United States Patent

Yamanaka

[15] **3,665,648**

[45] **May 30, 1972**

[54] GRINDING APPARATUS

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[73] Assignee: **Yugen Kaisha Yamanaka Seisakusho,** Chigasaki-shi, Kanafawa-ken, Japan

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[30] **Foreign Application Priority Data**

Dec. 18, 1969 Japan.....44/101837

[52] **U.S. Cl.**.....**51/134,** 51/165.78

[51] **Int. Cl.**.....**B24b 17/00**

[58] **Field of Search**.....51/134, 165.77, 165.78

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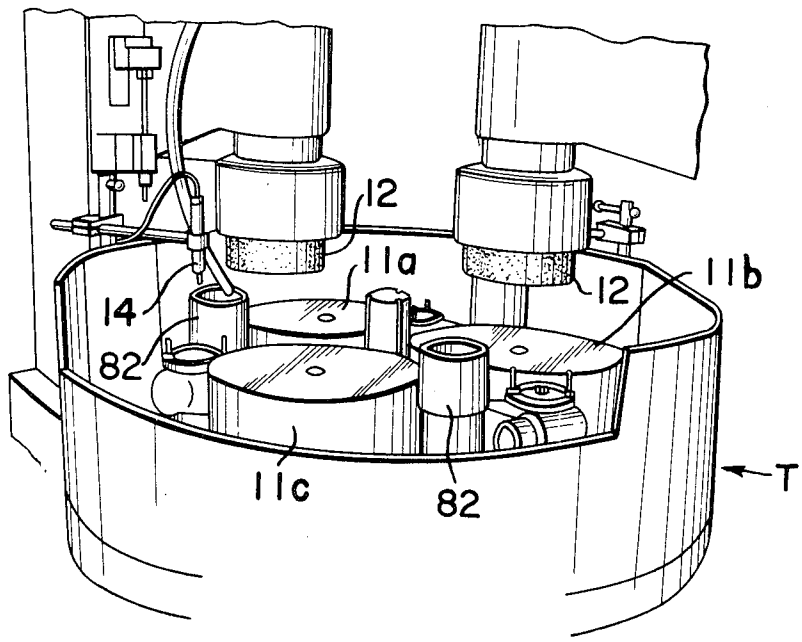
Primary Examiner—Harold D. Whitehead
Attorney—Stevens, Davis, Miller & Mosher

[57] **ABSTRACT**

A grinding apparatus which is so constructed that three workholders are rotatably mounted on a turn table in equally spaced relation peripherally of said turn table to be intermittently shifted from one to another of three positions consisting of an inoperative position and a first and second working positions. Two grinding mechanisms are arranged exterior of said turn table adjacent said first and second working positions respectively. The table is operative in such a manner that a workpiece mounted on one of said workholders in said inoperative position is carried thereon to said first working position where it is roughly ground and then to said second working position where it is subjected to a finishing grinding and then back to said inoperative position to be removed from the apparatus, the intermittent rotation of said turn table being controlled by a detecting device which detects the amount of the workpiece ground by way of a master which is ground concurrently with said workpiece.

7 Claims, 15 Drawing Figures



Patented May 30, 1972 3,665,648

9 Sheets-Sheet 1

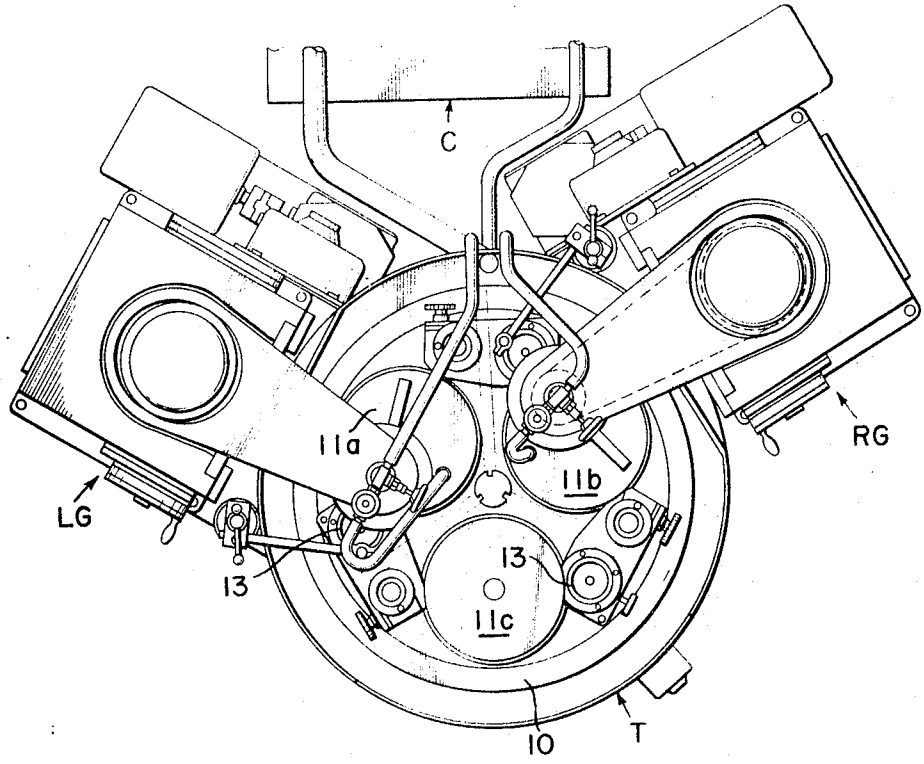


FIG. 1

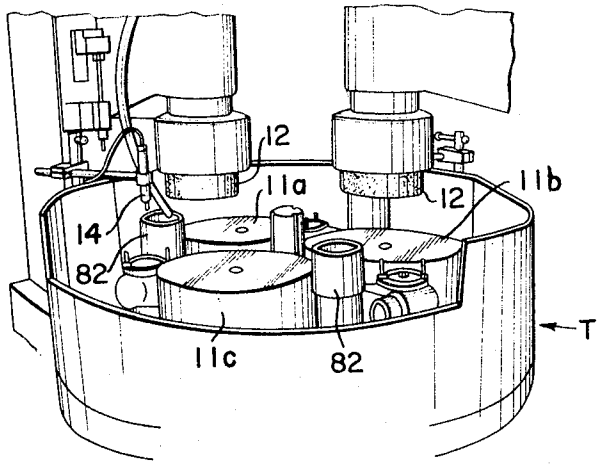


FIG. 2

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Stevens, Davis, Miller & Mosher
ATTORNEYS

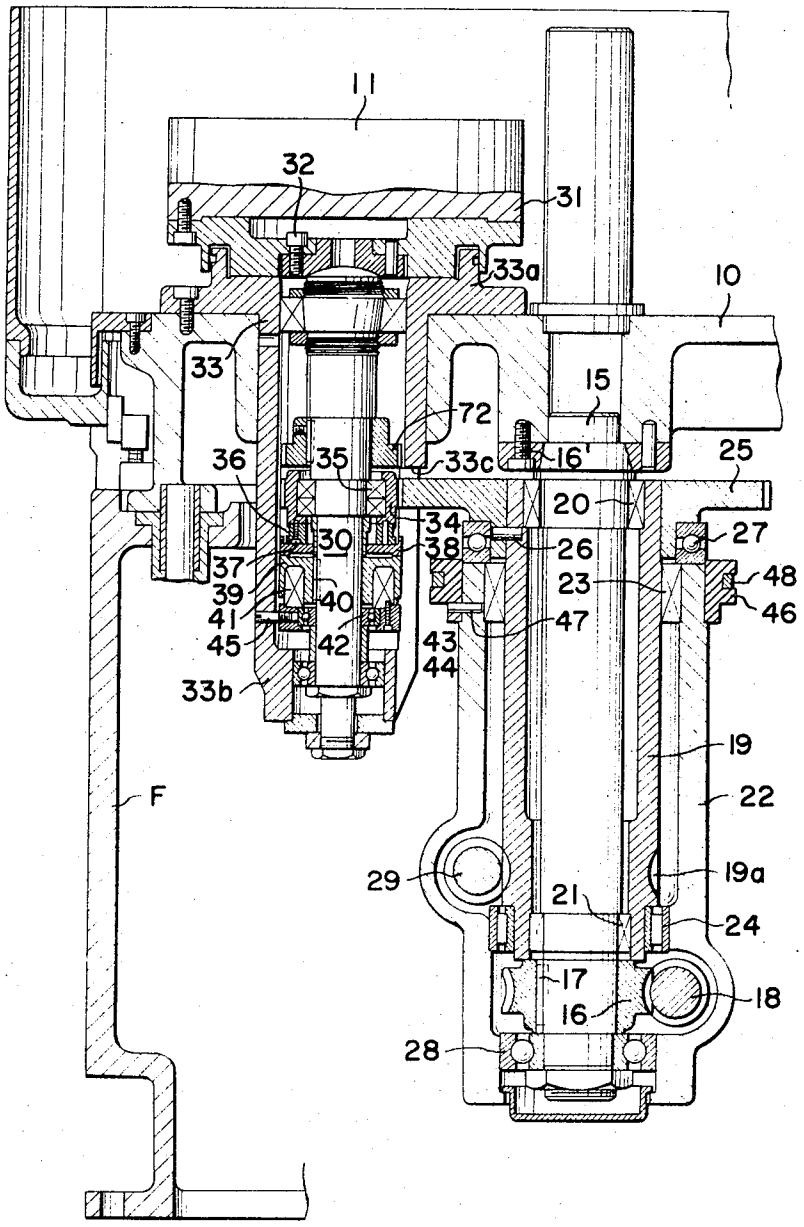
11
32
31
33a
10
33
15
72
36
35
33c
16'
25
20
34
30
38
26
27
37
48
39
40
23
41
47
46
45
42
43
44
33b
19
F
22
29
19a
21
24
17
18
16
28

FIG. 3

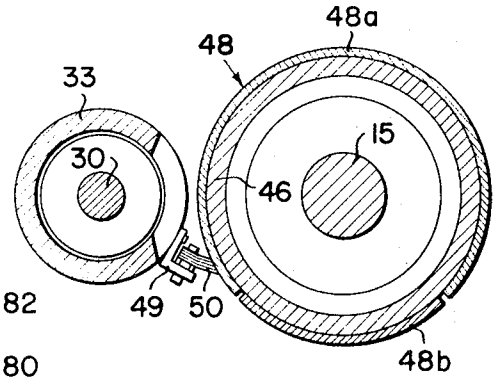

FIG. 4

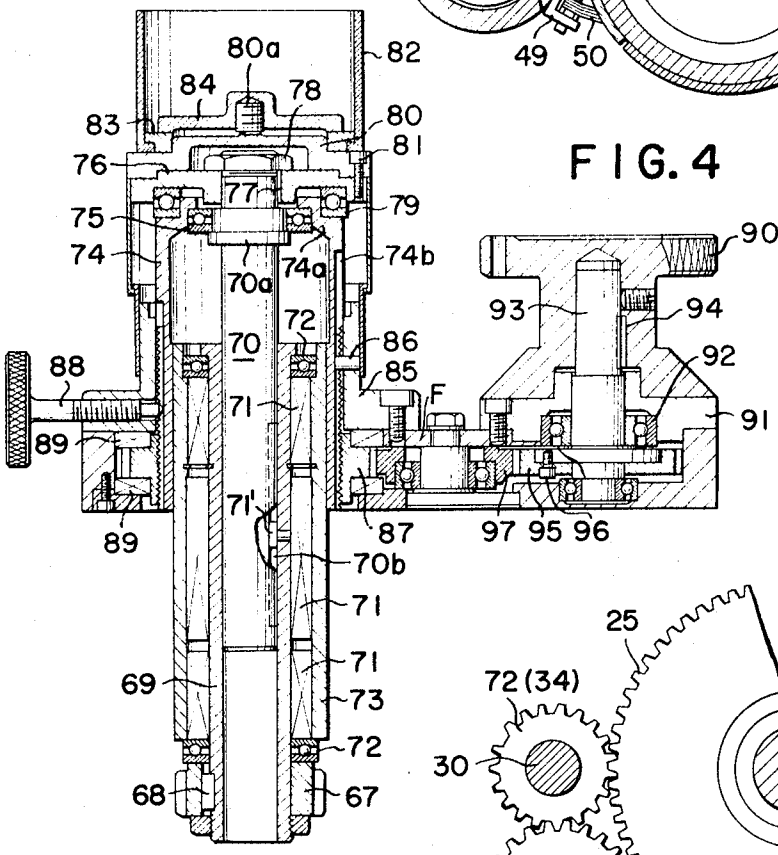

FIG. 6

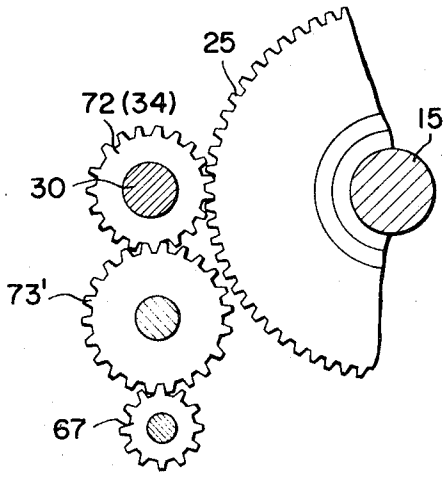

FIG. 7

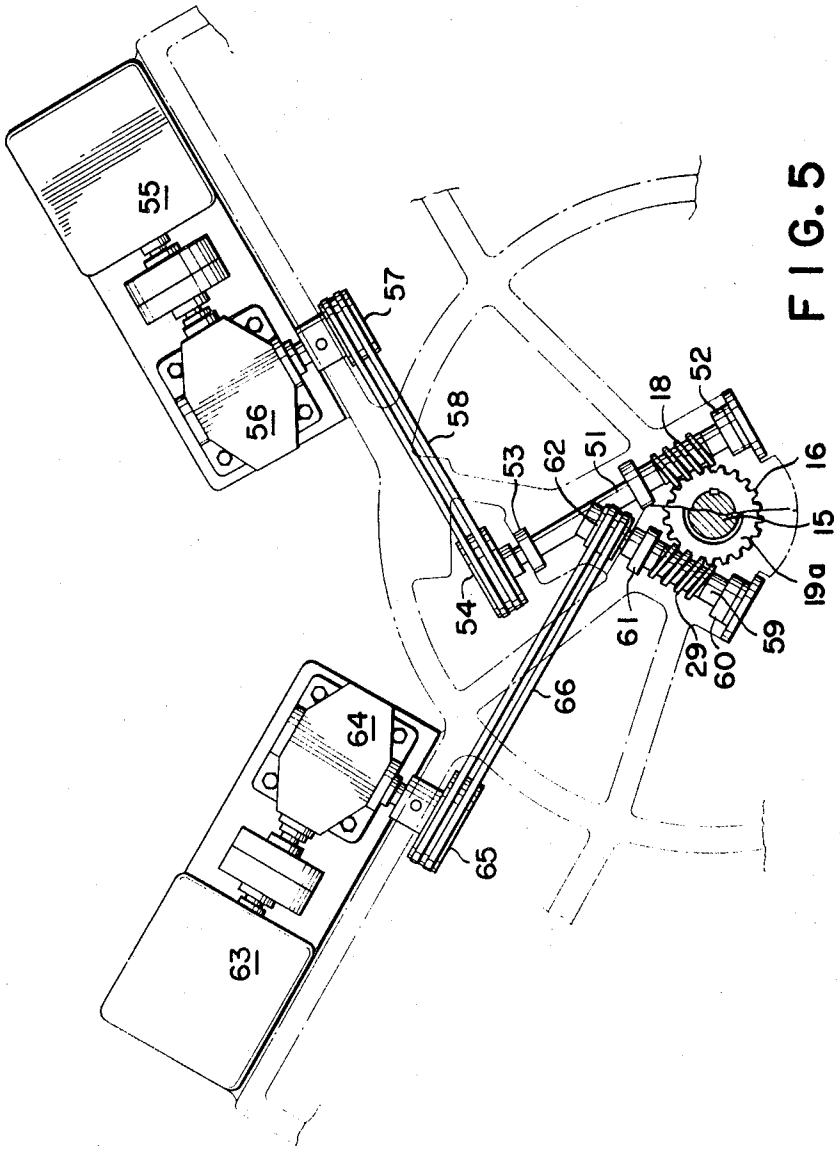

FIG. 5

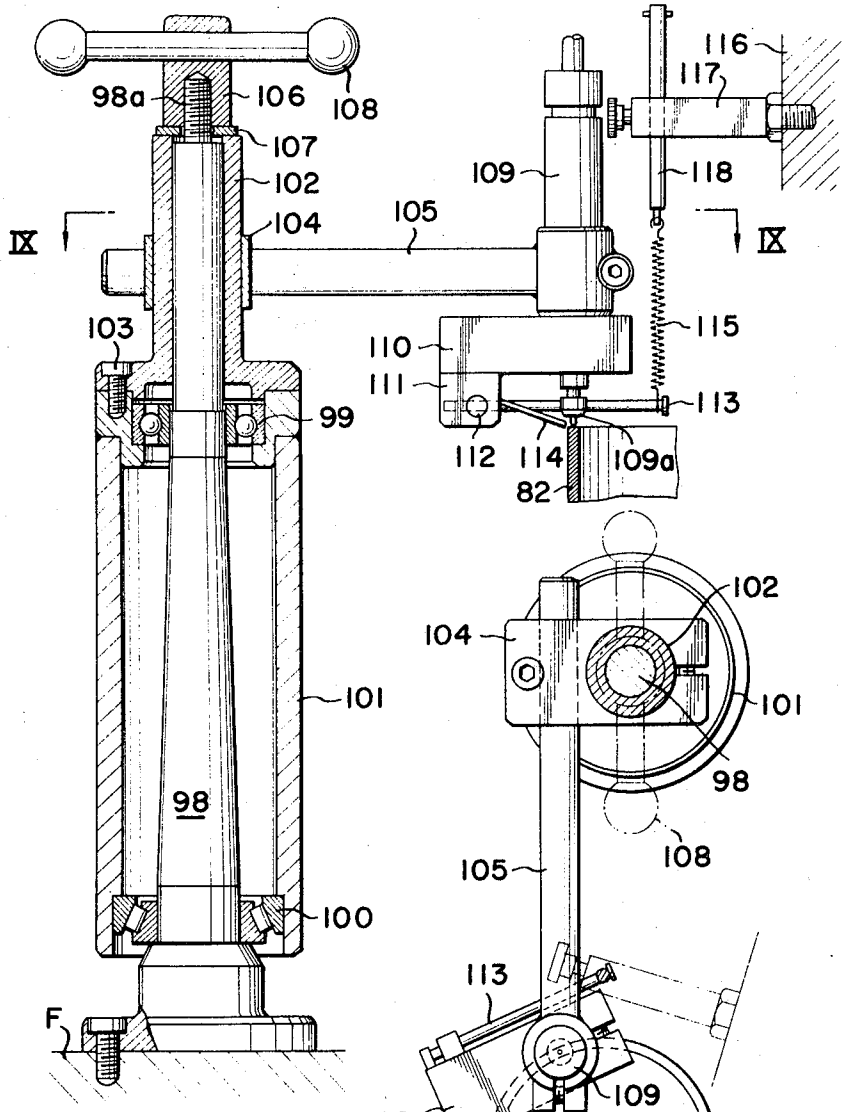
98a
106
108
107
102
104
105
116
117
109
118
IX
IX
103
115
110
111
113
99
112
114
109a
82
101
98
100
F

FIG. 8

102
104
101
98
108
105
113
109
110
82

FIG. 9

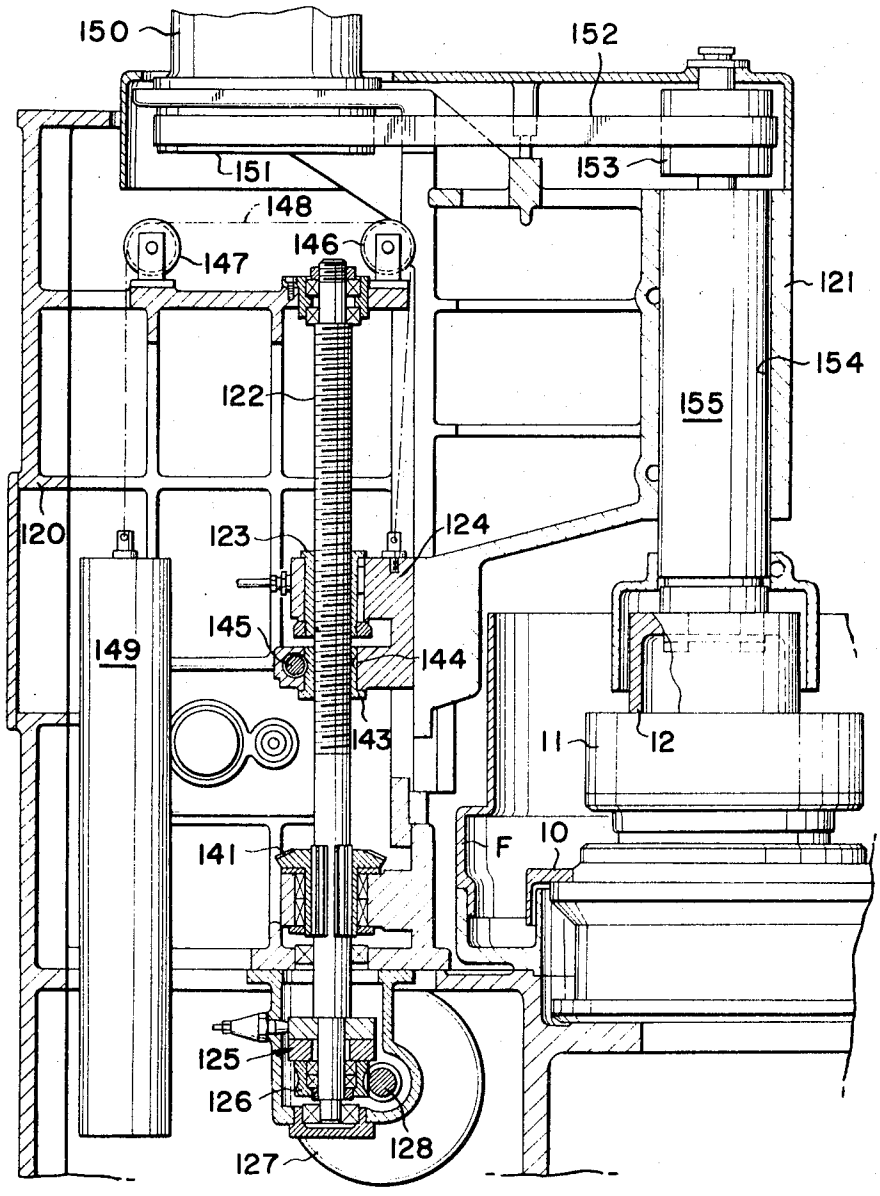
150
152
151
153
148
146
147
121
154
122
155
120
123
124
145
149
144
143
11
12
141
F
10
125
126
128
127

FIG. 12

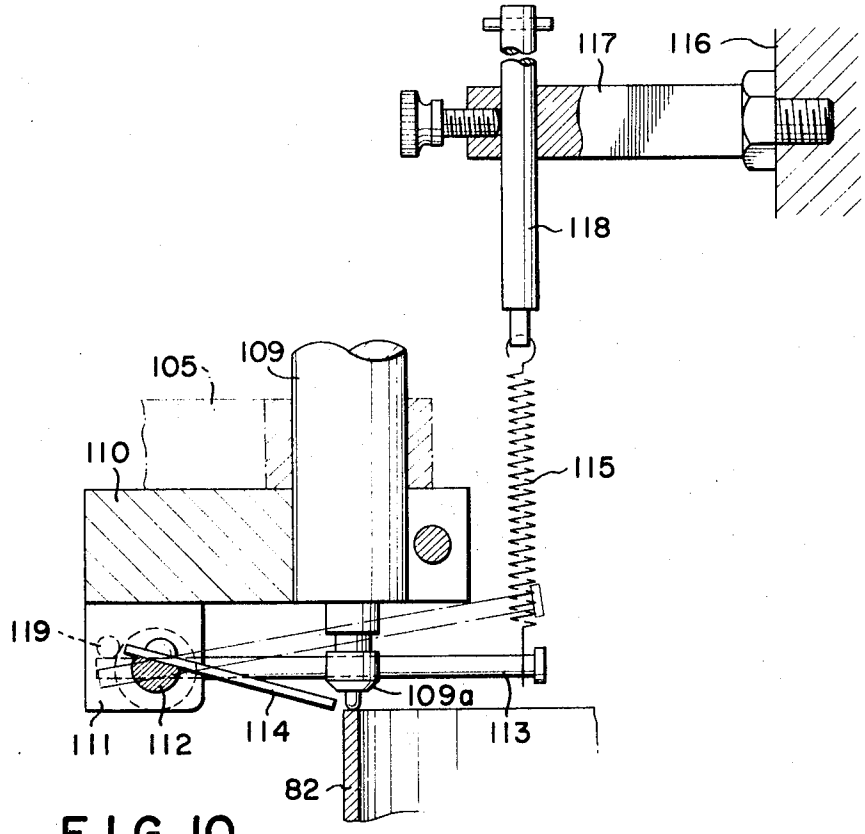
117
116
118
105
109
110
115
119
109a
111
112
114
113
82

FIG. 10

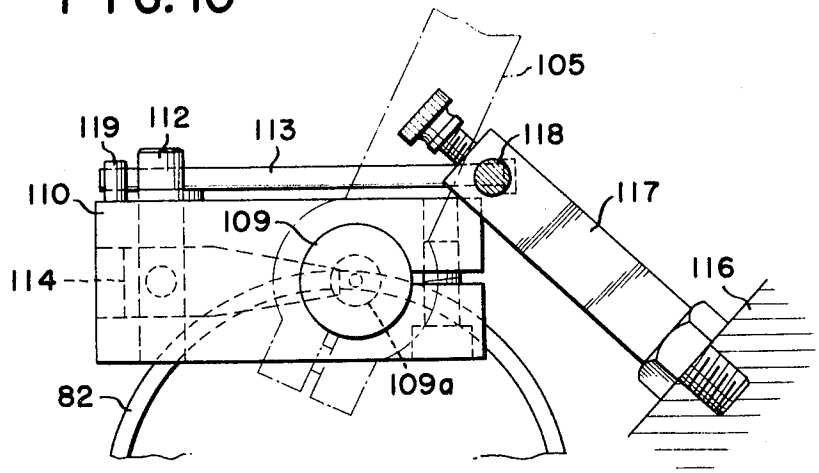
105
119
112
113
118
110
117
109
114
116
109a
82

FIG. 11

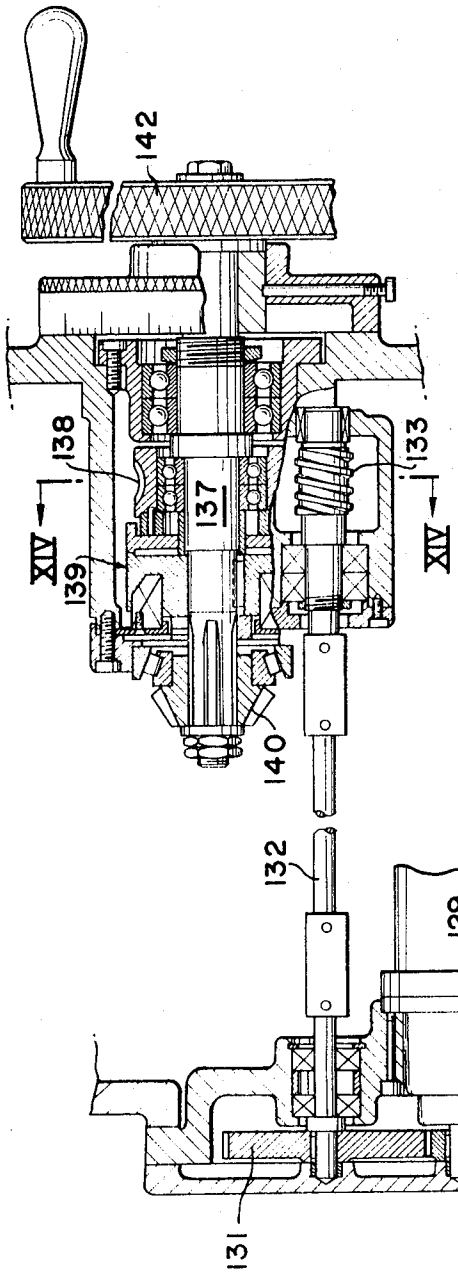
142
138
137
139
XIV
133
XIV
140
132
129
130
131

FIG. 13

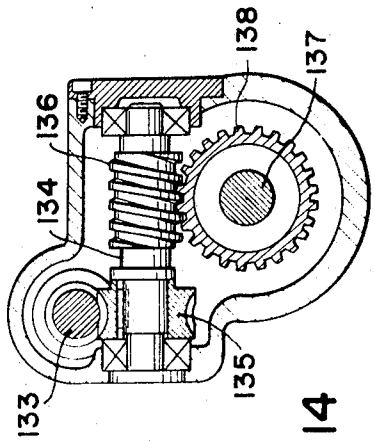
138
137
136
134
133
135

FIG. 14

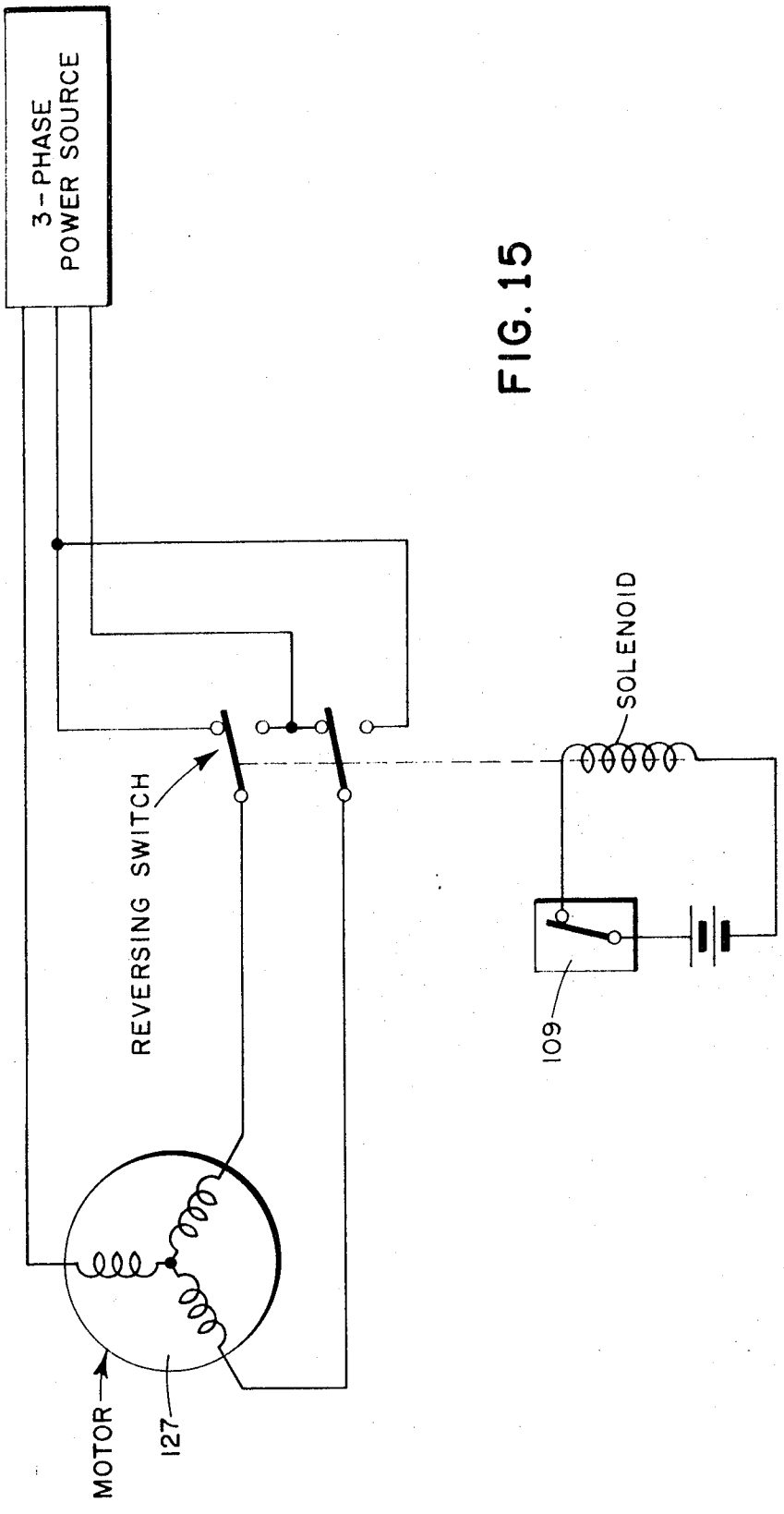
3-PHASE
POWER SOURCE
REVERSING SWITCH
SOLENOID
109
MOTOR
127

FIG. 15

GRINDING APPARATUS

The present invention relates to a grinding apparatus for a workpiece and has for its object the provision of such a grinding apparatus which is capable of grinding a workpiece more efficiently and finishing the same with higher accuracy than conventional apparatus.

An embodiment of the present invention will be described hereinafter with reference to the accompanying drawings, in which:

FIG. 1 is a plan view showing the overall arrangement of the grinding apparatus according to the present invention;

FIG. 2 is a perspective view of a portion of the apparatus;

FIG. 3 is a cross-sectional view of a turn table driving mechanism;

FIG. 4 is a plan view briefly showing the arrangement of a slip ring for controlling the rotation of a grinder;

FIG. 5 is a plan view showing the power transmitting arrangement of the turn table driving mechanism;

FIG. 6 is a cross-sectional view showing a master driving mechanism of a measuring device;

FIG. 7 is a plan view showing the arrangement the turn table, workholder and master driving mechanism;

FIG. 8 is a cross-sectional view of the measuring device;

FIG. 9 is a plan view of the measuring device looking in the direction of the line IX—IX of FIG. 8;

FIGS. 10 and 11 are a side view and a plan view respectively, showing in detail a portion of the measuring device;

FIG. 12 is a cross-sectional view of the entire grinding mechanism;

FIG. 13 is a cross-sectional view showing a driving device for the grinding mechanism; and

FIG. 14 is a cross-sectional view taken on the line XIV—XIV of FIG. 13.

FIG. 15 is a schematic wiring diagram of the control circuit of the measuring device.

OUTLINE OF THE APPARATUS

The apparatus of the instant invention comprises a turn table assembly T, a left hand grinding mechanism LG, a right hand grinding mechanism RG and a coolant supply mechanism C (FIG. 1). The turn table assembly T includes a turn table **10** rotatably arranged in a horizontal plane and three workholders **11** arranged in substantially the same direction as the turn table in equally spaced relation and rotatable relative to said turn table. The workholders **11** are made of a magnetic material and hold a workpiece (not shown) thereon under the magnetic force thereof. Two grinding mechanisms LR,RG are arranged in positions corresponding to two of the three workholders **11**, i.e. positions **11*a***, **11*b***. Each of the grinding mechanisms has a cup-shaped grinding wheel **12** supported in opposed relation to the upper surface of the workholder **11** (FIG. 2) and the grinding wheel is rotatably driven in contact with the workpiece, retained on the workholder **11** to grind said workpiece. The grinders **11** are rotatably driven when they are in the positions corresponding to the grinding mechanisms LG, RG, or in the working positions, and are held inoperative in the other position, i.e. the position indicated by **11*c*** in FIG. 1. The workpiece is mounted on the workholder while in the inoperative position **11*c*** and then the turn table **10** is rotated in a clockwise direction as viewed in FIG. 1 to place that workholder in a first working position indicated by **11*a***, where it is driven. At the same time, the grinding wheel **12** of the grinding mechanism LG is lowered to grind the workpiece. In the first working position, the workpiece is ground roughly. Then, the turn table is further rotated in a clockwise direction and the workpiece is brought to a second working position indicated by **11*b***, where it is subjected to a finishing grinding. Thereafter, the turn table **10** is further rotated in a clockwise direction and the grinder is shifted to the inoperative position indicated by **11*c***, where the finished workpiece is demounted from the workholder and a new workpiece is mounted on the workholder **11**.

In the apparatus of this invention, a measuring device or master **82** is provided adjacent each workholder **11**. This master **82** is a cylindrical body made of such a material, for example, as bakelite, and is driven in association with the workholder. In the grinding operation, the grinding wheel **12** in contact with the workpiece is also held in contact with the master **82** and grinds said it at the same rate as the workpiece. A detector element **109*a*** of an electric micrometer **109** is held in contact with the upper edge of the master **82** to detect the point when the master has been ground by a predetermined amount and thereby to control the interruption of the grinding operation and shifting of the workholder **11** to the next grinding step. Cooling water is supplied to the grinding portion from the cooling device C throughout the grinding operation.

Turn Table Assembly

The turn table **10** of the turn table assembly T is secured to a main vertical rotary shaft **15** at its center by means of a plurality of bolts **16'** (FIG. 3). A worm wheel **16** is fixedly mounted on the lower end of the main rotary shaft **15** as by key **17**, and a worm **18** is in meshing engagement with the worm wheel **16**. The main rotary shaft **15** is driven by the rotation of the worm **18**. A hollow cylindrical rotary sleeve **19** is provided concentrically around the lower portion of the main rotary shaft **15**, with the upper and lower ends thereof rotatably mounted on said main rotary shaft through bearings **20, 21** respectively. The exterior of the rotary sleeve **19** is surrounded by a hollow cylindrical fixed sleeve **22** which is secured to a frame F. The rotary sleeve **19** is rotatably supported on the fixed sleeve by bearings **23, 24**. A gear **25** is fixed to the upper end of the rotary sleeve **19** by a pin **26** and a bearing **27** is interposed between the underside of the gear **25** and the upper edge of the fixed sleeve **22**. Further, a bearing **28** is interposed between the lower end portion of the main rotary shaft **15** and the fixed sleeve **22**. A worm wheel **19a** is formed at the lower end portion of the rotary sleeve **19**, which is in meshing engagement with a worm **29**. The rotary sleeve **19** is rotated by the rotation of the worm **29**.

A work spindle **30** to drive the workholder **11** is arranged in parallel to the main rotary shaft **15** and spaced therefrom in the radial direction of the turn table **10**. A disc-shaped supporting plate **31** is fixed to the top end of the spindle **30** as by bolts **32** and rotatably supported by the upper surface of a spindle case **33**, fixed to the turn table **10**, and an annular projection **33*a*** formed thereon. The spindle case **33** has a cylindrical portion **33*b*** extending downwardly so as to surround the entire length of the spindle **30**. The cylindrical portion **33*b*** is formed therein with an opening **33*c*** on the side facing the main rotary shaft, through which the gear **25** extends into the spindle case **33**. On the spindle **30** is rotatably mounted by a bearing **35** a gear **34** which meshes with the gear **25**. A spline part **36** is fixed to the underside of the gear **34** by means of a bolt **37** and a clutch element **38** is in spline engagement with said spline part **36**. A clutch element **39** co-operating with the clutch element **38** is fixed to the spindle **30** by means of a key **40** and electromagnetic coil **41** is disposed within the clutch element **39**. The coil **41** is secured by means of a bolt **44** to an annular body **43** which is rotatably mounted on the spindle **30** through a bearing **42**. The annular body **43** is non-rotatably fixed to the spindle case **33** by means of a stop pin **45**. Therefore, when the coil **41** is excited, the clutch element **38** is attracted towards the clutch element **39** and brought into engagement therewith, so that the drive of the main rotary shaft is transmitted to the spindle **30** through the gear **34** and the clutch elements **38, 39**. As stated previously, the workholder **11** is made of a magnetic material and hence capable of holding the workpiece magnetically.

As shown in FIG. 3, an annular body **46** made of an insulating material is fixed to the outer surface of the fixed sleeve **22** as by a pin **47**, and a ring **48**, made of an electrically conductive material, is fitted around said annular body **46**. The ring **48**, as shown in FIG. 4 is split into a portion **48*a*** which extends along about three-fourths of the entire circumference of the annular body **46** and a position **48*b*** which extends along the remainder of said circumference. The portion **48*a*** is con-

nected to a power source through a conductor not shown. A brush **50** is fixed to the spindle case **33** by means of a bracket **49** as shown in FIG. **4**, which will slide on the ring **48** in contact therewith. The brush **50** is connected to the coil **41** through a suitable conductor (not shown). The arrangement is such that, when the brush **50** is in contact with the portion **48***a* of the ring **48**, the coil **41** is excited to drive the spindle **30**, whereas when the brush **50** is in contact with the portion **48***b* of said ring, the current supply to the coil **41** is interrupted and hence the spindle **30** stops rotating. The point where the brush **50** is brought into contact with the portion **48***b* of the ring **48**, corresponds to the inoperative position **11***c* of the workholder mentioned previously.

A mechanism for transmitting rotation to the worms **18** and **29** is shown in FIG. **5**. The shaft **51** of the worm **18** is horizontally and rotatably supported by a pair of bearings **52**, **53** and has a pulley **54** connected to one end thereof. A motor **55**, provided outside the column of the grinding mechanism RG to be described later, drives a pulley **57** through a reduction gear **56** and the drive of the motor **55** is transmitted to the worm shaft **51** through a belt **58** engaged around the pulley **57** and the aforesaid pulley **54**. The shaft **59** of the worm **29** is rotatably supported by a pair of bearings **60**, **61** and has a pulley **62** connected to one end thereof. A motor **63**, provided outside of the column of the grinding mechanism LG to be described later, drives a pulley **65** through a reduction gear **64** and the drive of the motor **63** is transmitted to the worm shaft **59** through a belt **66** engaged around the pulley **65** and the aforesaid pulley **62**. The motor **55** is operated by an instruction from the measuring device **109** as will be described later, and set in motion when the workpiece has been ground to a predetermined dimension, to cause rotation of the turn table **10**. An index means may be provided as required, to determine the position of the table **10**.

Measuring Device

A master **82** is provided adjacent each workholder **11**. As shown in FIG. **6**, its drive includes a hollow cylindrical drive shaft **69** having a gear **67** fixed on the lower end thereof by a key **68**, and a center shaft **70** extending through the axial bore of said drive shaft **69**. The center shaft **70** and the drive shaft **69** are combined by a key groove **70***b* and a key **71'** slidably received in said key groove, in such a manner that they are longitudinally slidable relative to each other but rotate all together. As shown in FIG. **3**, a gear **72'** is fixedly mounted on the spindle **30** above the gear **34**, and this gear **72'** turns with the aforesaid gear **67** through an intermediate gear **73'** (FIG. **7**). Therefore, when the spindle **30** is driven, the drive shaft **69** and the center shaft **70** of the measuring device **13** are driven concurrently. Exterior of the drive shaft there is provided an inner sleeve **73** through a roller bearing **71** and a ball bearing **72**, and an outer sleeve **74** is axially slidably provided around the inner sleeve **73**. The sleeve **74** is formed with an inward flange **74***a* at the upper end thereof and a bearing **75** is interposed between said flange **74***a* and an annular flange **70***a* formed on the center shaft **70** adjacent the upper end thereof. A support disc **76** is connected to the upper end of the center shaft **70** by a key **77** and fixed thereto by means of a nut **78**, for rotation therewith. A bearing **79** is interposed between the support disc **76** and the upper end of the outer sleeve **74**. A master supporting member **80** is fixed on top of the support disc **76** by means of a bolt **81** and a cylindrical master **82** is fixed on top of the master supporting member **80** by a retainer ring **83** and a cap **84**. The cap **84** is secured to the master supporting member **80** through threadable engagement between it and an externally threaded stud **80***a* provided centrally of the upper surface of the master supporting member **80**. The master **82** is preferably made of such a material as bakelike. When the gear **67** is driven, the master supporting assembly constructed as described above is rotated, with the drive shaft **69**, the center shaft **70**, the support disc **76**, the master supporting member **80**, the master **82**, the retainer ring **83** and the cap **84** as an integral unit.

The master supporting assembly described above is supported by axially slidably fitting the outer sleeve **74** in a supporting bracket **85** which is fixed to the frame F. The outer sleeve **74** is formed with a axial key groove **74b** in the outer peripheral surface thereof, and a key **86** fixed to the bracket **85** is received in said key groove. Further, external threads are formed in the lower portion of the outer peripheral of the outer sleeve **74** and a gear **87** is mounted on said outer sleeve, with internal threads of the former in engagement with said external threads of the latter. Therefore, when the gear **87** is rotated, the outer sleeve **74** and hence the master **82** is elevated. A lock screw **88** is extended horizontally through the wall of the supporting bracket **85**, with the inner end thereof engaging the external threads on the outer surface of the outer sleeve **74** to lock the vertical position of said outer sleeve. The gear **87** is rotatably supported by bearings **89** provided on the upper and lower surfaces thereof and can be rotated by a mechanism including a manual adjusting wheel **90**. The manual adjusting wheel **90** is fixed on a vertical shaft **93** by means of a key **94**, which vertical shaft **93** is supported by a supporting plate **91**, fixed to the frame F, through a bearing **92**. The vertical shaft **93** has a gear **95** fixedly mounted on the lower end thereof by a bolt **96**, and the gear **95** is meshing with the gear **97** through an intermediate gear **97**.

Detector Assembly

The detector assembly is provided in combination with each one of the left and right hand grinding mechanisms LG, RG. As shown in FIG. **1**, each detector assembly includes a vertical post **98** (FIG. **8**) fixed to the frame F exterior of the turn table, and a cylindrical housing **101** is rotatably mounted on the vertical post **98** to surround the same, through bearings **99**, **100**. A supporting cylinder **102** is fixed to the upper end of the cylindrical housing **101** by a bolt **103**, and an arm **105** is connected to the outer surface of said supporting cylinder **102** through a bracket **104**. The post **98** extends through the supporting cylinder **102**, and a lock screw **106** is mounted on a threaded portion **98***a* at the top end thereof. The lower surface of the lock screw **106** acts on the upper edge of the supporting cylinder **102** through a washer **107**, to hold the housing **101** and the supporting cylinder **102** against rotation. A handle **108** is provided on the lock screw **106** and, by loosening the lock screw **106** by said handle, the housing **101** and the supporting cylinder **102** are rendered rotatable relative to the post **98**.

The arm **105** has a detector such, for example, as an electric micrometer **109** fixed to one end thereof, and a detector operating bracket **110** is fixed to the detector **109** below the arm **105**. The bracket **110** is formed with a flange extending downwardly from one end thereof and a horizontal shaft **112** is rotatably fitted to said flange. A lever **113** and a lift plate **114** are connected to one end and the central portion of the horizontal shaft **112** respectively. A tension spring **115** has its lower end anchored to one end of the lever **113**, with the upper end thereof anchored to a rod **118** which is connected to a vertically movable head **116** of the grinding mechanism to be described later, through a bracket **117** in such a manner that the vertical position thereof may be adjusted. The free end of the lift plate **114** is located beneath the lower surface of a movable portion **109***a* of the micrometer **109**. Thus, when the vertically movable head **116** moves upwardly, the free end of the lift plate **114** is elevated, pushing the movable portion **109***a* of the micrometer **109**, so that the movement of the master **82** will not interfer with micrometer **109** during rotation of the turn table. The head **116** is lowered in the grinding operation and, therefore, the lift plate **114** is held away from the micrometer **109** as shown in FIG. **10**. Reference numeral **119** designates a stop pin to define the lowered position of the lever **113** and hence of the lift plate **114**. During the grinding operation, the tip end of a detecting needle of the micrometer rests on the upper surface of the master **82**, to detect the amount of the master and, therefore, the amount of the workpiece which has been cut.

Grinding Mechanism

The apparatus of the instant invention is provided with two grinding mechanisms LG, RG but, since both grinding mechanisms are identical in construction, only one of them will be described herein with reference to FIGS. 12, 13 and 14.

The grinding mechanism includes a head member 121 vertically slidably mounted in a column 120 fixed to the frame F, and a nut member 123 is fixed on the head member 121 by a bracket 124. The nut member 123 is in threadable engagement with a threaded drive shaft 122 vertically rotatably extending through the column 120. It will, therefore, be seen that the head member 121 can be moved vertically by rotating the threaded drive shaft 122. The shaft 122 is driven at two different speeds, i.e., a high speed and a low speed, by two systems, i.e. a quick feed feed mechanism and a grinding feed mechanism, respectively. The quick feed mechanism consists of a worm wheel 126 which is rotatably mounted on the lower end of a shaft 122 and coupled therewith by an electromagnetic clutch 125, and a worm 128 which is mounted on the output shaft of a motor 127 and adapted to engage said worm wheel 126. The grinding feed mechanism includes a grinding feed motor 129 (FIG. 13). The output shaft of the motor 129 is connected to a shaft 132 through gears 130, 131. The shaft 132 has a worm 133 formed at one end thereof, which meshes with the worm wheel 135 on an intermediate shaft 134 (FIG. 14). Intermediate shaft 134 has a worm 136 which meshes with a worm wheel 138 on a shaft 137. The worm wheel 138 is rotatably mounted on the shaft 137 and coupled therewith by an electromagnetic clutch 139. On one end of the shaft 137 is fixedly mounted a bevel gear 140 which meshes with a bevel gear 141 fixedly mounted on the shaft 122. Thus, when the clutch 139 is excited, with the motor 129 in motion, the shaft 122 is driven at the low speed, that is, the grinding feed speed. Further, a handle 142 is provided at the outer end of the shaft 137. By rotating the handle 142, the head member can be manually moved up and down. Further, on the bracket 124 supporting the nut 123 a second nut 143 is provided which is in threadable engagement with the shaft 122, and a worm wheel 144 is formed on the outer periphery of said nut 143, which meshes with an adjusting worm 145. Thus, it will be understood that, by rotating the adjusting nut 145, the nut 143 is rotated and the back-lash between the first nut 123 and the threads of the shaft 122 can be eliminated by the slight rotation of said nut 143. A balance weight 149 is provided on the head member 121 by means of a wire 148 which is engaged around pulleys 146, 147 provided on the column 120.

A motor 150 is fixed on the upper surface of the head member 121 and a pulley 151 is mounted on the output shaft of said motor. The pulley 151 is operatively connected with a pulley 153 through a belt 152, which pulley 153 is fixed on the upper end of a rotary shaft 155 rotatably received in a cylindrical vertical bore formed in the head member 121. The cup-shaped grinding wheel 12 is fixed to the lower end of the rotary shaft 155 by a suitable means. The grinding wheel 12 is positioned above the workholder 11 and the master 82 of the measuring device in the working position. Therefore, when the motor 150 is set in motion, the grinding wheel 12 is rotated at the grinding speed, whereby the workpiece on the workholder 11 can be ground.

Operation

In operating the apparatus of the present invention, a workpiece is mounted on the workholder in an inoperative position 11c, which is capable of holding the metallic workpiece thereon as it is made of a magnetic material. Here, the turn table 10 is turned in a clockwise direction as viewed in FIG. 1 and the workholder 11, with the workpiece mounted thereon, is shifted to below the grinding wheel 12 of the grinding mechanism LG, that is, the first working position. Immediately before reaching the first working position the workholder 11 is caused to rotate by the mechanism described previously with reference to FIGS. 3 and 4. When the workholder 11 has reached the first working position, the rotation of the turn table 10 is stopped and the head member 121 of the grinding mechanism LG is lowered and the grinding wheel 12 is brought into contact with the workpiece to grind the same.

The head member 121 is lowered in two steps. Namely, the head member is lowered by the motor 127 at a relatively high speed until immediately before the grinding wheel 12 contacts the workpiece and then is lowered by the motor 129 at a relatively low speed as a result of the electromagnetic clutch 125 being demagnetized and the electromagnetic clutch 139 being excited. As stated previously, the grinding wheel 12 grinds the workpiece and the master 82 of the measuring device concurrently. The amount of the master 82 ground is detected by the detecting device and, when the amount has reached to a predetermined value, the shaft 122 is driven in a reverse direction in response to an electric signal from the electric micrometer of the detecting device, to lift the head member 122. The control circuit to accomplish this reverse direction is shown in FIG. 15. When the master is sufficiently ground, a microswitch in micrometer 109 closes, actuating a solenoid which in turn actuates a reversing switch feeding motor 127. After the head is lifted, the turn table 10 is rotated and the workholder 11 is shifted to the second working position, i.e. a position corresponding to the grinding mechanism RG, with the roughly ground workpiece thereon, where the workpiece is subjected to a finishing grinding.

The apparatus of the invention is particularly adapted for use in grinding a number of small-sized workpieces on the grinder. In a case where it is impossible to measure the amount of the workpiece ground by contacting the electric micrometer directly with the workpiece, this problem can be solved by providing a master separate from the workpiece. In addition, the grinding is effected in two stages, i.e. by a rough grinding operation and a finishing grinding operation, and these grinding operations can be carried out concurrently by two grinders. Yet further, in the process of the grinding operations, the finished workpiece can be removed from and a new workpiece can be mounted on the workholder which is located in an inoperative position. Thus, the grinding operation can be carried out in a highly efficient manner.

I claim:

1. A grinding apparatus comprising a frame, a turn table rotatably mounted on said frame, three disc-shaped workholders rotatably mounted on said turn table in equally spaced peripheral relation on said turn table, two grinding mechanisms arranged exterior of said turn table in spaced relation from said turn table, means for rotating said turn table intermittently in such a manner that one of said workholders may be held stationary in position corresponding to one of said grinding mechanisms and another one in a position corresponding to the other grinding mechanism, means for rotating each one of said workholders in a path of movement from the position corresponding to one of said grinding mechanisms to the position corresponding to the other grinding mechanism and holding it stationary in the other position, a master provided adjacent each of said workholders and operatively connected to said workholder to be rotated thereby, each of said grinding mechanisms including a grinding wheel arranged to grind a workpiece on the workholder and said master concurrently, and means for detecting the amount of said master ground by said grinding wheel and emitting a signal to stop the grinding operation.

2. The apparatus of claim 1 including magnetic means associated with said workholders to retain the workpiece thereon.

3. The apparatus of claim 1 in which the turn table is circular and the workholders follow an arcuate path in movement from one position to the next.

4. The apparatus of claim 3 in which said turn table is horizontal and said grinding mechanisms are located vertically above the turn table.

5. The apparatus of claim 1 including means to move said grinding wheels in a rotary direction in a plane parallel to said workholders.

6. The apparatus of claim 5 in which the grinding wheels are cup-shaped.

7. The apparatus of claim 1 including a two speed means for moving the grinding mechanism toward the workpiece with a high speed for setting up operation and a low speed for grinding.

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