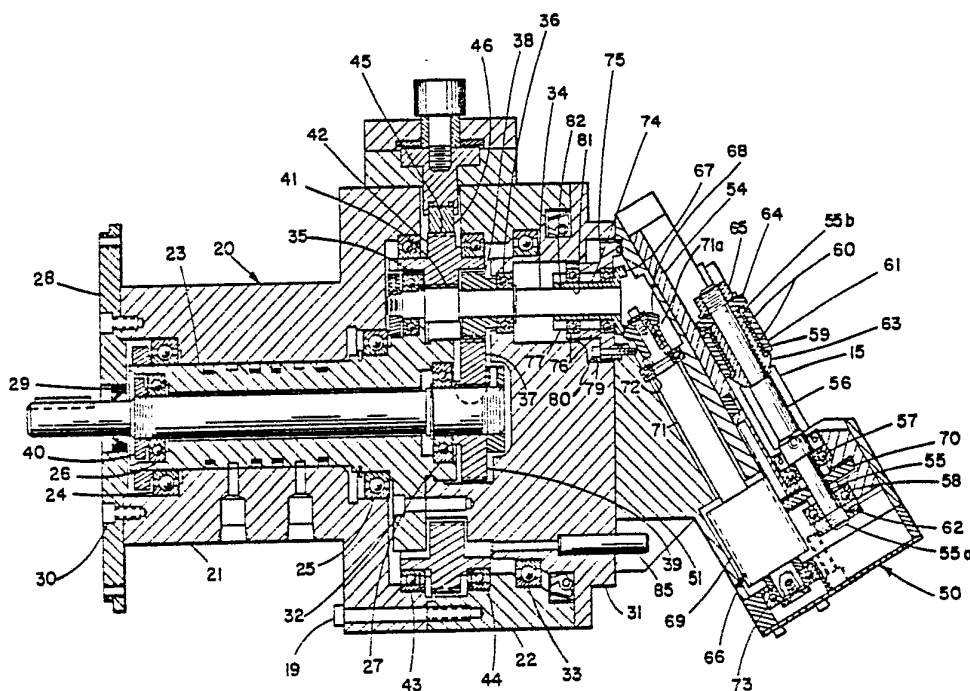


## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |           |                                                                                                                                                          |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>(51) International Patent Classification <sup>3</sup>:</b><br><b>B23C 1/12; B23F 5/20</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>A1</b> | <b>(11) International Publication Number:</b> WO 82/00263<br><b>(43) International Publication Date:</b> 4 February 1982 (04.02.82)                      |
| <p><b>(21) International Application Number:</b> PCT/US81/00594</p> <p><b>(22) International Filing Date:</b> 30 April 1981 (30.04.81)</p> <p><b>(31) Priority Application Number:</b> 170,369</p> <p><b>(32) Priority Date:</b> 21 July 1980 (21.07.80)</p> <p><b>(33) Priority Country:</b> US</p> <p><b>(71) Applicant:</b> BARBER-COLMAN COMPANY [US/US];<br/>1300 Rock Street, Rockford, IL 61101 (US).</p> <p><b>(72) Inventors:</b> HAUG, Edward, W.; 2031 North Mulford,<br/>Rockford, IL 61107 (US). FRANSSON, George, E.;<br/>1616 Benton Street, Rockford, IL 61107 (US). HACK-<br/>MAN, Roger, L.; 3819 Florida Drive, Rockford, IL<br/>61108 (US).</p> <p><b>(74) Agent:</b> HAMMES, Robert, M. Jr.; Barber-Colman Com-<br/>pany, 1300 Rock Street, Rockford, IL 61101 (US).</p> |           | <p><b>(81) Designated States:</b> BR, CH, DE, FR (European patent),<br/>GB, JP.</p> <p><b>Published</b><br/> <i>With international search report</i></p> |

**(54) Title:** REPLACEABLE CUTTER SWIVEL**(57) Abstract**

A replaceable cutter swivel assembly (50) is adapted to be mounted on a planetary assembly (20) of an orbital shape generating apparatus for orbiting the swivel assembly and its associated cutter (56) about a workpiece. The cutter swivel assembly has a gear train providing a predetermined helix angle and gear ratios for particular shape generating requirements. Means is also provided for adjusting the distance between the cutter axis and the workpiece axis to facilitate adjusting or presetting of the cutter swivel assembly for a predetermined depth of cut.

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## REPLACEABLE CUTTER SWIVEL

This apparatus relates to the generation of shapes on a workpiece by various shape generation methods, such as gear hobbing, shaping, and shaving. More particularly, this invention relates to improvements in orbital shape generating apparatus which substantially increases the productivity and efficiency capabilities of the machine.

An orbital shape generating apparatus, as disclosed in the co-pending application of Fransson et al, Serial No. 41,680 of common ownership with this application, is typically a machine which can be utilized to manufacture only a limited range of parts since the gear ratios and helix angle required for a particular shape generating application are built into the apparatus and are not readily changeable. Consequently, in an orbital hobbing apparatus, for example, cutting different numbers of teeth on different size workpieces requires completely separate orbital hobbing machines dedicated to the particular application and having the desired gear ratios and helix angle built into the machine.

In addition, overall efficiency is limited because set-up must be performed on the machine itself. Each time a cutter requires sharpening or replacement the machine must be stopped and the time consuming set-up



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operation must again be performed.

Accordingly, it is desirable to provide an orbital shape generating apparatus which overcomes the foregoing limitations and which can be readily adapted  
5 for any of a variety of shape generating requirements.

#### SUMMARY OF THE INVENTION

According to this invention, the productivity and efficiency of an orbital shape generating machine is enhanced by providing a replaceable cutter swivel assembly which is adapted to be mounted upon a planetary  
10 assembly of the machine so that the cutter swivel assembly and its associated cutter are orbited about the workpiece during the shape generating operation.

The cutter swivel assembly is provided with a gear train for driving the rotating cutter such that  
15 the swivel assembly has the required gear ratios and helix angle for the particular shape generating operation being performed. This design allows for quickly changing the entire swivel assembly and its dedicated gear train so as to facilitate rapid set-up  
20 of the machine for operating on a particular workpiece.

The cutter swivel assembly is preferably further provided with means for adjusting the distance between the workpiece axis and the cutter axis so as to facilitate adjusting or presetting the position of  
25 the swivel assembly on the planetary assembly for a predetermined depth of cut. This allows for performing set-up operations on a presetting fixture while the machine continues to operate with another cutter swivel assembly in place.

30 By providing a replaceable cutter swivel assembly as disclosed herein, machine versatility is improved while at the same time permitting reduction in down time which would normally be required for set-up and cutter replacement. A more thorough understanding of  
35 the invention, as well as other objects and advantages



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will be apparent from the following detailed description taken in conjunction with the drawing figures.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a side elevational view of a typical orbital hobbing machine.

5        Fig. 2 is a side view, partially in section, of the planetary assembly and helical hob swivel assembly of an orbital hobbing machine according to the invention.

10       Fig. 3 is an end view of the planetary assembly and a straight hob swivel assembly mounted thereon in an orbital hobbing machine according to the invention.

Fig. 4 is a side view of a presetting fixture with a straight hob swivel assembly mounted thereon.

15       Fig. 5 is a front view of a presetting fixture with a helical hob swivel assembly mounted thereon.

Fig. 6 is a view taken along the line 6-6 in Fig. 4 showing the position of the hob swivel assembly on the swivel table of the presetting fixture.

#### DESCRIPTION OF THE INVENTION

20       While it will be readily apparent to those skilled in the art that the principle of employing a replaceable cutter swivel assembly can be used in various types of orbital shape generating machines, the present invention will be described, by way of example, with respect to its applicability to an orbital hobbing machine. The construction and operation of orbital  
25       shape generating machines, including an orbital hobbing machine, is described in detail in the co-pending application Serial No. 41,680 of Fransson et al, of common ownership herewith, and this co-pending applica-  
30       tion is incorporated herein to the extent necessary for a complete understanding of the operation of orbital shape generating machines which are the subject matter of this invention.

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Referring to Fig. 1, a typical orbital hobbing machine, generally indicated at 10, comprises a casing 11 mounted on base 12 and being capable of lateral movement in the direction of the arrows. A hob head 13 is drivingly connected to a planetary gear assembly within casing 11 which is driven by means of drive shaft 14 so that hob head 13 and its associated hob 15 may be orbited about a workpiece 16 during a hobbing operation. Hob head 13 is also provided with a gear train for rotating the hob 15 in timed relation with the orbital rotation of the hob head and the lateral movement of casing 11 which is accomplished by means of actuator 17. The machine shown in Fig. 1 is exemplary of the type of orbital shape generating apparatus described in co-pending Serial No. 41,680. The present invention is described with reference to the same elements shown in Fig. 1 with the exception of hob head 13.

According to the preferred embodiment of the present invention, an orbital hobbing machine is provided with a planetary assembly 20, as shown in Figs. 2 and 3, which is located within casing 11 and is further provided with an associated hob swivel assembly 50 (50' in Fig. 3) which can be detached from planetary assembly 20. For purposes of illustrating two types of hob swivel assemblies, Fig. 2 is shown with a helical hob swivel assembly 50 and Fig. 3 is shown with a straight hob swivel assembly 50'. Hob swivel assembly components in Fig. 3 which correspond to components in Fig. 2 are identified with the same number plus a prime sign (''). Similar designations are used in Figs. 4 and 5. Planetary assembly 20 comprises a back housing 21, and a front housing 22 which are secured together by means of screws 19. A planetary support member 23 is mounted for rotation within back housing 21 by means of bearings 24, 25. Drive shaft 14 is in turn mounted within support member 23 for relative rotation there-



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with by means of bearings 26, 27. A backplate 28 carrying an oil seal 29 is fixed to back housing 21 by means of screws 30 so as to seal the rear end of planetary assembly 20. A face plate 31 is provided which pilots into front housing 22 and is secured to planetary support member 23 by means of screws 32 and is supported in front housing 22 by means of bearing 33. A jack shaft 34 is supported for rotation in planetary support member 23 by means of bearing 35 and in faceplate 31 by means of bearing 36. A drive gear 37 is fixed on the end of shaft 14 between bearing 27 and retaining nut 39 which is threaded on the end of shaft 14. Drive gear 37 mates with a driven gear 38 which is mounted on jack shaft 34 as shown. A retaining nut 40 is threaded onto shaft 14 against bearing 26 so as to cooperate with nut 39 to maintain shaft 14 in proper axial position. Jack shaft 34 is further provided with an integral planet gear 41. In order to provide planetary operation of the assembly an internal ring gear 42 is provided which mates with planet gear 41. Ring gear 42 may be fixedly supported in convenient fashion within back housing 21 and front housing 22. However, as shown ring gear 42 is mounted for relative rotation with respect to housings 21, 22 by means of bearings 43, 44 and is further provided with external teeth 45 for mating with a rack 46 to permit cutting of helical gears as more fully described in co-pending application Serial No. 41,680.

Helical hob swivel assembly 50 comprises means for positioning and mounting swivel assembly 50 such as a swivel base 51 adapted to be secured to faceplate 31 by means of screws 52 which extend through slotted holes 53 and are threaded into faceplate 31. Swivel base 51 is provided with a hob slide 54 which supports an end portion 55a of spindle shaft 55 and its associated



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arbor 56 by means of bearings 57, 58. Hob 15 is supported upon arbor 56 and is secured in position by means of sleeve 59 which is supported within end support portion 61 by means of bearings 60, sleeve 59 in turn supporting end portion 55b of spindle shaft 55. The axial position of spindle shaft 55 is maintained as shown by ring nut 62 which is threaded onto shaft end 55a. The hob 15 is clamped in place on arbor 56 by means of the tapered portion 63 of sleeve 59, clamping action being provided by means of axial movement of sleeve 59 imparted by tightening ring nut 65. Ring nut 64 is threaded onto sleeve 59 as shown to retain sleeve bearings 60 in position. In order to provide the proper helix angle and gear ratios for a particular hobbing application, cutter swivel assembly 50 is provided with a gear train 66 comprising a drive bevel gear 67 a mating driven bevel gear 68, a transmission gear 69 and a spindle gear 70. Driven bevel gear 68 is fixed as shown on an end 71a of shaft 71 which is in turn mounted for rotation by means of bearings 72, 73. Transmission gear 69, integral with shaft 71 and displaced axially from bevel gear 68, drives spindle gear 70 which is fixed on spindle shaft 55 between bearings 57, 58. The shaft 74 of bevel gear 67 is supported for rotation within housing 75 by means of bearings 76, the bearings and bevel gear being retained in position by means of ring nut 77 threaded on the end of shaft 74. Housing 75 is secured to swivel base 51 by means of screws 79.

In order to facilitate mounting the hob swivel assembly 50 on planetary assembly 20, faceplate 31 is provided with an opening 80 for receiving housing 75. Bevel gear shaft 74 is provided with a splined hole 81 which in turn receives the splined end portion 82 of shaft 34 to establish a rotational driving relationship between shaft 34 and bevel gear 67.



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The gear elements of gear train 66 as described above establish the particular helix angle and gear ratios required for cutting a specified gear during a hobbing operation. Previously, an orbital hobbing machine was dedicated to cutting a particular part since the complete drive train from shaft 14 and drive gear 37 through spindle 55 and its associated spindle gear 70 comprised a single unit. By providing a hob swivel assembly 50 which has built into it the variable gear train elements required for a particular hobbing operation, the orbital hobbing machine can be used for different gear cutting applications by simply replacing one hob swivel assembly with another hob swivel assembly having the desired gear ratios and helix angle built into it.

In addition, the provision of a hob swivel assembly according to the invention permits an orbital hobbing machine to be used for cutting both helical and spur gears by providing a hob swivel assembly having a pair of bevel gears set at the desired helix angle as shown in Fig. 2.

In another aspect of the invention, hob swivel assembly 50 is provided with means for adjusting the distance between the hob axis and the workpiece axis to obtain the desired depth of cut. In the preferred embodiment this adjusting means comprises an adjusting screw 83', best seen in Fig. 3, which is threaded through a rib 84' on swivel base 51'. A set screw 86' perpendicular to screw 83' is threaded into rib 84' to hold screw 83' in position after adjustment. When hob swivel assembly 50 is mounted on planetary assembly 20, the swivel assembly can be rotated about a swivel axis corresponding to the axis of bevel gear 67 until the threaded end of screw 83 abuts against an abutment such as dowel pin 85 fixed in faceplate 31, slotted screw holes 53 facilitating rotational movement of hob swivel assembly 50. Rotation of adjusting screw 83

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when in abutting relationship with pin 85 permits adjustment of the distance between the axis of hob 15 and the axis of workpiece 16 so that the proper depth of cut can be established for various workpiece and hob sizes. As shown in Fig. 3, the centers of bevel gear 67 and dowel pin 85 are located along a line passing through the axis of the planetary assembly. While this particular relationship is not necessarily required the device is constructed in this fashion so that the relationships can be easily duplicated in a presetting fixture as will be more fully described below.

In addition to facilitating adjustment of the distance between the workpiece and cutter axis, the provision of the adjusting means also permits presetting the required hob swivel assembly set-up without hob swivel assembly 50 being actually mounted on the planetary assembly 20. In order to accomplish this presetting operation, a presetting fixture, shown in Figs. 4, 5 and 6 is provided. As shown, presetting fixture 90 comprises a base 91 supporting a C-type frame having a swivel table 93 for supporting a hob swivel assembly 50. An indicator assembly 94 is mounted on a vertical spindle 95 which is mounted for rotation by means of bearings 96 within sleeve 97 which is in turn supported within sleeve supporting portion 98 of frame 92. Sleeve 97 is retained in position by means of ring nut 99 threaded onto the threaded end portion 100 of sleeve 97. The vertical position of sleeve 97, spindle 95 and indicator assembly 94 can be adjusted through rotation of ring nut 99. Ring nut 99 has an associated retaining bar 101 adapted to prevent vertical movement of ring nut 99. Indicator assembly 94 has a mounting bar 102 which supports a micrometer 103, an indicator 104, and a contact slide 105. Plunger 106

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of indicator 104 biases contact slide 105 against micrometer rod 107 such that axial movement of rod 107 resulting from rotation of micrometer 103 in turn results in lateral movement of contact slide 105 with indicator 104 producing a reading indicative of slide position. Swivel table 93 is provided with a bore 108 for receiving housing 75 of swivel assembly 50. Swivel table 93 is further provided with a dowel pin 109 positioned such that adjusting screw 83 of swivel assembly 50 can be brought into abutting relationship with pin 109. For purposes of illustration, Fig. 4 is shown with a straight hob swivel assembly 50' positioned on swivel table 93 and Fig. 5 is shown with a helical hob swivel assembly 50 positioned on swivel table 93.

As best seen in Fig. 6, bore 108 and pin 109 are located along a line passing through the center of swivel table 93 which corresponds to the axis of the planetary assembly 20 shown in Fig. 2. The positions of bore 108 and pin 109 correspond precisely with the positions of pilot opening 80 and dowel pin 85 on the planetary assembly so that a position obtained on swivel table 93 by means of adjusting screw 83' will be duplicated exactly when the hob swivel assembly 50 is subsequently mounted on planetary assembly 20.

A method of presetting the hob swivel assembly will now be described in more detail. Referring to Fig. 4, hob swivel assembly 50' is first mounted on swivel table 93 and positioned so that adjusting screw 83' is proximate to dowel pin 109. During the presetting operation, the ultimate result desired is that the outer circumference of the hob teeth be brought through adjustment of screw 83' to a position tangent to the root circle diameter of the workpiece to be cut thereby establishing the desired depth of cut. Indicator assembly 94 is preferably so constructed that the

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axis of spindle 95 falls within the vertical plane of contact surface 105a when micrometer 103 is set at zero. In setting up the fixture, micrometer 103 is adjusted to a reading equal to the desired root circle radius for the workpiece 16 and the reading on indicator 107 is noted. Indicator assembly 94 is then lowered by means of ring nut 99 to a position in which the vertical contact surface 105a of slide 105 is adjacent to the outer circumference of the hob teeth as shown in phantom in Fig. 4. Hob 15 is then brought into contact with contact surface 105a through rotation of hob swivel assembly 50' about its swivel axis. In order to insure that contact surface 105a is tangent to the outer circumference of hob 15, the hob is then rotated about its axis to the high point on a hob tooth so as to obtain a maximum displacement reading on indicator 104. Hob swivel assembly 50' is then rotated about its swivel axis until the noted reading of indicator 104 is reached, this position corresponding precisely with contact between contact surface 105a and the end of micrometer rod 107. Adjusting screw 83' is then rotated until it abuts against pin 109 while maintaining the noted reading on indicator 104, and set screw 86' is tightened against screw 83'. At this point, adjusting screw 83' is properly set so that when the hobswivel assembly is subsequently mounted on planetary assembly 20 with screw 83' in abutting relationship with pin 85, the required relationship between hob 15 and workpiece 16 will have been obtained.

From the foregoing, it is readily apparent that the provision of a replaceable hob swivel assembly incorporating a gear train for a predetermined hobbing condition, along with the described adjusting means, greatly enhances the capability of an orbital hobbing



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machine. As previously noted, other types of orbital  
shape generating machines can be similarly provided  
with replaceable cutter swivel assemblies in accordance  
with the invention. In addition it will be apparent  
5 to those skilled in the art that alternate embodiments  
can be provided without departing from the scope and  
spirit of the invention. The foregoing description  
of the preferred embodiment is therefore to be  
considered exemplary only and the invention is limited  
10 solely by the claims.



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## CLAIMS

We claim:

1. Apparatus for generating a shape on the periphery of a workpiece by orbiting a rotating cutter about said workpiece, comprising: a planetary assembly comprising a rotary portion and a drive train having a rotary  
5 output drive; a replaceable cutter swivel assembly mounted on said rotary portion, said cutter swivel assembly comprising means for positioning and mounting said cutter swivel assembly on said rotary portion, means for supporting the cutter for rotation about  
10 its axis and a gear train for rotating said cutter, said gear train dedicated to particular shape generating requirements and having an input for connection to said drive train; and means for drivingly connecting said gear train input to said rotary output drive;  
15 said planetary assembly orbiting said cutter swivel assembly and the associated cutter about the workpiece through rotation of said rotary portion imparted by said drive train.

2. A shape generating apparatus according to claim 1 wherein said mounting and positioning means comprises a base and means for fastening said base to said rotary portion in a selected position.



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3. A shape generating apparatus according to  
claim 2 wherein said cutter swivel assembly is  
selectively pivotable relative to said rotary portion  
about a swivel axis displaced from the axis of the  
5 workpiece.

4. A shape generating apparatus according to  
claim 3 wherein said swivel axis comprises the axis  
of said rotary output drive.

5. A shape generating apparatus according to  
claim 3 additionally comprising means for adjusting  
the distance between the cutter axis and the workpiece  
axis through pivotal cutter swivel assembly movement  
5 to obtain a predetermined depth of cut.

6. A shape generating apparatus according to  
claim 5 wherein said rotary portion has a fixed abut-  
ment thereon and said adjusting means comprises a  
screw threaded through a portion of said cutter swivel  
5 assembly and located to abut against said abutment.

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7. A replaceable cutter swivel assembly for use in an apparatus for generating a shape on the periphery of a workpiece by orbiting a rotatable cutter about said workpiece, the shape generating apparatus having  
5 a planetary assembly comprising a drive train having a rotary output drive and a rotary portion for supporting and orbiting the cutter swivel assembly about the workpiece, said replaceable cutter swivel assembly comprising:

- 10 means for mounting said cutter swivel assembly on said rotary portion of said planetary assembly;  
means for supporting the cutter for rotation about its axis;  
a gear train for rotating said cutter, said  
15 gear train dedicated to particular shape generating requirements; and  
means for drivingly connecting said gear train to the rotary output drive of the planetary assembly.

8. A cutter swivel assembly according to claim 7 wherein said mounting means comprises a base having a plurality of slotted holes therethrough adapted to receive fasteners for fixing said base to said rotary  
5 portion in predetermined relationship.

9. A cutter swivel assembly according to claim 7 additionally comprising means for presetting the distance between the cutter axis and the workpiece axis.

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10. A cutter swivel assembly according to  
claim 9 wherein said presetting means comprises a  
screw threaded through a portion of said cutter  
swivel assembly and positioned to abut against an  
5 abutment on said rotary portion of said planetary  
assembly.

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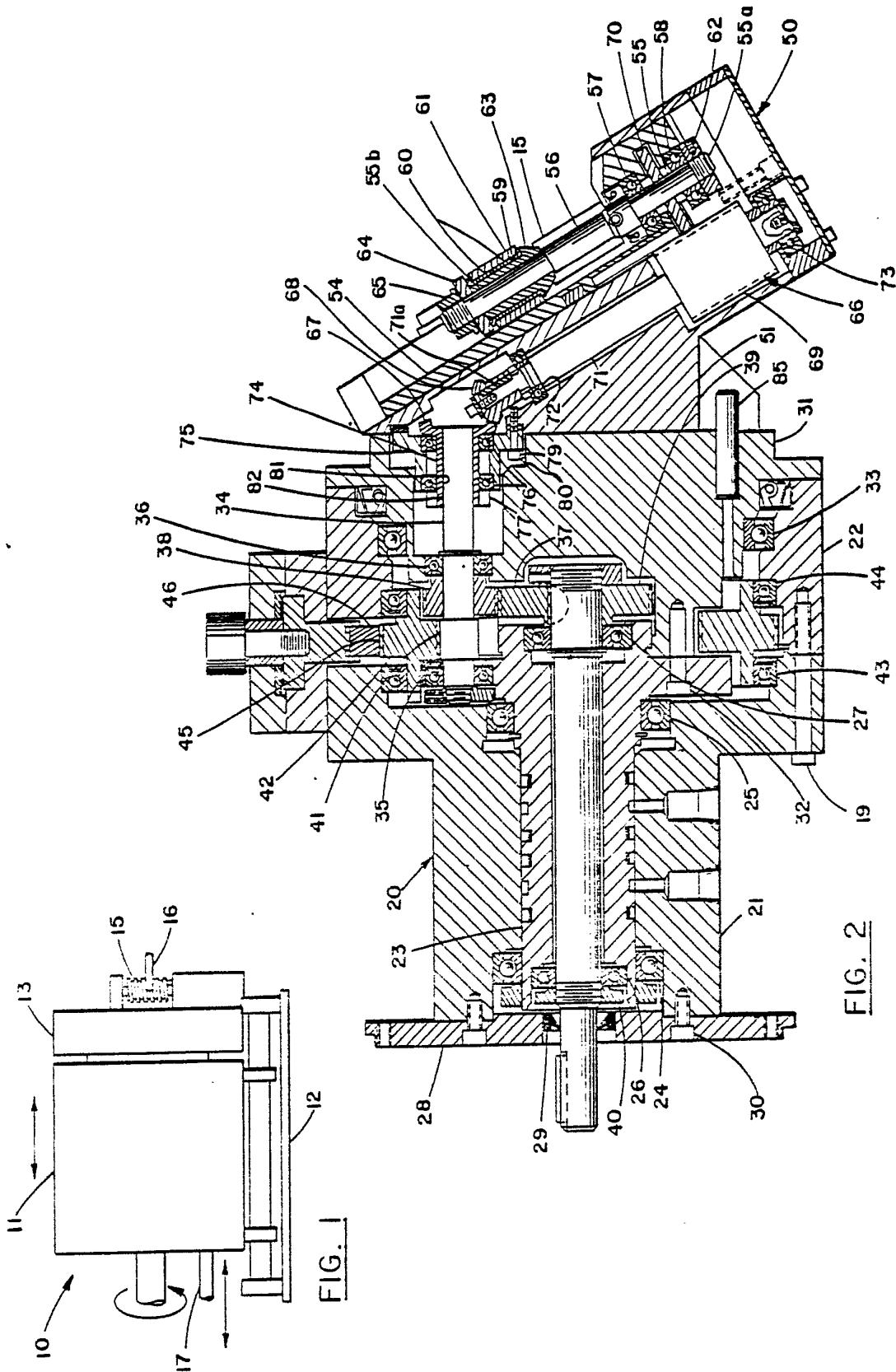
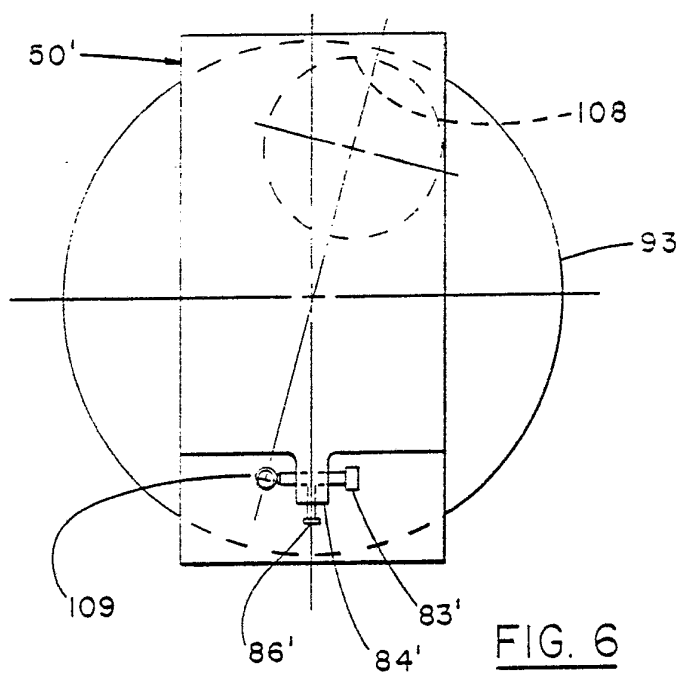
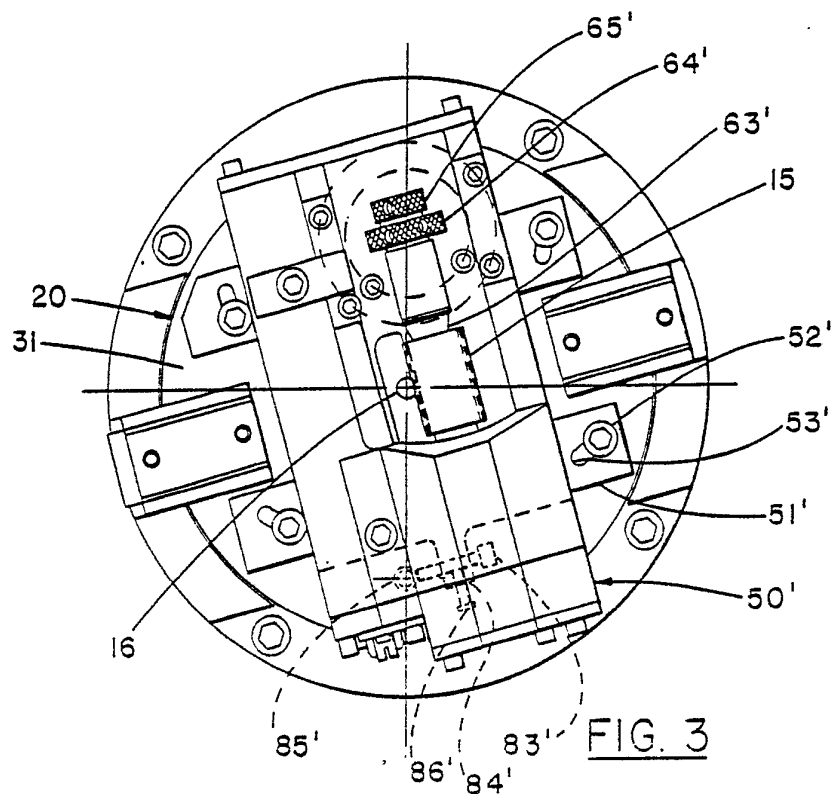


FIG. 2

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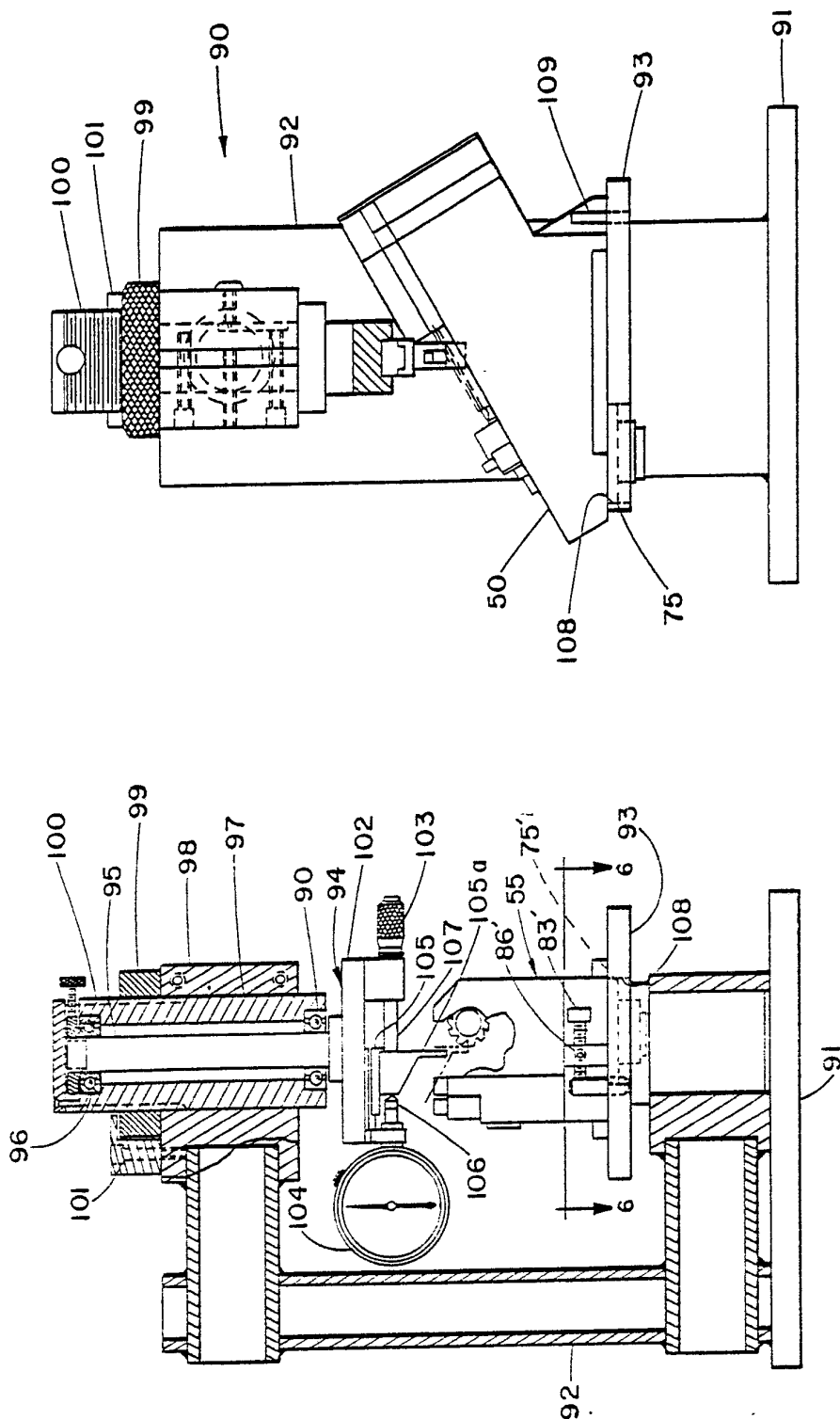


FIG. 5

FIG. 4

# INTERNATIONAL SEARCH REPORT

International Application No. PCT/US 81/00594

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                |                                     |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|-------------------------------------|
| <b>I. CLASSIFICATION OF SUBJECT MATTER</b> (If several classification symbols apply, indicate all) <sup>3</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                |                                     |
| According to International Patent Classification (IPC) or to both National Classification and IPC                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                |                                     |
| INT CL. <sup>3</sup> B23C 1/12; B23F 5/20                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                |                                     |
| US CL. 409/11, 74; 51/241.B                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                |                                     |
| <b>II. FIELDS SEARCHED</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                |                                     |
| Minimum Documentation Searched <sup>4</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                |                                     |
| Classification System                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Classification Symbols                                                                                         |                                     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 409/11, 24, 31, 66, 74, 144, 200<br>51/90, 241.B                                                               |                                     |
| Documentation Searched other than Minimum Documentation<br>to the Extent that such Documents are Included in the Fields Searched <sup>5</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                |                                     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                |                                     |
| <b>III. DOCUMENTS CONSIDERED TO BE RELEVANT</b> <sup>14</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                |                                     |
| Category <sup>6</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Citation of Document, <sup>16</sup> with indication, where appropriate, of the relevant passages <sup>17</sup> | Relevant to Claim No. <sup>18</sup> |
| X                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | US, A 1,269,857 Published 18 June 1918,<br>Richards                                                            | 1,7                                 |
| X                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | US, A 1,386,279 Published 2 August 1921,<br>Richards Et Al.                                                    | 1,7                                 |
| X                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | US, A 2,312,354 Published 2 March 1943,<br>Norberg                                                             | 1, 2, 7, 8,<br>9                    |
| X                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | US, A 2,802,320 Published 13 August 1957,<br>Nagle                                                             | 1, 2, 7, 8,<br>9                    |
| X                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | US, A 3,690,220 Published 12 September<br>1972, Escobedo                                                       | 1-10                                |
| X                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | US, A 3,762,272 Published 2 October<br>1973, Escobedo                                                          | 1-10                                |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | US, A 2,451,497 Published 19 October 1948,<br>Kratchman                                                        | 1,7                                 |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | US, A 2,553,669 Published 22 May 1951,<br>Norberg Et Al.                                                       | 1,7                                 |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | US, A 3,533,195 Published 13 October                                                                           | 1,7                                 |
| <p><sup>6</sup> Special categories of cited documents: <sup>15</sup></p> <p>"A" document defining the general state of the art</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document cited for special reason other than those referred to in the other categories</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but on or after the priority date claimed</p> <p>"T" later document published on or after the international filing date or priority date and not in conflict with the application, but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance</p> |                                                                                                                |                                     |
| <b>IV. CERTIFICATION</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                |                                     |
| Date of the Actual Completion of the International Search <sup>2</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Date of Mailing of this International Search Report <sup>2</sup>                                               |                                     |
| 4 August 1981                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 18 AUG 1981                                                                                                    |                                     |
| International Searching Authority <sup>1</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Signature of Authorized Officer <sup>10</sup>                                                                  |                                     |
| ISA/US                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <i>W. R. Brijp</i>                                                                                             |                                     |

## FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

|   |                                                  |     |
|---|--------------------------------------------------|-----|
|   | 1970, Schumann Et Al.                            | 1,7 |
| A | US, A 4,125,057 Published 14 November 1978, Cox  | 1,7 |
| A | SU, A 582,920 Published 5 December 1977, Kadylin | 1,7 |

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE <sup>10</sup>

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers \_\_\_\_\_, because they relate to subject matter <sup>12</sup> not required to be searched by this Authority, namely:

2. ☐ Claim numbers \_\_\_\_\_, because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out <sup>13</sup>, specifically:

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING <sup>11</sup>

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

## Remark on Protest

- ☐ The additional search fees were accompanied by applicant's protest.  
☐ No protest accompanied the payment of additional search fees.