holder of FIG. 4 employing a clamp rotating means;

FIG. 9 is an enlarged plan view of the object of FIG. 8;

FIG. 10 is an elevational view illustrating an alternate form of gem holder;

FIG. 11 is a fragmentary enlarged view of a vacuum operated gem holder;

FIG. 12 ia a diagrammatic representation illustrating the procedure for cutting a "Marquise" design;

FIG. 13 is a similar diagrammatic illustration showing the procedure for cutting circular designs; and

FIGS. 14–19 illustrate different types of designs capable of being produced by my invention.

## DESCRIPTION OF A PREFERRED EMBODIMENT

The general concept of the present apparatus can best be understood from FIGS. **1** and **2**. The faceting machine is mounted to a stationary base **10**. The gem **13** is located at the outer or upper end of a dop **12**. The dop **12** and gem **13** are aligned along a first upright axis (X—X), shown in the drawings as being vertical with respect to base **10**. The desired facets about the upper portion of gem **13** are cut by a grinding surface **17** illustrated as being the outer plane surface of an abrasive wheel that is rotatably powered on a shaft **19**. During a faceting operation, the grinding surface **17** is movably located relative to the supporting framework on base **10** and with respect to gem **13** so as to grind or polish the gem surface along the desired planes and to the depths required by the desired finished gem configuration.

The grinding surface **17** of this apparatus is mounted for movement relative to gem **13.** By proper control of the location of gem **13** and the orientation and positioning of grinding surface **17,** the faceting of a gem can be automated and controlled by electrical or mechanical signal generation. This can be accomplished in the faceting of reproducible artificial gems.

In the preferred structure, the grinding surface **17** is movable about a selected circular or arcuate path in a vertical plane containing the axis X—X. This plane extends across FIG. **1** and would be viewed on edge in FIG. **2.** There also is provision for rotational indexing of grinding surface **17** and gem **13** relative to one another about axis X—X as a center. In addition, the grinding surface **17** can be angularly indexed about a second axis (Y—Y) independently of its relation to axis X—X. Axis Y—Y is parallel to and spaced from the first axis X—X. Finally, axis Y—Y can be moved to vary the radial separation between axis X—X and axis Y—Y, permitting variation in the arcuate curvature of the path of surface **17** about a gem centered along axis X—X.

Since the gem **13** is typically cut by producing a series of polished plane facets about its exterior surfaces, it is necessary to provide clearance between grinding surface **17** and gem **13** between individual facet operations except in those instances where curved gem surfaces are desired, such as in pre-forming operations. Such clearance can be alternately provided by controlled translational movement of dop **12** along axis X—X, or by controlled translational movement of grinding surface **17** along the rotational axis of shaft **19** or by horizontal movement of grinding surface **17.**

Such clearance can be achieved by lowering gem **13** from its grinding position. It can also be achieved by retracting grinding surface **17** along the axis of shaft **19** or by moving surface **17** radially outward from the axis X—X.

Referring now in detail to the drawings, base **10** supports a fixed upright hollow pedestal **11** centered along the first axis X—X. A telescoping dop support **20** is located within pedestal **11** and carries dop **12** at its upper end in such fashion as to raise or lower vertical dop **12** along the first axis X—X. Dop **12** protrudes upwardly from an indexing motor **21** at the upper end of dop support **20.** The indexing motor **21,** when provided as shown, is capable of revolving and angularly positioning dop **12** and gem **13** about the first axis X—X.

The operative grinding surface **17** is movably carried by support means extending over gem **13.** As illustrated, this support means includes a pair of inwardly facing curved semicircular tracks **22.** Tracks **22** movably mount a support unit **23** carrying the motor **24** that rotates shaft **19.**

The support means comprising tracks **22** and support unit **23** are adjustably mounted to pedestal **11** by a combination of adjustable support elements that provide the required degree of movement of the grinding surface **17** about the periphery of gem **13.** Due to the wide variety of gem configurations, considerable latitude in the choice of a selected path of movement of the grinding surface **17** is necessary in order to provide a versatile machine for faceting operations.

Pedestal **11** rotatably supports a turntable **14** supported by annular bearings **18** which locate turntable **14** on pedestal **11** for rotation about the first axis X—X. A horizontal eccentric ring **15** is rotatably mounted to ring **14** for rotation relative to turntable **14** about the second axis Y—Y.



Provision is preferably made for variation of the spacing between the axis Y—Y for ring **15** and the axis X—X of turntable **14** and gem **13.** As will be evident below, this permits change of the curved path of the grinding surface **17** as it is indexed about the gem.

As can be seen in FIGS. **1** and **2,** ring **15** is rotatably supported by annular bearings **34** centered about axis Y—Y. The bearings **34** are interposed between the lower surface of ring **15** and the upper surface of a movable support plate **9** that is part of turntable **14.** Plate **9** is movably guided on the main structure of turntable **14** by guides **36** providing dovetail ways which permit horizontal movement of plate **9** in a straight path. Such movement is controlled by a motor **37** on turntable **14** that powers a worm ***37a*** that meshes with a worm gear ***37b*** on plate **9.** The translational motion of plate **19** is facilitated by transverse roller bearings **39.**

The tracks **22** are shown as being fixed to horizontal annular plates **26** which are guided by guides **27** forming dovetail ways across the upper surface of ring **15** (FIGS. **2** and **5**). The plates **26** can be shifted in a plane perpendicular to the axes X—X and Y—Y to vary the location of tracks **22** and grinding surface **17** with respect to the second axis Y—Y.

Turntable **14** is rotatably powered by a motor **28** fixed to pedestal **11** (FIGS. **1, 3**). The lower portion of turntable **14** provides circular worm gear **30** which meshes with a worm **31** driven by motor **28.** Turntable **14,** when powered by motor **28,** rotates or pivots relative to the stationary pedestal **11** about a circular path centered about the first axis X—X.

A second motor **32** is fixedly mounted to turntable **14** at the upper surface of plate **9.** When operating, it pivots or rotates ring **15** relative to turntable **14.** The driving relationship is established through a beveled gear drive generally indicated at **33, 35,** and centered about the eccentric second axis Y—Y.

The beveled gear drive **33, 35** may be selectively locked by holding the shaft of motor **32** stationary. This results in rotatably locking ring **15** to turntable **14,** whereby ring **15** (and the rotational axis Y—Y) can be selectively indexed about axis X—X by operation of motor **28.** Motor **32** may, however, be activated independently of motor **28** to rotate ring **15** independently or simultaneously during rotation of turntable **14.** The object of this flexible motor operation is to provide means for varying the eccentricity of grinding surface **17** relative to the gem **13.** The combined rotation of ring **15** and turntable **14** in conjunction with suitable indexing about axis X—X facilitates the cutting of a variety of gem designs along curved paths which are circular or non-circular.

Tracks **22** are supported on ring **15** for relative horizontal translational movement along the V-guides **27** (FIGS. **2, 5**). The movement of tracks **22** is controlled by a motor **38** that drives a worm **40** meshing with a worm gear **41** that is formed integrally at the underside of plate **26.** Motor **38** itself is fixed to ring **15** and can be operated to move tracks **22** simultaneously during rotation of ring **15** if such simultaneous motion is required.

The tracks **22** (FIGS. 5–7) are semi-circular, being illustrated as generated about a center shown at **25** (FIG. 1). They cooperatively carry the support unit **23** by providing opposed inwardly facing arched channels for guide rollers, slides or other track supported elements. As illustrated, one track **22** also includes an integral worm gear **44**a which is in meshing engagement with a worm **44** powered by motor **43** (FIG. 1). Selective operation of motor **43** causes the support unit **23** to be moved along tracks **22.**

A similar motor **45** and worm **46,** mounted within the support unit **23,** serve to pivot the unit **23** about a worm gear **42** that is slidably mounted by tracks **22.** Worm gear **42** does not rotate and acts as a reactive member. Motor **45** controls angular positioning of support unit **23** and grinding surface **17** relative to tracks **22,** facilitating compound angular adjustment of grinding surface **17** during a faceting operation.

The grinding surface **17** may be axially movable along the axis of shaft **19** by means of a telescoping assembly **47** interposed between the support unit **23** and motor **24.** The retracted or inoperative position of these elements is shown in full lines in FIG. **1**, while the extended or operative position is shown in dashed lines. The selective extension of grinding surface **17** may be utilized to axially position the surface to a selected limit during grinding of a facet. After extension to a preset stop corresponding to a selected facet depth, the grinding surface **17** may be retracted for subsequent indexing of the grinding surface **17,** gem **13,** or both, in preparation for a subsequent faceting operation.

Further details of an exemplary arrangement for securing and indexing a gem **13** are illustrated in FIGS. **4, 8, 9** and **11.** The illustrated structure, which may be used in place of more conventional adhesives or wax, utilizes an upright suction tube **48** that has a concave conical upper or outer end. The gem **13** is seated at this end upon a resilient pad **49.** The pad **49** is constructed of a resilient material that has heat-resistive properties. Vacuum pressure is selectively applied through tube **48** to draw the gem **13** downwardly against the outer surface of pad **49.** Pad **49,** being resilient, can conform to the shape of the gem **13** and to the end of the tube **48,** thereby creating an effective seal during handling of gem **13.**

Gem **13** is further held mechanically by a movable clamp arm **51.** Arm **51** comprises an upright shaft having an upper horizontal section **52.** As seen in FIG. **9,** the section **52** is bifurcated, providing a laterally spread bearing surface that engages the gem **13** across its upper area. Longitudinal tension is applied to clamp arm **51** through action of an air cylinder **52,** fixed to a sleeve **54** rotatably mounted to dop **12.** A motor **55** and worm gear **56** are carried on sleeve **54** and mesh with gear teeth **57** formed integrally on dop arm **12.** Selected operation of motor **55** therefore serves to rotate the sleeve **54** relative to both dop **12** and the dop support **20** to maintain the clamp assembly **51** at the side of the gem **13** opposite to that at which a particular facet is being ground. Operation of motor **55** is suitably timed with respect to operation of cylinder **52** so as to momentarily release the clamp assembly **51** during rotation of sleeve **54** and the clamp **51** carried thereby.

FIG. **10** illustrates a variation of dop **12** comprising a multiple dop turret **59.** The turret **59** permits production faceting of several gems where a common facet configuration is desired on each gem. Turret **59** includes a support shaft **58** having a rotatable cone **60** mounted to its upper end, the cone axis being at an angle of 45° relative to the shaft axis of shaft **58.** Several dops **61** are spaced about cone **60.** Each dop **61** is extended at a 45° incline relative to the axis of cone **60.** Therefore, by rotating cone **60** on its axis, each dop **61** may be moved to the upright position illustrated in FIG. **10** as being occupied by dop **61***a*. By utilizing a turret **59** or other equivalent turret structures, several gems may be faceted in sequence to a common facet configuration. The grinding surface **17** need be set only once to cut s specific facet in each of the gems mounted to the dops on the turret **59.** This particularly lends itself to production repetitive faceting of gems.

The general scheme of the machine illustrated and described herein provides total flexibility in the faceting of a gem by permitting selective rotation of the gem itself, angular positioning and indexing of grinding surface **17** about several different axes and translational movement of both the gem and grinding surface. Where this degree of movement is not necessary, such as in the cutting of circular designs, certain of the above mechanisms for adjustment of the gem or grinding surface may be omitted. As an example, it might not be necessary to provide for retraction of the grinding surface **17** in instances where the gem is retracted axially along the axis X—X, this movement being utilized to control the depth of cut during a specific faceting operation.

FIG. **13** diagrammatically illustrates the several steps required in the processing of a circular facet pattern, the path of movement being shown at **63.** To accomplish this grinding operation, the ring **15** is locked to pedestal **14** by holding motor **32** inoperative. Rings **15** and pedestal **14** are then simultaneously rotated by operation of motor **28** to move the grinding surface **17** in the circular path shown at **64.** The motor **28** can angularly step grinding surface **17** about circular path **64** by electrical inpulses directed by a manual operator or from machine controls set from a computer. As an alternative, the circular grinding operation can also be accomplished by selectively moving the dop **12** along axis X—X and rotating dop **12** by operation of indexing motor **21.** Motor **21,** like all the other motors described above, may be computer controlled for incremental rotational movement upon command. The necessary clearance between grinding surface **17** and gem **13** during indexing of the gem relative to the grinding surface may be accomplished by retracting grinding surface **17** or by retracting the dop **12.** After the components are repositioned for the next faceting operation, the grinding surface **17** or gem **13** is extended a pre-selected distance corresponding to the desired depth of cut. After completion of each faceting operation, the retraction and indexing steps are repeated until the desired facet angle has been cut about the periphery of the gem. The support unit **23** is then repositioned along the tracks **22** for a successive row of facets which are then cut about the gem in a repetitive pattern.

FIG. **12** diagrammatically illustrates the general process for forming a "Marquise" design, indicated at **65.** Ring **15** is first indexed by motor **32,** causing the grinding surface **17** to cut successive facets along the arcuate path shown at "A". The radius of path "A" is controlled by operation of motor **37.** Motor **32** is then locked and motor **28** is activated to rotate both ring **15** and pedestal **14** to the position indicated by phantom lines in FIG. **12.** Motor **28** is then locked and motor **32** is stepped to index the grinding surface **17** during the cutting of facets on the path designated at "B". Upon completion of the facet cutting operation, the grinding surface **17** is repositioned along track **22** and the process is repeated until the gem configuration has been completed.

FIGS. **14–19** show basic outlines of conventional gem designs that can be formed by machine control of this apparatus. FIG. **14** illustrates a "Marquise" shape. FIG. **15** shows a "Seminavette" design which would partially involve an operation similar to that described in the forming of a "Marquise" cut to form the two arcuate sides, while the flat top surface may be formed by aligning the grinding surface **17** perpendicular to the imaginary line of intersection of the two arcuate sides. FIG. **16** illustrates a "pear" design, incorporating portions of both basic operations shown in FIGS. **12, 13.** FIG. **17** shows a "Lisbon" cut, involving a variation of the "Marquise" cutting process. FIG. **18** shows an oval cut that may be produced by a combination of the processes described for "Marquise" and circular cuts. An oval shape may also be formed by utilizing motor **38** simultaneously during operation of motor **28** to vary the position of axis Y—Y while maintaining gem **13** stationary. FIG. **19** illustrates a pear-shaped design incorporating a part of the "Marquise" design procedure and a repetition of half-circular cuts to form the upper portion.

It is to be noted that the examples described above are only a selected few of the gem designs that may be produced by this machine. By proper control of the various motors, one may reposition the grinding surface **17** relative to the gem to form any desired pattern of facets about the gem surfaces. The control of these motors can be accomplished by conventional tape controls, using magnetic or punched tape machine controls known in other machining industries. The computer controls can be either special purpose, including mechanical control, or can be supplied by a properly programmed general purpose computer. Many gem designs incorporating geometric configurations of all shapes can be carried out in a production manner by the automatic apparatus generally described above.

Many modifications can obviously be made with respect to the schematic presentation of the physical components of this apparatus. The above description and accompanying drawings are not intended to limit or restrict the scope of this application beyond the definition of the appended claims.

Having thus described my invention, I claim:

**1.** In a gem faceting apparatus:

a stationary base;

a dop mounted to said base along a first axis, the outer end of said dop including gem mounting means for holding a gem along said first axis;

powered grinding surface means;

curved support means movably mounted to said base for movement relative to said base about said first axis and extending across the dop and spaced outwardly therefrom, said support means presenting a concave configuration facing towards said gem mounting means;

said grinding surface means being movably mounted to said curved support means for motion along a path conforming to the concave configuration thereof for permitting angular adjustment of said powered grinding surface means in a plane containing said first axis;

first power means operatively connected between said base and said support means for selectively moving said grinding surface means in said plane along said curved support means so as to vary the angular orientation of said grinding surface means with respect to the first axis;

and means operatively connected between said curved support means and said base for imparting rotational motion to said curved support means about said first axis.

**2.** An apparatus as set out in claim **1** further comprising:

means operatively connected between said base and said dop for imparting rotational motion to said dop about said first axis.

**3.** The apparatus set out in claim **1** further comprising:

means operatively connected between the base and said curved support means mounting said curved support means relative to said base about a second axis that is parallel to and spaced from said first axis.

**4.** The apparatus set out in **1** further comprising:

means operatively connected between the base and said curved support means mounting said curved support means relative to said base about a second axis that is parallel to and spaced from said first axis; and

means operatively connected between the base and said curved support means for translationally moving the curved support means relative to the base along a plane that is perpendicular to said first axis.

**5.** The apparatus set out in claim **1** further comprising:

means operatively connected between the base and said curved support means mounting said curved support means relative to said base about a second axis that is parallel to and spaced from said first axis; and

means operatively connected between the base and said curved support means for translationally moving said second axis relative to the base while maintaining the second axis parallel to said first axis.

**6.** The apparatus set out in claim **1** further comprising:

first and second bearing means operatively interposed between the curved support means and said base, said first bearing means being centered about said first axis and said second bearing means being centered about a second axis parallel to and spaced from said first axis.

**7.** In a gem faceting apparatus:

a stationary base;

a dop mounted to said base along a first axis, the outer end of said dop including gem mounting means for holding a gem along said first axis;

a first support member rotatably mounted to said base for movement about said first axis;

first power means operatively connected between said first member and said base for selectively moving said first member relative to said base about said first axis;

a second support member mounted to said first member for motion relative thereto;

second power means operatively connected between said second member and said first member for selectively moving said second member relative to said first member;

arched track means mounted to said second member extending across said second member and presenting a concave configuration facing toward the gem mounting means of said dop;

and powered grinding surface means movably mounted to said track means for motion along a path conforming to said concave configuration for surface engagement with a gem held by said gem mounting means.

**8.** The apparatus as set out in claim **7**, wherein said second member is mounted to said first member about second axis of rotation parallel to and spaced from said first axis.

**9.** The apparatus as set out in claim **7**, wherein the concave configuration of said track means is centered along a second axis parallel to and spaced from said first axis;

and third support means mounting said second member to said first member for translational movement of said second member relative to said first member in a direction perpendicular to said first axis.

**10.** The apparatus as set out in claim **9** wherein said second member is mounted to said first member about an axis of rotation parallel to and spaced from said first axis.

**11.** An apparatus as set out in claim **7**, further comprising:

movable dop support means mounting said dop to said base for selectively translating said dop along said first axis.

**12.** An apparatus as set out in claim **11**, wherein said dop support means mounts said dop for rotation about said first axis and includes means for angularly indexing the dop about said first axis.

**13.** In a gem faceting apparatus:

a stationary base;

a dop mounted to said base along a first axis, the outer end of the dop including a gem mounting device seating a gem along said first axis in a position releasably fixed to said dop;

a first annular member rotatably mounted to said base about said first axis;

a second annular member rotatably mounted to said first annular member about a second axis parallel to and spaced from said first axis;

a powered grinding surface;

a support for said grinding surface, said support being mounted to said second annular member for rotation about said second axis in unison with said second annular member; said support comprising relatively movable elements adjustably locating the angular relation of the powered grinding surface with respect to said first axis;

and powered means connected to said first and second annular members and to said base for selectively indexing said annular members about said first and second axes.

**14.** The apparatus as set out in claim **13**, further comprising:

a translational support connected between said first and second annular members permitting motion of said second member relative to said first member along a plane perpendicular to said first axis;

and a controllable power device operatively connected between said first and second members for imparting translational motion to said second member relative to said first axis.

**15.** The apparatus as set out in claim **13** further comprising:

movable dop support means mounting said dop to said base for selectively translating said dop along said first axis.

**16.** An apparatus as set out in claim **15**, wherein said dop support means mounts said dop for rotation about said first axis and includes means for angularly indexing the dop about said first axis.

**17.** An apparatus as set out in claim **1** further comprising:

means operatively connected between said base and said dop for imparting translational movement to said dop along said first axis.

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