

April 6, 1954

M. MARTELOTTI
CONTOURING MACHINE

2,674,160

Filed March 7, 1952

8 Sheets-Sheet 1

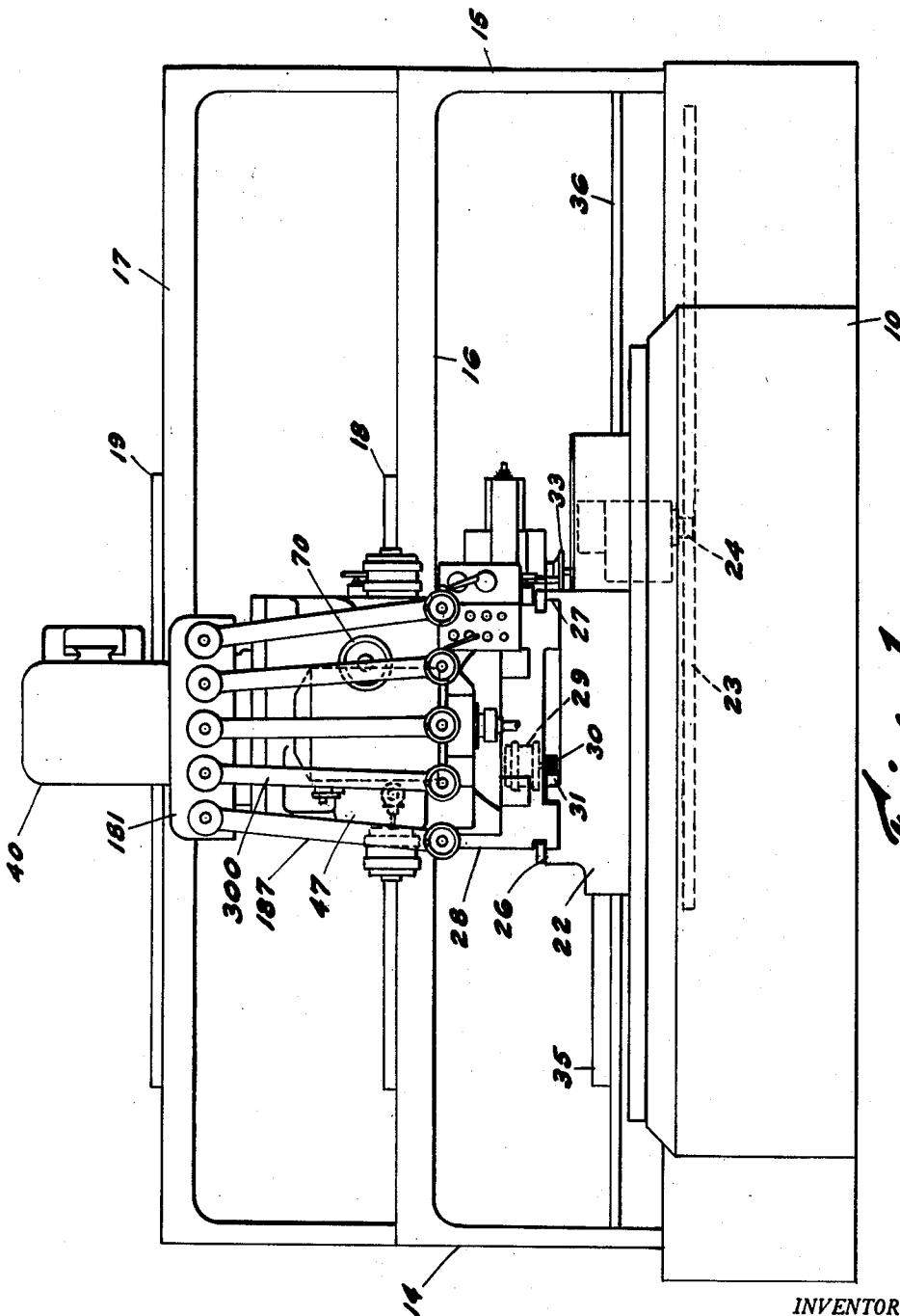


Fig. 1.

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8 Sheets-Sheet 2

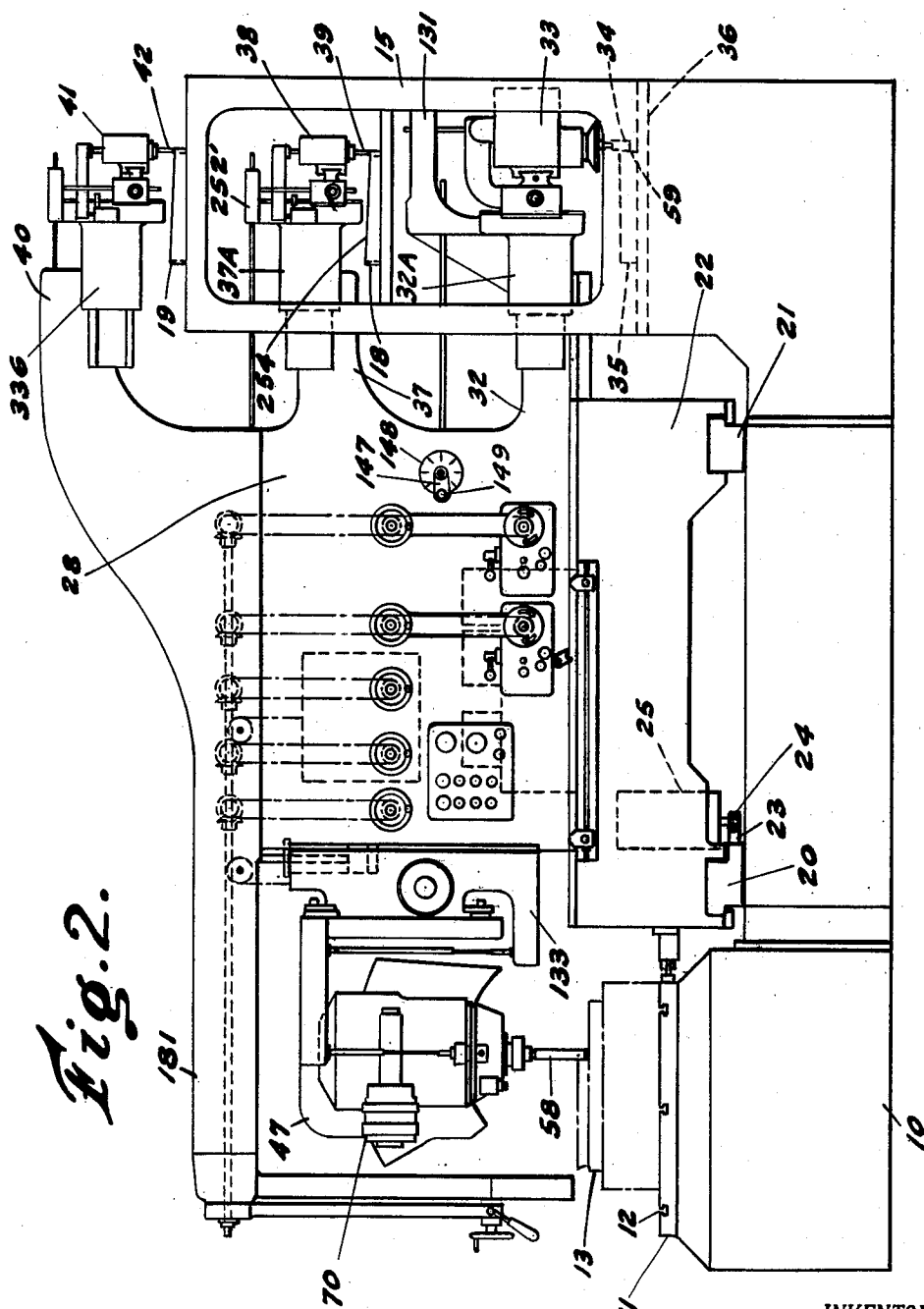


Fig. 2.

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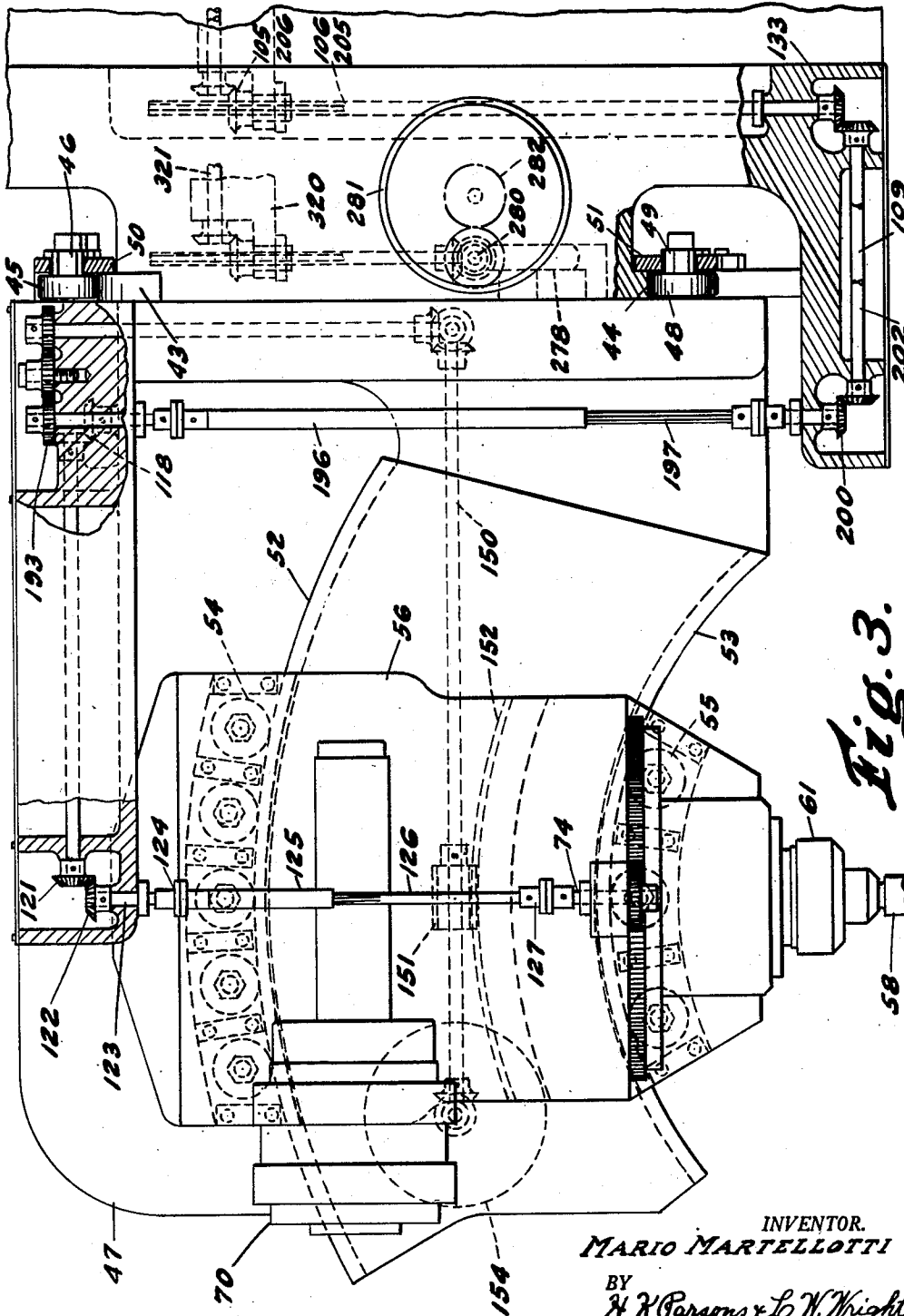
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8 Sheets-Sheet 3



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8 Sheets-Sheet 4

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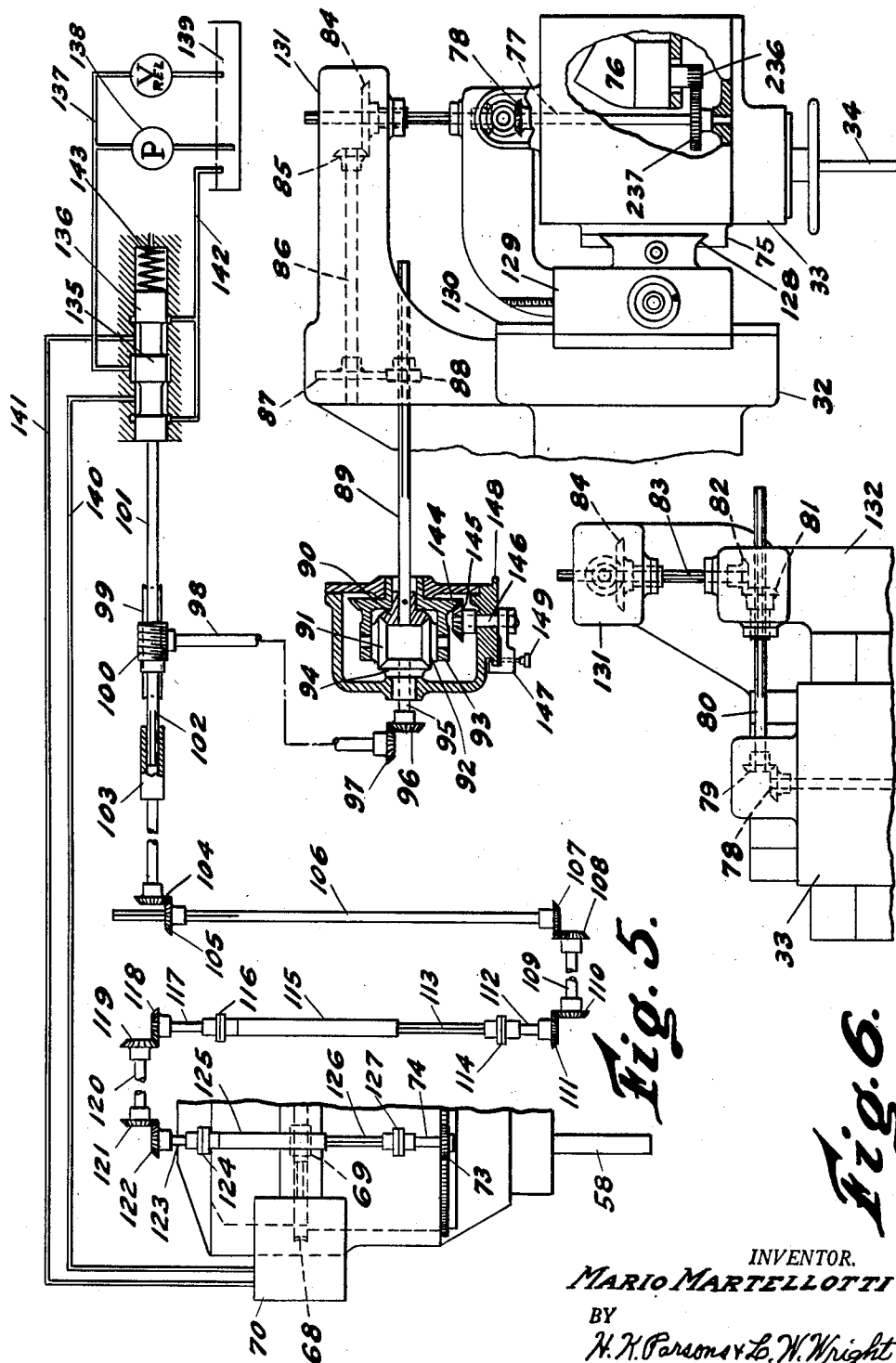
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8 Sheets-Sheet 5



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8 Sheets-Sheet 6

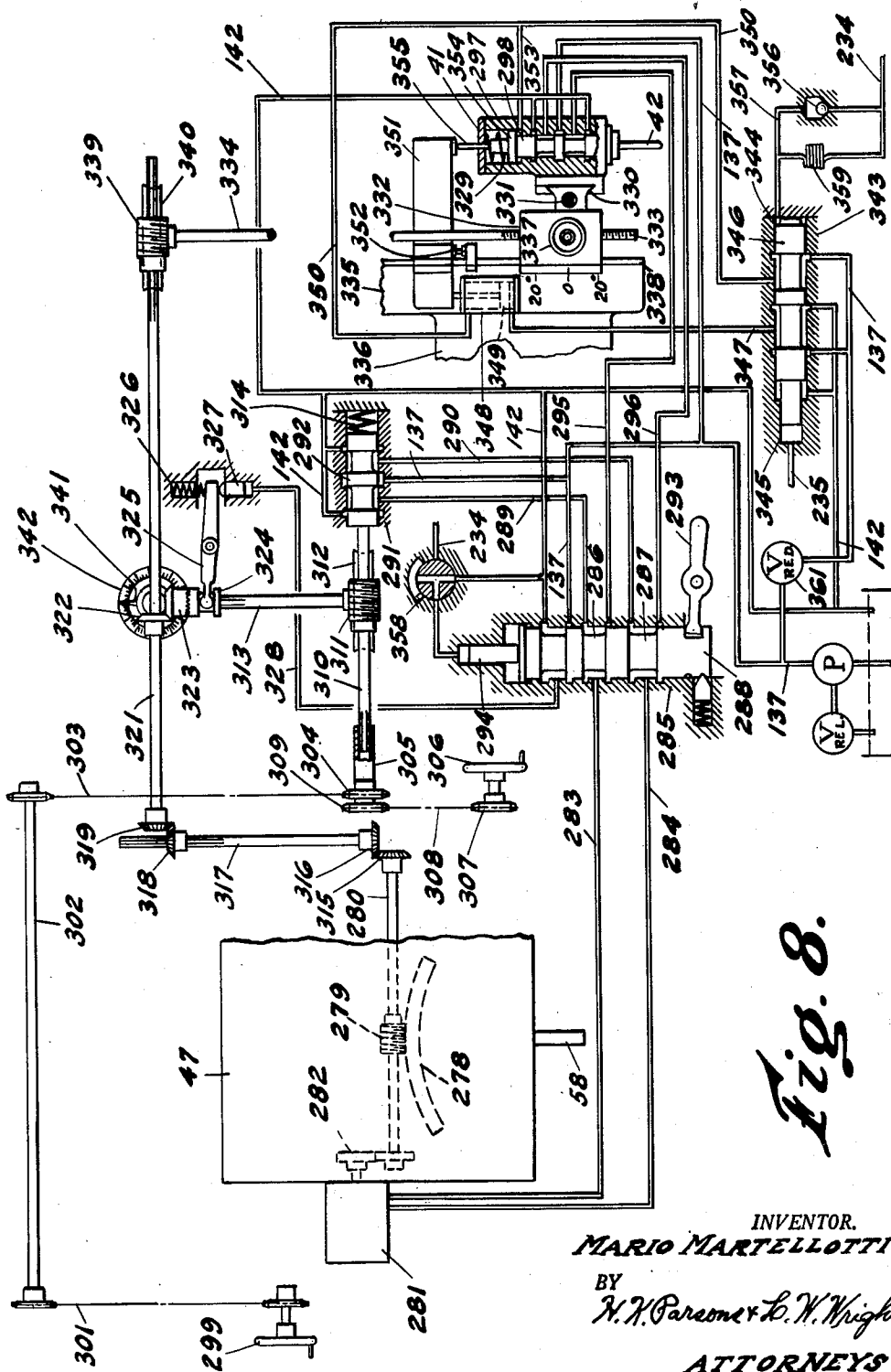
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2,674,160

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8 Sheets-Sheet 8

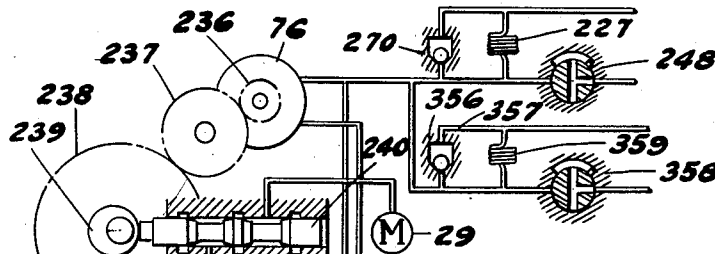


Fig. 9.

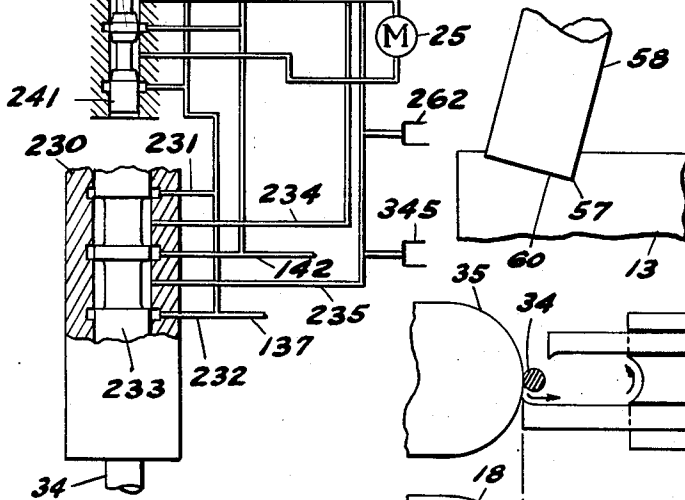


Fig. 10.

Fig. 11.

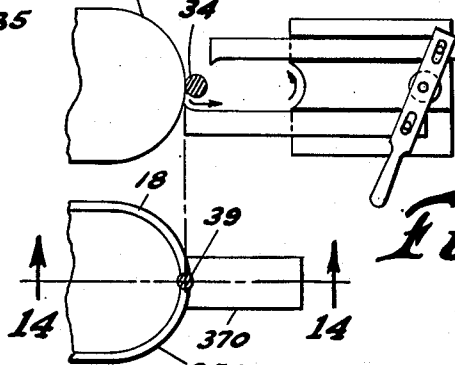


Fig. 13.

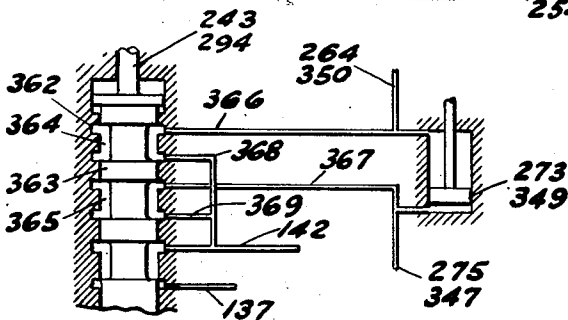


Fig. 12.

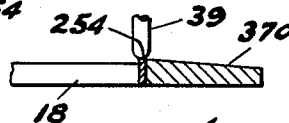


Fig. 14.

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UNITED STATES PATENT OFFICE

2,674,160

CONTOURING MACHINE

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Application March 7, 1952, Serial No. 275,307

18 Claims. (Cl. 90—13.5)

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This invention relates to improvements in contouring machines and has particular reference to an improved machine for automatic rapid production of contoured surfaces and varying angle contours by milling, grinding, or like machine operations, whose use will facilitate utilization of forgings and large one-piece sections rather than riveted or otherwise fabricated parts in the manufacture of airplanes or like structures.

One of the principal objects of the present invention is the provision of a contouring machine particularly adapted for the production of variable pitch walls or surfaces of prescribed curved outline or automatically variably outlined and surfaces as respects the traversing plane of the cutting tool.

A further object of the invention is the provision of a machine in which the variable angular relations between tools and work may be controlled by simple templates, thus eliminating the necessity for production and utilization of replica patterns.

Additional objects of the present invention are the provision of improved control mechanism for accurate production of variable surfaces irrespective of the relative effective radii of the cutter and the tracer contactor; of a contouring machine alternatively employable for a complete automatic or semi-automatic operations in either reproduction or initial generative forming of parts and of a control mechanism for accurate manufacture of large work which will be equally efficient in production of corresponding work surfaces on work pieces of varying heights.

Other objects and advantages of the present invention should be readily apparent by reference to the following specification, considered in conjunction with the accompanying drawings forming a part thereof, and it is to be understood that any modifications may be made in the exact structural details there shown and described, within the scope of the appended claims, without departing from or exceeding the spirit of the invention.

Figure 1 is a front elevation of an embodiment of the present invention.

Figure 2 is an end elevation.

Figure 3 is an enlarged view of the cutter head supporting arm and associate part.

Figure 4 is a vertical section through the cutter head and associate parts.

Figure 5 is a diagrammatic view of the control mechanism for determining the rotary movement of the cutter head.

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Figure 6 is a fragmentary view of a portion of the feed back train.

Figure 7 is a diagrammatic view of the mechanism for controlling angular movement of the cutter head with respect to its supporting arm.

Figure 8 is a similar view of the mechanism for controlling the angular movement of the cutter head arm as respects its supporting ram.

Figures 9 and 10 show the relationship of cutter and work respectively in peripheral and surface machining operations.

Figure 11 is a diagrammatic view of a portion of the hydraulic slide control circuits of the machine.

Figure 12 is a diagrammatic view of the centralizer control circuit.

Figure 13 is an expanded view showing the relationship of the contour and angle control tracers to their respective patterns, and

Figure 14 is a section on the line 14—14 of Figure 13.

In the drawings the numeral 10 designates the bed of the machine provided at the front with the work supporting table portion 11 having T slots 12 for securing bolts to retain work piece 13 in suitable machining position on the bed. At the rear the bed is provided with the end frames 14 and 15 connected by the beams 16 and 17. Beam 16 provides a support for a template pattern, such as 18, for determining the angular positioning of the head while the beam 17 provides a support for the template 19 to determine the angular positioning of the cutter supporting arm.

Intermediately, the bed is formed with the longitudinal extending ways 20 and 21 which support the saddle 22 for longitudinal reciprocatory movement with respect to the bed 10. As shown, the bed 10 is provided with a rack 23 engaged by pinion 24 on the shaft of the hydraulic motor 25 mounted on saddle 22. Actuation of pinion 24 by motor 25 controls the longitudinal positioning of saddle 22 with respect to the bed.

Saddle 22 is formed with the transverse ways 26 and 27 for the support or ram 28. The ram is, in turn, provided with hydraulic motor 29 for actuation of pinion 30 meshing with rack 31 on the saddle 22 to determine the in and out or forward and back movement of the ram as respects the saddle. Ram 28 has a first rearwardly extending arm 32 supporting the tracer mechanism designated as an entirety by the numeral 33 which includes the tracer finger or stylus 34 properly engaging the pattern 35 carried by the table portion 36 at the rear of the bed 10. Ram 28 has an additional rearwardly extending arm 37 bearing

the tracer unit 38 having a depending stylus 39 for engagement with the template pattern 18 and a third arm 40 supporting the tracer unit 41 having the depending stylus 42 for cooperative engagement with the template or pattern 19.

By the superimposed relationship thus illustrated, the several tracer contactors 34, 39, and 42 may be positioned with their pattern contacting portions in substantial alignment one with the other for corresponding positional engagement with their respective controlling patterns or templates facilitating determination of the various reactions effectable by the several control mechanisms at any point during the cycle of operation of the machine, thus facilitating adjustment for modification of tracer unit or template positions or effects as respects any point of the surface being produced on the work piece.

The front of the ram supports for movement therewith as a part thereof the vertically adjustable slide 133 which is provided with an upper convex arcuate track or way 43 and a lower concentric concave track or guideway 44, which ways together support the cutter arm or primary tilting support 47 for arcuate oscillatory movement in a plane parallel to the axis of reciprocatory movement of the saddle 22. Such free oscillatory movement is facilitated by the upper series of anti-friction rolls 45 mounted for adjustment on eccentric bushings on studs 46 carried by the arm 47, and the lower series of anti-friction rolls 48 mounted on the studs 49 similarly carried by the arm 47. The retaining plates 50 and 51 engaging the rear faces of the arcuate track flanges hold the parts securely together in a unitary manner.

The arm structure 47 is, in turn, provided with the convex trackway 52 and concave trackway 53 engaged respectively by the anti-friction rolls 54 and 55 mounted for adjustment on eccentric bushings carried by the head 56. These rolls mount the head or second angularly adjustable support 56 for tilting or angular adjustment in a plane at right angles to the plane in which the arm or support 47 is tilted. Particular attention is invited to the fact that the intersection of the axes of the arcuate ways 43, 44 and the arcuate ways 52, 53 is at the point 57 as indicated in Figure 4, which is the common center of oscillation of the first support or arm 47 and second support or head 56. By reference to Figure 4 it will be noted that the inner corner of the peripheral edge of cutter 58 has been shown coinciding with intersection point 57. Consequently, either forward and back or transverse tilting movements may be imparted to the head 56 without in any way varying the position of inner corner of cutter 58 from point 57. As a result, the effective distance between the inner corner of cutter 58 and the point of engagement at 59, between the tracer finger or contactor 34 and the contour determining template or pattern 35 remains unchanged, thus insuring exact dimensional reproduction of the pattern by the cutter.

It will, of course, be understood that a varying angle contour may be produced on a wall, as illustrated at 59' in Figure 9, by the periphery of the cutter or in a groove, such as at 60 in Figure 10, by a combination of the periphery and face of the cutter, but that in either event the reference contact point 57 will remain a constant as respects its relationship to the 360 degree plane of movement determined by the contactor 34 irrespective of any angular adjustment of the head

in either or both of its potential planes of tilting movement.

It will be evident that for maintenance of this constant relationship it is preferable that the radius of the cutter extending to the contact point 57 should be at all times be normal to the particular portion of the contour of the work being operated upon. For attainment of this result, the cutter 58 is indicated as mounted in a spindle 61 carried by the vertical adjustable quill 62 adjustable with respect to the sleeve 63 by a rack and screw device 64. Sleeve 63 mounts the driving motor 65 for spindle 61 and is laterally adjustable, in parallelism with the cutter contact radius normal to the point 57, with respect to the circumscribing sleeve 66 rotatably supported within the head 56. Suitable adjusting means such as the micrometer screw 67 may be utilized for effecting the desired eccentric adjustment of member 63 with respect to member 66. The member 66 may be rotated to maintain the proper relationship of the contact radius to the surface of the work by means of worm gear 68 meshing with worm 69 driven by hydraulic motor 70. The sleeve 66 is further provided with the circular gear or rack 71 operating through pinion 72 on the head 56, a second pinion 73 on shaft 74 to operate the feedback control mechanism for control of the extent of rotary adjustment of the spindle carrier or sleeve 66.

For proper performance of the contouring portion of the machining operation, the longitudinal movement of saddle 22, the transverse movement of ram 28 and the rotary movement of spindle carrier 66 are all placed under control of the tracer contactor 34 and contour pattern 35.

The structural elements for synchronization of rotary movement of the tracer finger 34 and the spindle carrier 66 have been particularly illustrated in Figures 5 and 6. It is to be understood that the tracer mechanism 33 and its finger 34 may be of conventional commercial type embodying the principle of constant pressure of a side of the tracer against the controlling pattern in a direction at right angles to the path of relative movement of tracer and pattern so that a selected point on the tracer contactor at all times engages the pattern, this being effected by imparting a rotary directional control movement to the tracer finger 34 by means of the hydraulic motor 76. The principles here utilized are shown and described in Patents 1,959,178 and 2,036,362, while the specific hydraulic circuit for effecting the 360 degree pattern controlled relative movement of work and cutter, as well as the rotary movements of the tracer head and the cutter head may be that illustrated in detail in Figure 11 of Patent 2,412,549 in which the tracer controlled rotatable hydraulic motor 162 corresponds to the motor 76 here illustrated.

In the present invention the motor 76, in addition to rotating the tracer finger 34 simultaneously, rotates shaft 77 and through direction changing bevel gears 78, 79 the spline shaft 80 slidable through bevel gear 81 which through bevel gear 82 drives spline shaft 83 slidable in gear 84. Gear 84, in turn, through bevel gear 85, shaft 86, and gear 87 drives pinion 88 splined on shaft 89 having pinion 90 which through pinions 91, 92 of differential 93 and pinion 94 operates shaft 95. Shaft 95 has pinion 96 meshing with pinion 97 on shaft 98 which is provided with a worm wheel 99 which when rotated will impart longitudinal movement to worm 100 on valve stem 101.

Alternatively, when member 98 is stationary,

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worm wheel 99 will serve as a nut against which worm 100 operates to effect feed back movement of valve stem 101. Valve stem 101 has a spline portion 102 fitting in sleeve 103 coupled by bevel gear 104 with beveled pinion 105 splined on shaft 106 which through pinions 107, 108, shaft 109, and pinions 110, 111 transmit power from shaft 112. Spline shaft 113 is coupled with 112 by a universal or gimbal joint 114 and slides in sleeve 115 coupled by universal or gimbal joint 116 to shaft 117. Bevel pinions 118, 119, shaft 120, bevel pinions 121, 122, in turn, couple 115 in driving relation with stub shaft 123. An additional universal or gimbal joint 124 couples sleeve 125 with 123, while slidable in sleeve 125 is spline shaft 126 coupled from the universal or gimbal joint 127 with stub shaft 74 which carries the pinion 73 connected through idler 72 with the ring gear 71 on the spindle carrier 66.

The purpose of the series of connections just described will be clear from a consideration of the diagrammatic view, Figure 5, in connection with Figures 2, 3, 4, and 6. As respects the drive to the shaft 98 it will be noted that the rotary tracer mechanism 33 is mounted on slide 75 transversely adjustable for positioning purposes on ways 128 of the vertical slide 129 adjustable on the vertical ways 130 on the slide 32A at the rear face of the ram arm 32, which is provided with the upper extension 131. These adjustments are designed to take care of desired vertical and transverse positionings of the tracer and tracer finger 34, the sliding of spline shaft 80 through bevel gear unit 81, maintaining the relationship of the parts during transverse adjustment of the tracer unit 33, while the joint vertical movement of unit 33 and bearing block 132 with respect to arm 131 effects sliding movement of spline shaft 83 with respect to gear 84.

Considering the left hand portion of the diagram representing the front of the machine it will be clear from reference to Figures 3 and 4 that the forward and back angular adjustment of the head 56 will cause variation in the distance between an angular relationship of the stub shaft 74 journaled in the head and the stub shaft 123 journaled in the arm 47. This difference in spacing and angular relationship will be taken care of by the relative movement of the telescoping sections 125 and 126 in connection with the universal joints 124 and 127 which are of a type to transmit constant angular velocity from one shaft to the other so that proper positional drive relationship will be maintained between the pinions 73 and 122. Likewise, the provision of the telescoping members 113 and 115 in connection with the universal joints 114 and 116 maintain proper drive relationship during angling of the arm 47 with respect to the vertical slide 133 in which shaft 109 is journaled, while the sliding of spline shaft 106 through the gear unit 105 compensates for any adjustment imparted to slide 133. Consequently, any desired and available adjustment, either vertically or angularly, into planes at right angles to each other may be imparted to the tool carrier, and desired vertical and transverse adjustments may likewise be imparted to the tracer unit with respect to the supporting ram without affecting the drive relationship connection extending through the gearing train connecting the tracer head and tool spindle.

In operation, when the tracer contactor 34 is deflected, effecting rotary movement of the tracer contactor 34 by motor 76 a corresponding rotation is imparted through the gear train, just described,

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to shaft 98. This will cause a longitudinal displacement of valve stem 101 and thus of the spool 135 of valve 136 shown in Figure 5 from the neutral or centralized position. Assuming that this displacement is effective in a right hand direction, the pressure conduit 137 from pump 138, which derives actuating medium from the reservoir 139, will be directed into conduit 140 extending to one side of motor 70. At the same time, the opposite motor conduit 141 will be coupled by the valve to the exhaust or return conduit 142, and motor 70 will be driven to effect rotation of the spindle carrier 66. Such rotation will actuate the feed back train from the cutter head from 73 to 103, rotating worm 100 in a direction to move valve stem 101 toward the left to counteract the effect of the rotary drive train from the motor 76 and restore the valve 136 to its neutral position. This action is assisted by spring 143 which reacts on the parts with a constant directional urge against the valve, eliminating backlash. It will be evident that there has been provided a continuously operable servo-type mechanism in which rotative movement of the tracer head in either direction as effected by motor 76 will react against valve 136 to effect corresponding operation of motor 70 and rotation of the cutter head, while the feed back mechanism shown, in any adjusted relationship of the parts, will oppositely react to effect neutralization of the valve and stopping of the drive motor 70 concurrently with the neutralization of motor 76.

To permit of phase adjustment between the rotative movements of the tracer head and the cutter head, the differential spider 93 is provided with bevel gear portion 144 meshing with pinion 145 on shaft 146. A handle 147 is secured to the shaft 146 and is movable over the dial plate 148 on the face of ram 28 and locked in desired adjusted position by pin 149. Rotation of this handle in one direction or another will impart corresponding movement to the spider 93, thus varying the phase relationship between the pinions 90 and 94 and thus the basic setting of member 98 as respects the feed back worm 103.

Determination of the angular adjustment or setting of the tool head 56 is effected and controlled by worm shaft 150 carrying worm 151 meshing with the worm rack 152 on the head. At one end the shaft is provided with a bevel gear 152' meshing with the drive gear 153 on the head angling motor 154, which is coupled by conduits 155 and 156 with the manual or automatic selector valve 157. In the manual control position of the parts illustrated in Figure 7, conduit 155 is coupled by way of valve groove 158 with conduit 159 leading to groove 160 of the valve member 161 while conduit 156 is coupled by groove 162 of valve 157 to conduit 163 and groove 164 of valve 161. This valve is shown in its central or neutral position, being urged toward the left by the valve spring 155 and maintained in position by engagement of worm member 165 on valve stem 167 with the worm wheel 168 on splined shaft 169. The pressure conduit system 137 from pump 138 is coupled with the groove 170 opposite spool 171 of the valve 161. Clockwise rotation of worm wheel 168 will effect a movement of valve 161 toward the right, coupling pressure conduit 137 by way of 159, 155, to motor 154 while opposite motor line will in this instance be coupled with the reservoir conduit 142, effecting rotation of the motor in one direction while for opposite movement of worm wheel 168 the valve 161 will be effective to reverse the pressure and exhaust connections as

respects the motor to cause operation of the motor in the opposite direction. Alternatively, if the worm wheel 168 is held against rotation and the shaft 167 rotated by way of its spline connection 172 telescoping with sleeve 173, bearing sprocket 174, the worm 166 will effect translation of the valve stem in one direction or the other for effecting shiftings of the valve 151. To permit of such manual control there is mounted on the side of the ram 28 pilot wheel 175 coupled by chain 176 with the sprocket 174 while a second sprocket 177 is coupled by way of chain 178, sprocket 179, shaft 180 journaled in the overarm 181, sprocket 182, chain 183 and sprocket 184 to the pilot wheel 185 carried by shaft 186 journaled in bracket 187 depending from the overarm structure 181.

To effect proper feed back of the valve 161 and stop actuation of motor 154, shaft 150 journaled in the spindle carrier arm 47 is provided with pinion 188 meshing with pinion 189 on vertical shaft 190 carrying the spur pinion 191 connected through idler 192 with pinion 193 on the upper end of shaft 194. This shaft is coupled by way of the universal joint 195, sleeve 196, spline shaft 197 and universal joint 198 to the shaft 199 journaled in slide 133. The joints 195 and 198 are of a type which will transmit constant and uniform rotation from pinion 193 to the bevel pinion 200 on shaft 199, while the combination of this pair of universal joints and the intermediate telescoping splined sleeve and shaft connection 196, 197 will permit of desired angular or tilting adjustments of the head with respect to the slide 133 while transmitting a uniform feed back from shaft 150 to pinion 200. Pinion 200 is, in turn, connected by pinion 201, shaft 202 and pinions 203, 204 to vertical spline shaft 205, these various elements being carried by slide 133. The shaft 205 slides through pinion 206 of the combination 206-207 carried by the ram. This structure, in turn, permits of vertical movement of the slide on the ram for effecting the desired uniform rotational movement by way of 207 of the control shaft 208 mounted in the ram 28. This shaft 208 is provided intermediate its length with the pinion 209 meshing with pinion 210 freely rotatable on shaft 169 but couplable with the shaft for rotation of same by clutch 211. A shifter 212 pivoted to the ram determines the position of the clutch being urged in one direction by spring 213 and operable in the opposite direction for disengagement of the clutch by the hydraulic plunger or piston 214 movable in cylinder 215 to which is coupled the control conduit 216. In the position shown, this conduit is coupled through selector valve 157 to the low pressure or exhaust conduit system 142 but is alternatively couplable when the valve 157 is moved downwardly from the position shown in Figure 7 with the pressure line 137. In the relationship shown, manual actuation of valve 161 will cause hydraulic reaction on motor 154 to effect power tilting or angular adjustment of the head 56 while the feed back will be from shaft 208 through the clutch mechanism shown and shaft 169 to worm wheel 168 to restore the valve to a neutral position and stop the power angling adjustment when actuation as by movement of control wheel 175 is discontinued.

Alternatively, the angular adjustment may be automatically effected through employment primarily of the tracer mechanism and associate parts shown at the right of Figure 7. The rear

face of the arm 37 of the ram supports adjustable slide 37A which is provided with ways 217 for the vertically movable slide 218 having ways 219 supporting the tracer head 38 for transverse adjustment with respect to the arm. Shaft 208 has a splined portion 220 engaging the worm 221 meshing with worm wheel 222 which is mounted on the upper end 223 of shaft 224.

The basic essential portions of the tracer controlled 360 degree relative movement of work and cutter, and the interlock controls for the automatic control of the tilting of the spindle carrying arm and head have been diagrammatically illustrated in Figure 11, reference being made to Patent 2,412,549 for a complete detailed illustration of an appropriate utilizable control circuit mechanism. As has been indicated, the pump 138 supplies the pressure circuit 137 which is coupled to the bushing 230 in the tracer head 75 by the conduits 231 and 232. When the pattern contactor 34 is in completely undeflected position the traver valve 233 is likewise at its lower limit of movement and the conduit 234 is coupled by the valve with exhaust conduit 142 while conduit 235 is coupled to pressure conduit 232. As the tracer contactor 34 is deflected, the valve will be raised toward a position to couple pressure conduit branch 231 with 234, shutting off the exhaust connection and at the same time closing down the coupling between 232 and 235 to produce balanced pressure conditions in these lines which are coupled to and control the rate and direction of the tracer head rotating motor 76. This motor through pinions 236 and gear 237 drives gear 238 of the rotary tracer head unit 75 which includes the cam 239 reacting on the rate and direction control valve 240 for motor 29 and a corresponding valve 241 for motor 25. It will be understood that these two valves have a 90 degree phase relationship so that the respective motors are put through oppositely phased accelerations and decelerations, the combined effect of the resultant movements of the slide and ram resulting in a relative controlled path of shifting of the tool and work throughout a potential 360 degree orbit.

Referring to Figure 7, the structure utilizable for manual angular adjustment of the tool head and its operation has been described in connection with the raised position of the valve 157. When automatic control is desired the valve is designed to be moved to a lower position either by introduction of pressure in the cylinder 242, reacting on the plunger 243 or manually by manipulation of the hand control 244, the detent 245 serving to secure the valve in its adjusted position. For automatic movement the cylinder 242 may be coupled with line 234 so that plunger 243 will be actuated when the line or conduit 234 is energized. Movement of the valve disconnects motor conduits 155 and 156 from the hydraulic power circuit under control of valve 161 and couples these respectively with the conduits 246 and 247 extending to the bushing of tracer valve 38. In the event that it is desired to prevent this automatic operation of valve 157 or to release the valve for independent manual operation, use may be made of the pressure shut-off or bypass valve 248. The valve 38 is basically of conventional construction in that the pressure line 137 is centrally connected to the valve, admission of pressure to the cylinder line spaces 249 and 250 being controlled by the central valve spool 251 while the spool portions 252 and 253' by their variable positioning with

respect to the valve portions coupled to the reservoir conduit 142 determines the relative pressures in the conduits 155-246 and 156-247 and thus the extent and direction of operation of the head angling motor 154. When operating under tracer control, the feed back movement from the head will be transmitted from shaft 150 to shaft 208 but as the down movement of valve 157 has disconnected conduit 216 from 142 and connected it with 137, clutch 211 would have been retracted by plunger 214 so that there is no feed back action affecting valve 161. Rotation of shaft 208, however, through worm 221 and worm wheel 222 will rotate shaft 224 which is journaled in but held against axial movement as respects the overarm 252' supported by the adjustable slide 37A at the rear of arm 37. Thus shaft 224 has the threaded portion 253 interfitting with adjustable nut carried by the vertical slide 218 so that rotation of the member 224 in one direction or another will raise or lower the slide 218 to compensate for deflection of pattern contactor 39 as a result of its engagement with the elevated or depressed portions of the edge of the annulus or template 254 carried by or forming a part of the template member 18.

It will be evident that as the shafts 208 and 224 are permanently coupled together that whether the angling of the head is effected under manual control or under power control that the slide 218 will receive a corresponding follow-up movement, the pointer or index mark 255 cooperating with the angle scale 256 on the arm 37A to indicate the angular setting existing at any time. Additionally, a pointer 257 is preferably provided driven by pinion 258 meshing with the pinion 209 and moving over dial 259 for indicating on the face of the ram the extent of this angular adjustment. It has been found preferable to have the spindle vertical when the 360 degree tracer is free from the pattern and that the template control angular setting in automatic operation be entirely distinct and independent of any previously existing manual setting. For accomplishment of this, there has been provided the neutralizing valve 260 carried by the bushing 261 having at one end the small diameter cylinder 262 and at the opposite end a larger diameter cylinder portion 263. The constant pressure line 137 has a pair of branches communicating with the valve chamber within the bushing at spaced points. A pair of additional branch conduits, likewise spaced with respect to each other and to the pressure conduits, form part of the return conduit system 142. One branch of conduit 235 or its equivalent is coupled with the small cylinder 262. As has been mentioned, when the 360 degree tracer contactor is in its free position the pressure conduit system is coupled by valve 233 with 235 with the result that this pressure holds valve 260 to the right as indicated in Figure 7. When so positioned, the pressure conduit system 137 is connected with conduit 264 having a branch 265 coupled to chamber 266 to react on the underside of piston flange 267 of valve 252 moving the valve upward against the pressure of spring 263. This upward movement being limited by engagement of the valve spindle 269 with the neutralizer slide 270. This slide is independently movable on the ways 217, its lower position being determined by the adjustable stop 271 carried by the arm extension 37A. This extension is further provided with a cylinder 272 containing a piston 273 coupled by rod 274 with the neutralizer. The

conduit 264 is coupled with the upper end of the cylinder for moving the piston and thus the neutralizer slide 270 downward into engagement with the stop 271, when the pressure effective in 264 and the conduit 275, from the lower end of the cylinder, is coupled through valve 260 with the reservoir or return conduit system 142. At this time the conduit 234 is coupled through the 360 degree tracer control valve 233 to reservoir.

During the neutralizing operation it will be understood that if the member 218 is in a lowered position due to a manually effected angular positioning of the spindle carrier head, the pressure on the underside of flange 267 will raise the valve 252, reacting on motor 154 so that the feed back mechanism will operate screw 253 to move member 218 upward until the head arrives at the zero angle positioning at which time the valve extension 269 will contact the lowered member 270, stabilizing the parts in the zero angle relationship.

Alternatively, if the head has been oppositely angled with a resultant upward positioning of the member 218, member 270 will react on spindle 269 pressing the valve downward for opposite directional actuation of motor 154 until the feed back mechanism shifts member 218 downward to the zero angle position relationship. The exact limit of this downward movement of the member 270 and thus the reaction on stem 269 is determined by adjustment of the neutralizer stop 271.

It will, of course, be understood that these reactions take place in their entirety only if the contactor 39 is free from its pattern since if the valve 252 is in upwardly displaced position due to contact of the member 39 with the template or pattern the downward limit of the neutralizing structure will be determined by the pattern follower. When the tracer 34 is deflected, coupling pressure conduit 231 with conduit 234, this pressure will rapidly flow past the ball check valve 276 into the large end of the cylinder 263, thus overcoming any pressure existing in the smaller cylinder portion 262, moving valve 260 to the left, coupling conduit 264 with reservoir, releasing the pressure on the underside of flange 267 and the pressure on the upper side of piston 273. At the same time, 275 will be connected to pressure conduit 137, moving the neutralizer 270 upward to disengage the valve stem 269.

As varying pressure conditions may exist in the lines 234 and 235 during the complete automatic operation of the machine, the cylinder area 263 has been made appreciably greater than the cylinder area 262 so that a lesser existing pressure will be effective to maintain the valve 260 in its left hand position. Additionally, check valve 276 shuts off the free return flow through line 234 in the event that the effective pressure in this line on the piston valve is less than the effective pressure on the valve from conduit 235. Such return flow must be through the throttling or choke coil 277 which thus holds and stabilizes the valve 260 in its left hand position and provides for a delayed slow movement of the same toward the right as the impounded fluid is forced out of cylinder 263.

As has been particularly illustrated in Figures 4 and 8, the spindle carrier supporting arm 47 is provided with the arcuate worm rack 278 engaged by worm 279 on shaft 280 journaled in the slide 133. The slide carries the motor 281 connected by gearing 282 with shaft 280 to effect its rotation. Hydraulic conduits 283 and 284 extend

from the motor to the valve bushing 285. As shown in Figure 8, these conduits are coupled by grooves 286 and 287 of the valve 288 with conduits 289 and 290 extending to the bushing 291 of the servo-valve 292. Alternatively, when the valve 288 is moved downwardly either by the setting handle 293 or the hydraulically actuable plunger 294, the conduits 283 and 284 will be connected with the conduits 295 and 296 extending to the bushing 297 of the tracer 41 for automatic control of the angular positioning of the arm. For manual angling of the arm there is provided a first pilot wheel 299 carried by bracket 300 and coupled by sprocket chain 301 with shaft 302, in turn, coupled by chain 303 with sprocket 304 on the spline sleeve 305.

A second pilot wheel 306 is coupled by sprocket 307 and chain 308 and an additional sprocket 309 on the sleeve 305. Splined for rotation with and slidable within the sleeve 305 is shaft 310 coupled with valve 292 for determining longitudinal movement of the valve. Intermediately, shaft 310 is provided with the worm 311 meshing with worm wheel 312 on shaft 313. Rotation of shaft 310 with member 313 stationary, according to the direction of rotation of 310, will cause a longitudinal advance or retraction of valve 292, a spring 314 reacting on the valve to take up any backlash. Alternatively, rotation of 313 will react through the worm gear to effect such axial movement of the valve. Pressure conduit 137 is connected to the bushing 291 and is couplable by longitudinal movements of valve 292 with conduit 289 or conduit 290 to effect one or another directional actuation of motor 281, the non-pressure conduit being coupled by the valve to the low pressure or exhaust conduit system 142 of the machine. When the motor 281 is actuated, imparting rotation to shaft 280 a feed back drive will be effected through the bevel pinions 315, 316, shaft 317 journaled on the slide 133, the bevel couplet 318, 319 carried by the bracket portion 320 of the ram to shaft 321 rotatably mounted on the ram. The spline connection between 317 and 318 permits of vertical movement of the slide and arm for variance in the uniform rotation transmitted from 280 to 321. Shaft 321 is provided with a bevel gear 322 meshing with the freely rotating bevel gear 323 on shaft 313. Shaft 313 carries the spline clutch 324, movable by shifter arm 325, intermeshing with clutch portion of 323 which position is normally held by spring 326. Hydraulically actuable plunger 327 coupled by conduit 328 with the valve bushing 285 provides for either reservoir connection to 142 or pressure connection with 137, automatically, to throw out the clutch depending on whether the valve 288 is in the manual or automatic control position.

When the valve 288 is shifted downwardly to condition the machine for automatic operation, motor 281 is placed under control of the tracer 41. Upward movement of the template contactor 42 reacting to lift the tracer valve 298 above its neutral position while engagement of the member 42 with a resetting or lower portion of the template will permit spring 329 to move the tracer valve downward. Pressure conduit 137 is intermediately connected to bushing 297 so that upward movement of the valve 298 will connect motor conduit 295 to pressure while connecting conduit 296 to the low pressure exhaust conduit 142, while downward movement will effect a reversal of the pressure and exhaust connections as respects the conduits 295 and 296 and a consequent reverse actuation of motor 281. For accurate positioning

purposes the tracer unit 41 is supported by the cross slideways 330 on which it is adjustable by the screw 331, these ways being, in turn, carried by the vertically movable slide 332 supported by the screw threaded lower portion 333 of shaft 334 journaled in arm 335 carried by the slide 336 at the rear of arm 40 of ram 28. Rotatable nut means operable by hand wheel 337 permit manual vertical adjustment of slide 332 along member 334. The slide itself is guided in its vertical movement by vertical ways 338 on the member 336. Feed back shaft 321 has splined thereon for axial movement the worm 339 meshing with worm wheel 340 for effecting rotation of shaft 334 in any in and out adjusted position of the shaft as effected by movement of the slide 336. In this manner a feedback is effected from the rotary movement produced by motor 281 from shaft 280 to shaft 334, correspondingly to vary the vertical position of slide 332.

The indicator 341 driven by pinion 322 cooperates with pilot 342 on the ram to indicate the angular position of the spindle carrier arm at any particular moment. The feedback connections are such as to move the tracer head 41 vertically in the same direction as the template contactor determined direction of movement of the valve 298 acting as a continuous follow-up to close off the flow to motor 281 and maintain a positional angular displacement of the arm 47 corresponding to the amount of displacement at any given instant with respect to zero or neutral position, which has been imparted to the tracer contactor 42 by its traverse over the template 19.

To provide for automatic centering of the spindle carrier arm at zero angle with 360 degree tracer is not in contact with pattern, irrespective of the previous manually selected angular position of the arm, there has been provided a neutralizing valve including bushing 343 having a large diameter cylinder area 344 at one end and a small diameter cylinder area 345 at the other end. Slidably mounted within the bushing is the valve 346 having terminal piston portions received in the respective cylinders and intermediate pressure flow controlling portions. Conduit 235 is coupled to the smaller cylinder 345 normally urging the valve to the right as shown in Figure 8. In this position reservoir conduit 142 is coupled with conduit 347 extending to the lower end of cylinder 348 containing the piston 349. Concurrently, the pressure conduit 137 is coupled with conduit 350 introducing pressure into the upper end of cylinder 348 to force the piston and thus the connected neutralizer arm 351 downward to an extent limited by the adjustable stop 352. Concurrently, branch 353 of conduit 350 introduces pressure under the piston flange 354 of the tracer valve 298 urging same upward to an extent limited by contact of the valve rod 355 with the neutralizing arm 351. The stop 352 is so set that when the arm 351 is in engagement with the stop and with the upper end of the valve rod 355, the tracer valve will be in the neutral position corresponding to zero angle of the arm 47 so that the actuating fluid will be coupled to motor 281 to effect its rotation in one direction or the other until the feedback moves the valve bushing 297 into position to shut off flow to the motor when the arm will have been automatically positioned at zero angle.

As previously described, in connection with the operation of the corresponding mechanism for head angle control, particularly illustrated in Figure 7, when the 360 degree pattern contactor

34 is deflected by engagement with its pattern 35 conduit 234, previously connected to reservoir, will be energized or connected to pressure which will then quickly flow past check valve 345 to the left. This will take effect irrespective of any pressure then existing in 235 due to the pronounced differential in effective pressure areas of the respective piston termini of the valve. Such movement of the valve will connect 350 to reservoir conduit 142 and 347 to pressure, releasing the pressure urging valve 298 upward and at the same time moving neutralizer arm 351 to a raised position out of the normal path of movement of valve rod 355 so that the template contactor 42 may now take control. It will be noted that the introduction of pressure into 234 normally reacts against plunger 294 to move valve 288 into automatic control position if it has previously been placed in a manual setting. If, for set-up purposes, or otherwise, it is desired to maintain the valve 288 in the manual control position this may be effected by closing off the manually operable shut-off valve 358.

When, in operation of the machine, the 360 degree movement control tracer 34 loses its deflection and conduit 234 is coupled to reservoir, pressure will exist in conduit 235, tending to restore valve 346 to the right hand position shown in Figure 8. Due, however, to closing of check valve 356, this movement can only be at a rate determined by the rate of flow in choke coil 359 so that there will be a delay period between the tracer disengagement and the operation of the automatic neutralizers. Similarly, this choke or resistance affords a stabilization of the valve 346 in its left hand position in the event of pressure fluctuations as respects the conduits 235 and 357.

As but slight power is required for effecting operation of the neutralizer mechanism it is preferable that a pressure reducing valve such as indicated at 361 be inserted in the line 137, limiting the effective pressure in 264 and 350.

It will be understood that in initial setting up of the machine or for effecting manual control of one or both of the cutter head angling movements it may be desirable to render the neutralizing mechanism ineffective, relieving the hand controls of the additional load which would be imposed if movements of the automatic angling tracer control mechanisms were to be made against the neutralizing pressure. To attain this result and at the same time render the neutralizing mechanism available at all times during complete automatic operation of the machine, the valves 157 and 288 may be provided with an additional integral section including the spools 362, 363 and the grooves 364 and 365 as shown in Figure 12. In this event the line 264 or the line 350 is coupled with the respective selector valve by a line or conduit 366 and the conduits 275 or 347 is connected to the selector valve by a conduit 367. When the selector valve is in its upper or hand control position as shown in Figure 12, conduit 366 is connected by groove 364 and conduit 368 with the reservoir conduit system 142, and conduit 367 is connected by groove 365 and conduit 369 with reservoir conduit 142 so that there is no effective pressure on piston 273 or 349, thus releasing the neutralizer arms 270 or 351 for free sliding movement in connection with movement of the tracer heads 38 and 41. When the selector valves are moved into their lower position, either manually or automatically the respective spools 362 and 363 will close or blank off the by-pass conduits 366 and 367 impounding

the neutralizer actuating fluid into its respective effective channels, thereby placing the neutralizers under direct control of the 360 degree tracer mechanism.

This feature may advantageously be utilized in starting operation of the machine in that with the selector valves in hand control position the screws 253 and 333 may be rotated to raise the slides 218 and 332 to insure adequate clearance between the tracers 39 and 42 with respect to the upper effective and controlling faces of the templates such as 254 which determines the position of the tracers and thus the angling of the cutter head when the machine is in operation. This avoids the necessity of otherwise adjusting the slides by operation of the pilot wheels such as 337 which has the disadvantage of distributing the zero angle effective position of the vertical tracer carrying slides with respect to their supporting screw shafts. Additionally, the templates 254 may be provided with a lip portion 370, as shown in Figures 13 and 14, to facilitate riding up of the tips of the tracer contactors or fingers 39 and 42 as the profiling tracer 34 moves laterally into engagement with the profile determining pattern 35.

From the foregoing description taken in connection with the drawings it will be noted that there has been provided an improved automatic machine for production of desired outlines or contours throughout a potential orbit of 360 degrees embodying a cutter head which may be adjusted for varying diameters of cutters and which may be angled in two planes normal to each other whose dihedral angle coincides with the effective cutting face of the cutter when the same is set at zero angle so that a point on the periphery of the cutter will be maintained in a constant position as a dividing center irrespective of the individual or joint angling adjustments of the cutter to maintain constant the contour reproduced as respects the contour followed by the controlling tracer.

It will further be noted that in the present improved construction a ram structure is employed carrying the cutter and tracer in corresponding paths of movement and which is provided with additional tracer mechanisms disposed in superimposed axial alignment with the contouring tracer which are themselves subject to vertical movement under the influence of simple plate templates or the like which later are disposed in superimposed relationship as respects the contoured determining template so that the several parts may be most accurately located for setting up purposes of the machine and the corresponding reactions of the several tracers at any point throughout the contour readily checked and determined.

It will be further noted that the complete automatic operation of the machine is under control of the primary tracer mechanism which determines the contour to be followed, and by its deflection directly or indirectly render the various manual control and feed back mechanisms inoperative, and additionally determines the neutralization or effectiveness of the angling mechanisms and tracer controls therefor, but that means have been provided for selective elimination of the automatic controls and for complete manual control of the several movements when desired.

Additionally, mechanism has been provided for effecting orbital movement of the cutter spindle by adequate power means operating independently of but in corresponding timed relation to

the orbital movement of the tracer head under either manual control or automatic control with minimum control power requirement by deflections of the 360 degree tracer, which synchronized movements will be unaffected by the various angular adjustments of the cutter head and in which the face relationship between the rotary positions of the tracer head and the cutter may be adjusted and controlled with the machine at rest or alternatively during power operation thereof.

What is claimed is:

1. A contouring machine including a ram, means mounting the ram for longitudinal and transverse contour following movements, a first support means carried by the ram and angularly adjustable with respect thereto, a second support means carried by the first support means and angularly adjustable with respect thereto in a plane at right angles to the plane of angular adjustment of the first support means, bearing means carried by said second support, a rotary cutter head journaled in said bearing means, a power motor carried by the said second support, driving connections intervening the motor and cutter head for effecting rotation thereof, a hydraulic power circuit couplable with the motor for operation thereof, valve means for determining the effective couplings of the circuit as respects the motor, a contouring tracer control for the ram, a tracer actuating motor coupled with the contouring tracer for effecting rotation thereof, and power connections intervening the tracer motor and the head power motor valve means variably to position the valve means upon operation of the motor.

2. A contouring machine including a ram, means mounting the ram for longitudinal and transverse contour following movements, a first support means carried by the ram and angularly adjustable with respect thereto, a second support means carried by the first support means and angularly adjustable with respect thereto in a plane at right angles to the plane of angular adjustment of the first support means, bearing means carried by said second support, a rotary cutter head journaled in said bearing means, a power motor carried by the said second support, driving connections intervening the motor and cutter head for effecting rotation thereof, a hydraulic power circuit couplable with the motor for operation thereof, valve means for determining the effective couplings of the circuit as respects the motor, a contouring tracer control for the ram, a tracer actuating motor coupled with the contouring tracer for effecting rotation thereof, power connections intervening the tracer motor and the head power motor valve means variably to position the valve means upon operation of the motor, and a feed back linkage intervening the rotary head and the motor valve control means for repositioning the valve means to counteract the movement imparted thereto by the tracer head motor.

3. A contouring machine including a ram, means mounting the ram for longitudinal and transverse contour following movements, a first support means carried by the ram and angularly adjustable with respect thereto, a second support means carried by the first support means and angularly adjustable with respect thereto in a plane at right angles to the plane of angular adjustment of the first support means, bearing means carried by said second support, a rotary cutter head journaled in said bearing means, a

power motor carried by the said second support, driving connections intervening the motor and cutter head for effecting rotation thereof, a hydraulic power circuit couplable with the motor for operation thereof, valve means for determining the effective couplings of the circuit as respects the motor, a contouring tracer control for the ram, a tracer actuating motor coupled with the contouring tracer for effecting rotation thereof, power connections intervening the tracer motor and the head power motor valve means variably to position the valve means upon operation of the motor, and a feed back linkage intervening the rotary head and the motor valve control means for repositioning the valve means to counteract the movement imparted thereto by the tracer head motor, said feed back means including a power transmitting shaft journaled on the first pivoted support, a power shaft journaled in the second support, an oscillatable connection between said power shafts for transmitting drive from one shaft to the other irrespective of the angular positioning of the second support with respect to the first support, power shaft transmission means carried by the ram, and a second oscillatable extensible power connection intervening the shaft on the first support and the transmission carried by the ram for effecting actuation of the latter from the power shaft on the first support irrespective of the angular positioning of the first support with respect to the ram.

4. A variable pitch surface contour producing machine including a ram, means supporting the ram for movement in two angularly related directions whereby any desired directional component of movement may be imparted thereto, a first angularly adjustable support carried by the ram, a second support mounted on the first support for angular adjustment relative thereto, a first hydraulic motor coupled to the ram and to the first support for effecting relative angular adjustment thereof, a second hydraulic motor carried by one of the supports and coupled with the other for determining the relative angular adjustment of said supports, and a hydraulic actuation and control circuit for effecting relative movements of the ram and the supports including a first 360 degree tracer control mechanism for the ram, and superimposed independent tracer control mechanisms for the respective support coupled motors, each of said tracer mechanisms including a pattern contactor, and means for supporting superimposed pattern elements in position for engagement with the respective contactors whereby said contactors may be simultaneously engaged with corresponding sections of respective patterns for determination of the relative positioning of the parts at any point in the cycle of operation of the machine.

5. A variable pitch surface contour producing machine including a ram, means supporting the ram for movement in two angularly related directions whereby any desired directional component of movement may be imparted thereto, a first angularly adjustable support carried by the ram, a second support mounted on the first support for angular adjustment relative thereto, a first hydraulic motor coupled to the ram and to the first support for effecting relative angular adjustment thereof, a second hydraulic motor carried by one of the supports and coupled with the other for determining the relative angular adjustment of said supports, and a hydraulic actuation and control circuit for effecting rela-

tive movements of the ram and the supports including a first 360 degree tracer control mechanism for the ram, and superimposed independent tracer control mechanisms for the respective support coupled motors, each of said tracer mechanisms including a pattern contactor, means for supporting superimposed pattern elements in position for engagement with the respective contactors whereby said contactors may be simultaneously engaged with corresponding sections of respective patterns for determination of the relative positioning of the parts at any point in the cycle of operation of the machine, and a hydraulic interlock intervening the 360 degree control tracer and the angling motor control tracers for determining the effectiveness of the latter in accordance with the positioning of the 360 degree contactor.

6. A variable pitch surface contour producing machine including a ram, means supporting the ram for movement in two angularly related directions whereby any desired directional component of movement may be imparted thereto, a first angularly adjustable support carried by the ram, a second support mounted on the first support for angular adjustment relative thereto, a first hydraulic motor coupled to the ram and to the first support for effecting relative angular adjustment thereof, a second hydraulic motor carried by one of the supports and coupled with the other for determining the relative angular adjustment of said supports, and a hydraulic actuation and control circuit for effecting relative movements of the ram and the supports including a first 360 degree tracer control mechanism for the ram, and superimposed independent tracer control mechanisms for the respective support coupled motors, each of said tracer mechanisms including a pattern contactor, means for supporting superimposed pattern elements in position for engagement with the respective contactors whereby said contactors may be simultaneously engaged with corresponding sections of respective patterns for determination of the relative positioning of the parts at any point in the cycle of operation of the machine, independent control valve means for the respective support angle determining motors, manual actuating means for said valves, and selector valve means shiftable alternatively to couple the tracer control mechanisms or the manual control valve means with the respective support angle controlling motors.

7. A variable pitch surface contour producing machine including a ram, means supporting the ram for movement in two angularly related directions whereby any desired directional component of movement may be imparted thereto, a first angularly adjustable support carried by the ram, a second support mounted on the first support for angular adjustment relative thereto, a first hydraulic motor coupled to the ram and to the first support for effecting relative angular adjustment thereof, a second hydraulic motor carried by one of the supports and coupled with the other for determining the relative angular adjustment of said supports, and a hydraulic actuation and control circuit for effecting relative movements of the ram and the supports including a first 360 degree tracer control mechanism for the ram, and superimposed independent tracer control mechanisms for the respective support coupled motors, each of said tracer mechanisms including a pattern contactor, means for supporting superimposed pattern elements in

position for engagement with the respective contactors whereby said contactors may be simultaneously engaged with corresponding sections of respective patterns for determination of the relative positioning of the parts at any point in the cycle of operation of the machine, independent control valve means for the respective support angle determining motors, manual actuating means for said valves, selector valve means shiftable alternatively to couple the tracer control mechanisms or the manual control valve means with the respective support angle controlling motors, and hydraulic power connections intervening the 360 degree tracer control means and said selector valve means for shifting the latter to place the support angle controlling motors under control of the respective tracers.

8. A variable pitch surface contour producing machine including a ram, means supporting the ram for movement in two angularly related directions whereby any desired directional component of movement may be imparted thereto, a first angularly adjustable support carried by the ram, a second support mounted on the first support for angular adjustment relative thereto, a first hydraulic motor coupled to the ram and to the first support for effecting relative angular adjustment thereof, a second hydraulic motor carried by one of the supports and coupled with the other for determining the relative angular adjustment of said supports, and a hydraulic actuation and control circuit for effecting relative movements of the ram and the supports including a first 360 degree tracer control mechanism for the ram, and superimposed independent tracer control mechanisms for the respective support coupled motors, each of said tracer mechanisms including a pattern contactor, means for supporting superimposed pattern elements in position for engagement with the respective contactors whereby said contactors may be simultaneously engaged with corresponding sections of respective patterns for determination of the relative positioning of the parts at any point in the cycle of operation of the machine, and a feed back connection intervening each of the angularly adjustable supports and its controlling tracer mechanism for limiting the extent of energization of the support coupled member for a given actuation of the tracer mechanism.

9. A variable pitch surface contour producing machine including a ram, means supporting the ram for movement in two angularly related directions whereby any desired directional component of movement may be imparted thereto, a first angularly adjustable support carried by the ram, a second support mounted on the first support for angular adjustment relative thereto, a first hydraulic motor coupled to the ram and to the first support for effecting relative angular adjustment thereof, a second hydraulic motor carried by one of the supports and coupled with the other for determining the relative angular adjustment of said supports, and a hydraulic actuation and control circuit for effecting relative movements of the ram and the supports including a first 360 degree tracer control mechanism for the ram, and superimposed independent tracer control mechanisms for the respective support coupled motors, each of said tracer mechanisms including a pattern contactor, means for supporting superimposed pattern elements in position for engagement with the respective contactors whereby said contactors may be simultaneously engaged with corresponding sections of

respective patterns for determination of the relative positioning of the parts at any point in the cycle of operation of the machine, a feed back connection intervening each of the angularly adjustable supports and its controlling tracer mechanism for limiting the extent of energization of the support coupled member for a given actuation of the tracer mechanism an independent manually adjustable valve mechanism for controlling each of the respective support angle determining motors, and a branch feed back transmission intervening the feed back connection and the manually adjustable valve mechanism for effecting a corresponding compensatory movement of the manually adjustable valve mechanism upon actuation of the support.

10. A variable pitch surface contour producing machine including a ram, means supporting the ram for movement in two angularly related directions whereby any desired directional component of movement may be imparted thereto, a first angularly adjustable support carried by the ram, a second support mounted on the first support for angular adjustment relative thereto, a first hydraulic motor coupled to the ram and to the first support for effecting relative angular adjustment thereof, a second hydraulic motor carried by one of the supports and coupled with the other for determining the relative angular adjustment of said supports, and a hydraulic actuation and control circuit for effecting relative movements of the ram and the supports including a first 360 degree tracer control mechanism for the ram, and superimposed independent tracer control mechanisms for the respective support coupled motors, each of said tracer mechanisms including a pattern contactor, means for supporting superimposed pattern elements in position for engagement with the respective contactors whereby said contactors may be simultaneously engaged with corresponding sections of respective patterns for determination of the relative positioning of the parts at any point in the cycle of operation of the machine, a feed back connection intervening each of the angularly adjustable supports and its controlling tracer mechanism for limiting the extent of energization of the support coupled member for a given actuation of the tracer mechanism an independent manually adjustable valve mechanism for controlling each of the respective support angle determining motors, a branch feed back transmission intervening the feed back connection and the manually adjustable valve mechanism for effecting a corresponding compensatory movement of the manually adjustable valve mechanism upon actuation of the support, and selector means for determining the effective coupling of said branch transmission with the feed back connection.

11. A variable pitch surface contour producing machine including a ram, means supporting the ram for movement in two angularly related directions whereby any desired directional component of movement may be imparted thereto, a first angularly adjustable support carried by the ram, a second support mounted on the first support for angular adjustment relative thereto, a first hydraulic motor coupled to the ram and to the first support for effecting relative angular adjustment thereof, a second hydraulic motor carried by one of the supports and coupled with the other for determining the relative angular adjustment of said supports, and a hydraulic actuation and control circuit for effecting relative movements of the ram and the supports in-

cluding a first 360 degree tracer control mechanism for the ram, and superimposed independent tracer control mechanisms for the respective support coupled motors, each of said tracer mechanisms including a pattern contactor, means for supporting superimposed pattern elements in position for engagement with the respective contactors whereby said contactors may be simultaneously engaged with corresponding sections of respective patterns for determination of the relative positioning of the parts at any point in the cycle of operation of the machine, a feed back connection intervening each of the angularly adjustable supports and its controlling tracer mechanism for limiting the extent of energization of the support coupled member for a given actuation of the tracer mechanism an independent manually adjustable valve mechanism for controlling each of the respective support angle determining motors, a branch feed back transmission intervening the feed back connection and the manually adjustable valve mechanism for effecting a corresponding compensatory movement of the manually adjustable valve mechanism upon actuation of the support, selector means for determining the effective coupling of said branch transmission with the feed back connection, a selector valve and alternative hydraulic control circuits completable by way of the selector valve for controlling the position of the selector means.

12. A machine of the character described including a ram, means mounted on the ram for movement in two angularly related directions enabling same to follow the contour of a pattern, a support carried by the ram for angular adjustment relative thereto, a tool carrier mounted on the support, a hydraulic motor for effecting angular movement of the tool carrier and support with respect to the ram, a first contour following tracer mechanism carried by the ram for controlling the contour following movements thereof, and additional tracer mechanism for control of the angling motor carried by the ram including a valve member having a centralized position corresponding to a zero angle positioning of the cutter head and oppositely deflectible to effect positive and negative angular adjustments of the head by the angling motor, a pattern engageable contactor coupled with the valve for determining angle effecting positions thereof, a hydraulically actuatable neutralizer mechanism for effecting a neutral zero angle positioning of the valve when the contactor is disengaged from a pattern, a control circuit for the neutralizer including a shiftable valve and hydraulic connections intervening the contour following tracer mechanism and said valve variably to position the valve in accordance with variations in position of the contour tracer mechanism.

13. A machine of the character described including a ram, means mounted on the ram for movement in two angularly related directions enabling same to follow the contour of a pattern, a support carried by the ram for angular adjustment relative thereto, a tool carrier mounted on the support, a hydraulic motor for effecting angular movement of the tool carrier and support with respect to the ram, a first contour following tracer mechanism carried by the ram for controlling the contour following movement thereof, and additional tracer mechanism for control of the angling motor carried by the ram including a valve member having a centralized position corresponding to a zero angle positioning of the cutter head and

oppositely deflectible to effect positive and negative angular adjustments of the head by the angling motor, a pattern engageable contactor coupled with the valve for determining angle effecting positions thereof, a hydraulically actu-
 5 able neutralizer mechanism for effecting a neutral zero angle positioning of the valve when the contactor is disengaged from a pattern, a control circuit for the neutralizer including a shiftable valve and hydraulic connections intervening the
 10 contour following tracer mechanism and said valve variably to position the valve in accordance with variations in position of the contour tracer mechanism, a selector valve for determining the effective coupling of the angling motor control
 15 tracer with said motor and an auxiliary control circuit for the neutralizer circuit variably completable according to the positioning of said selector valve.

14. A machine of the character described including a ram, means mounted on the ram for movement in two angularly related directions enabling same to follow the contour of a pattern, a support carried by the ram for angular adjust-
 20 ment relative thereto, a tool carrier mounted on the support, a hydraulic motor for effecting angular movement of the tool carrier and support with respect to the ram, a first contour following tracer mechanism carried by the ram for controlling the contour following movement thereof,
 25 an additional tracer mechanism for control of the angling motor carried by the ram including a valve member having a centralized position corresponding to a zero angle positioning of the cutter head and oppositely deflectible to effect positive and negative angular adjustments of the head by the angling motor, a pattern engageable
 30 contactor coupled with the valve for determining angle effecting positions thereof, a hydraulically actuatable neutralizer mechanism for effecting a neutral zero angle positioning of the valve when the contactor is disengaged from a pattern, a control circuit for the neutralizer including a shiftable valve and hydraulic connections intervening the contour following tracer mechanism
 35 and said valve variably to position the valve in accordance with variations in position of the contour tracer mechanism, a selector valve for determining the effective coupling of the angling motor control tracer with said motor and an auxiliary control circuit for the neutralizer circuit variably completable according to the positioning of said selector valve, and hydraulic connections between the contour tracer control and the selector valve for effecting positioning of said selector valve.

15. In a contouring machine, a support, a cutter head mounted on the support for angular adjustment relative thereto, a hydraulic motor carried by the support and coupled to the head for effecting relative angular adjustment of the head and support, said support having guiding ways formed thereon, a slide translatable on said ways, a tracer head carried by the slide and movable therewith, a valve mechanism carried by the tracer head including a pattern contactor and a valve coupled with the contactor for actuation thereby, a hydraulic operating circuit coupled with the tracer head and completable by way of the valve mechanism to the motor variably to determine the rate and direction of actuation thereof, a feed back mechanism operable by the motor including a power transmission, actuating connections between said transmission and the slide to effect compensatory adjustment of the slide and tracer head as respects the pattern con-

tactor determined positioning of the valve, and a neutralizer mechanism including an adjustable arm, an abutment on the valve for engagement with the arm and a hydraulic control circuit couplable with the valve and the arm to effect interengagement thereof.

16. In a contouring machine, a support, a cutter head mounted on the support for angular adjustment relative thereto, a hydraulic motor carried by the support and coupled to the head for effecting relative angular adjustment of the head and support, said support having guiding ways formed thereon, a slide translatable on said ways, a tracer head carried by the slide and movable therewith, a valve mechanism carried by the tracer head including a pattern contactor and a valve coupled with the contactor for actuation thereby, a hydraulic operating circuit coupled with the tracer head and completable by way of the valve mechanism to the motor variably to determine the rate and direction of actuation thereof, a feed back mechanism operable by the motor including a power transmission, actuating connections between said transmission and the slide to effect compensatory adjustment of the slide and tracer head as respects the pattern contactor determined positioning of the valve, a neutralizer mechanism including an adjustable arm, an abutment on the valve for engagement with the arm and a hydraulic control circuit couplable with the valve and the arm to effect interengagement thereof, and adjustable stop means to limit the movement of the arm in the direction of the valve.

17. In a contouring machine, a support, a cutter head mounted on the support for angular adjustment relative thereto, a hydraulic motor carried by the support and coupled to the head for effecting relative angular adjustment of the head and support, said support having guiding ways formed thereon, a slide translatable on said ways, a tracer head carried by the slide and movable therewith, a valve mechanism carried by the tracer head including a pattern contactor and a valve coupled with the contactor for actuation thereby, a hydraulic operating circuit coupled with the tracer head and completable by way of the valve mechanism to the motor variably to determine the rate and direction of actuation thereof, a feed back mechanism operable by the motor including a power transmission, actuating connections between said transmission and the slide to effect compensatory adjustment of the slide and tracer head as respects the pattern contactor determined positioning of the valve, a neutralizer mechanism including an adjustable arm, an abutment on the valve for engagement with the arm and a hydraulic control circuit couplable with the valve and the arm to effect interengagement thereof, adjustable stop means to limit the movement of the arm in the direction of the valve, a first valve means for determining the effective coupling of the neutralizer circuit with the valve and arm, and additional means independent of said first valve means for selectively rendering the neutralizer circuit ineffective as respects the valve and arm.

18. In a contouring machine, a support, a cutter head mounted on the support for angular adjustment relative thereto, a hydraulic motor carried by the support and coupled to the head for effecting relative angular adjustment of the head and support, said support having guiding ways formed thereon, a slide translatable on said ways, a tracer head carried by the slide and movable

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therewith, a valve mechanism carried by the tracer head including a pattern contactor and a valve coupled with the contactor for actuation thereby, a hydraulic operating circuit coupled with the tracer head and completable by way of the valve mechanism to the motor variably to determine the rate and direction of actuation thereof, a feed back mechanism operable by the motor including a power transmission, actuating connections between said transmission and the slide to effect compensatory adjustment of the slide and tracer head as respects the pattern contactor determined positioning of the valve, a neutralizer mechanism including an adjustable arm, an abutment on the valve for engagement with the arm and a hydraulic control circuit couplable with the valve and the arm to effect interengagement thereof, adjustable stop means to limit the movement of the arm in the direction of the valve, a valve means for determining the effective cou-

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pling of the neutralizer circuit with the valve and arm, a pattern controllable tracer mechanism carried by the support, an actuator for shifting said valve means, and operating connections between said actuator and the tracer mechanism, whereby said tracer mechanism controls the shifting of said valve means.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,959,178	Sassen	May 15, 1934
1,978,389	Sassen et al.	Oct. 23, 1934
2,036,362	Sassen et al.	Apr. 7, 1936
2,389,653	Turchan et al.	Nov. 27, 1945
2,412,549	Yates et al.	Dec. 10, 1946
2,572,756	Plimmer et al.	Oct. 23, 1951
2,585,376	Dyer et al.	Feb. 12, 1952