Jan. 19, 1943. A. H. HAWLEY, SR., ET AL 2,308,689

BROACHING MACHINE

Filed May 23, 1940 4 Sheets-Sheet 1

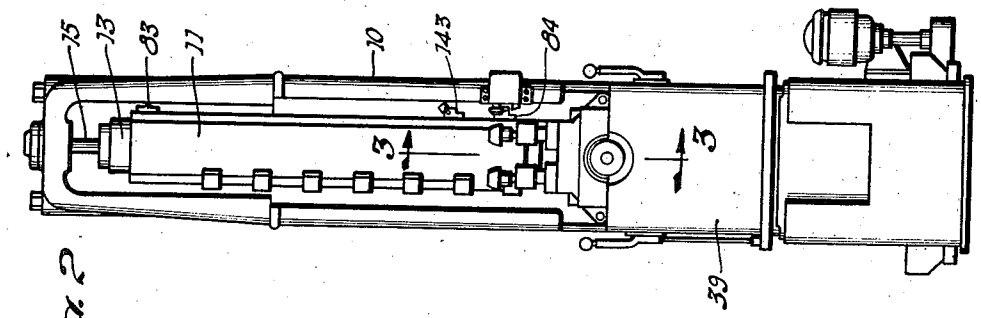


Fig. 2

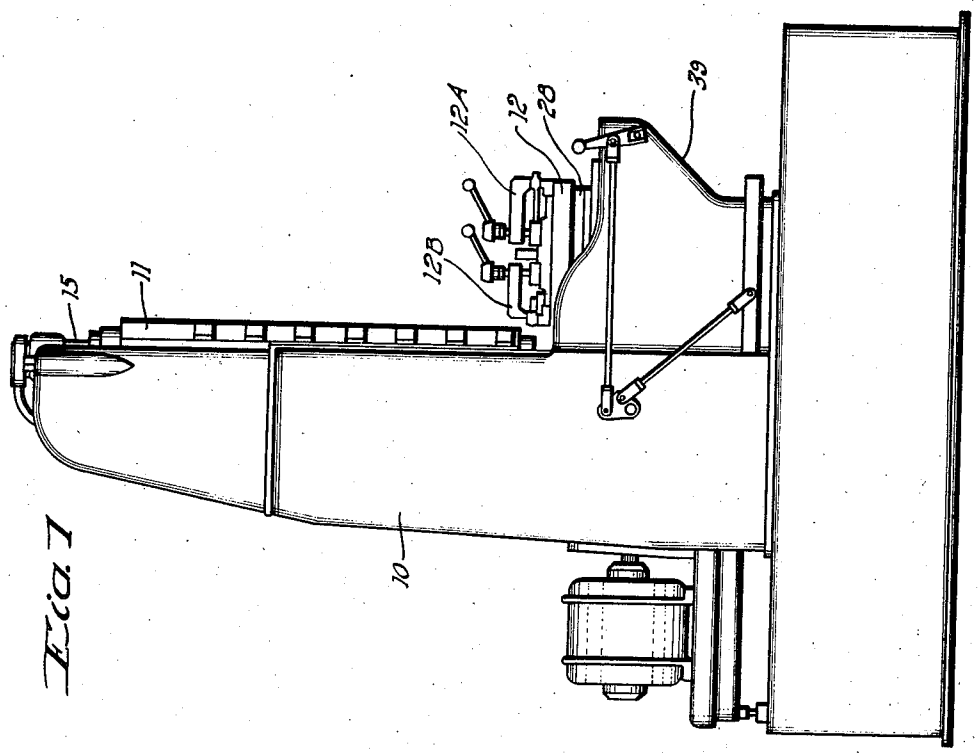


Fig. 1

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BROACHING MACHINE

Filed May 23, 1940 4 Sheets-Sheet 2

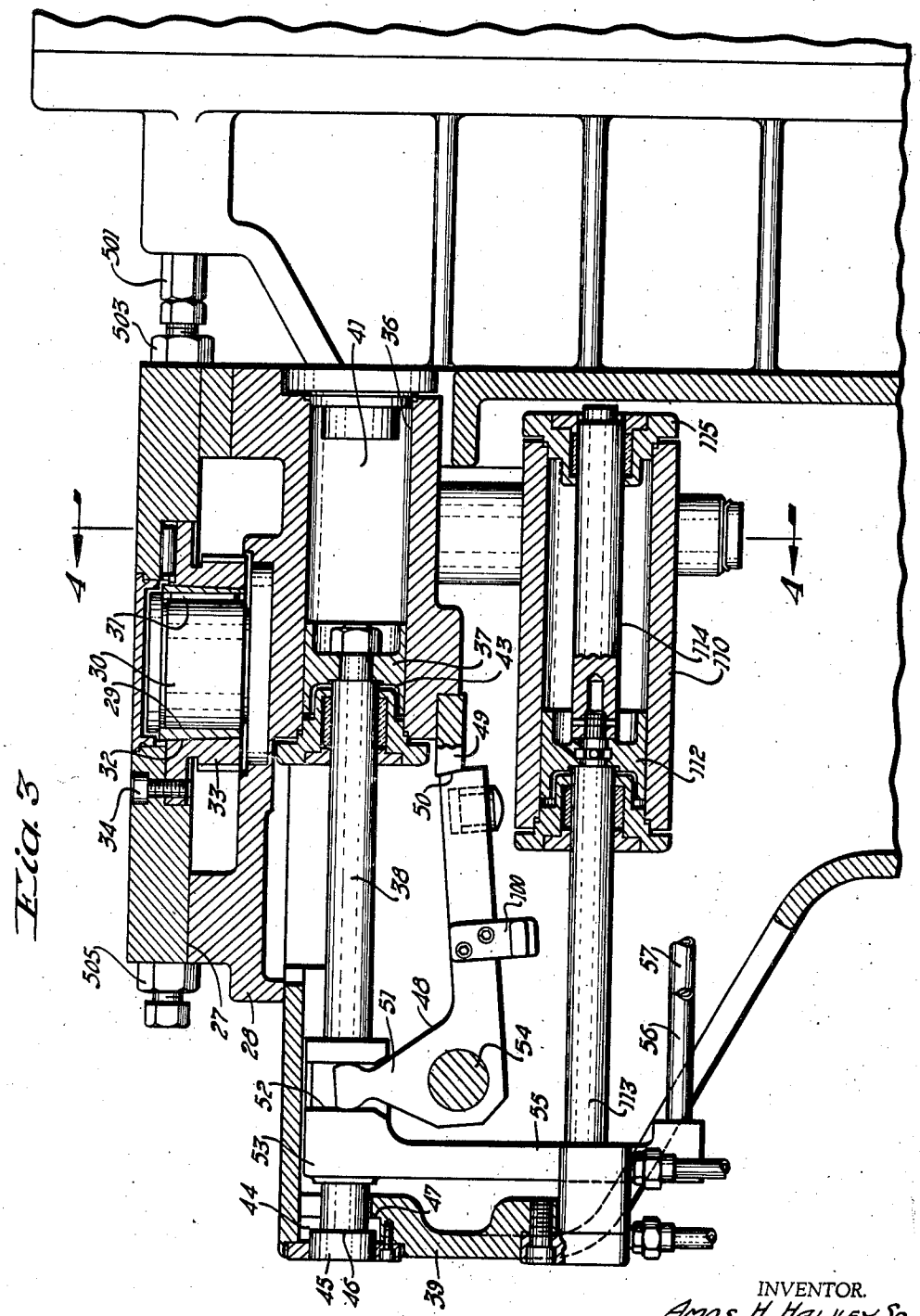


Fig. 3

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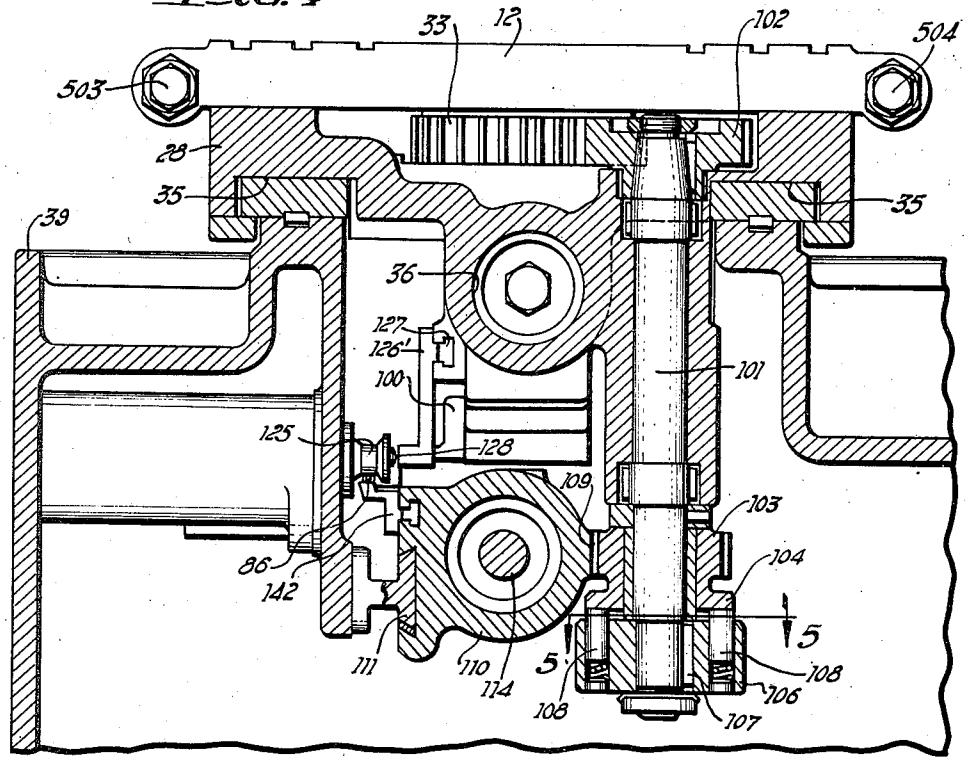
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BROACHING MACHINE

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Fig. 4



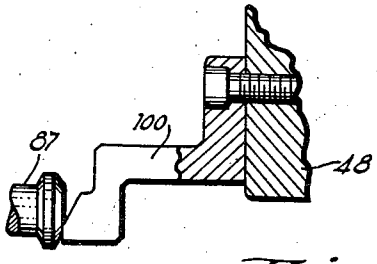


Fig. 6

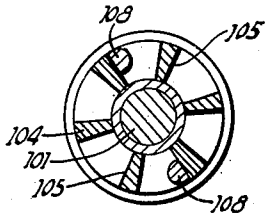


Fig. 5

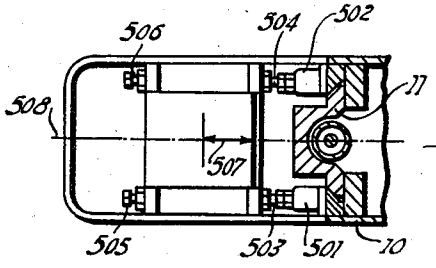


Fig. 8

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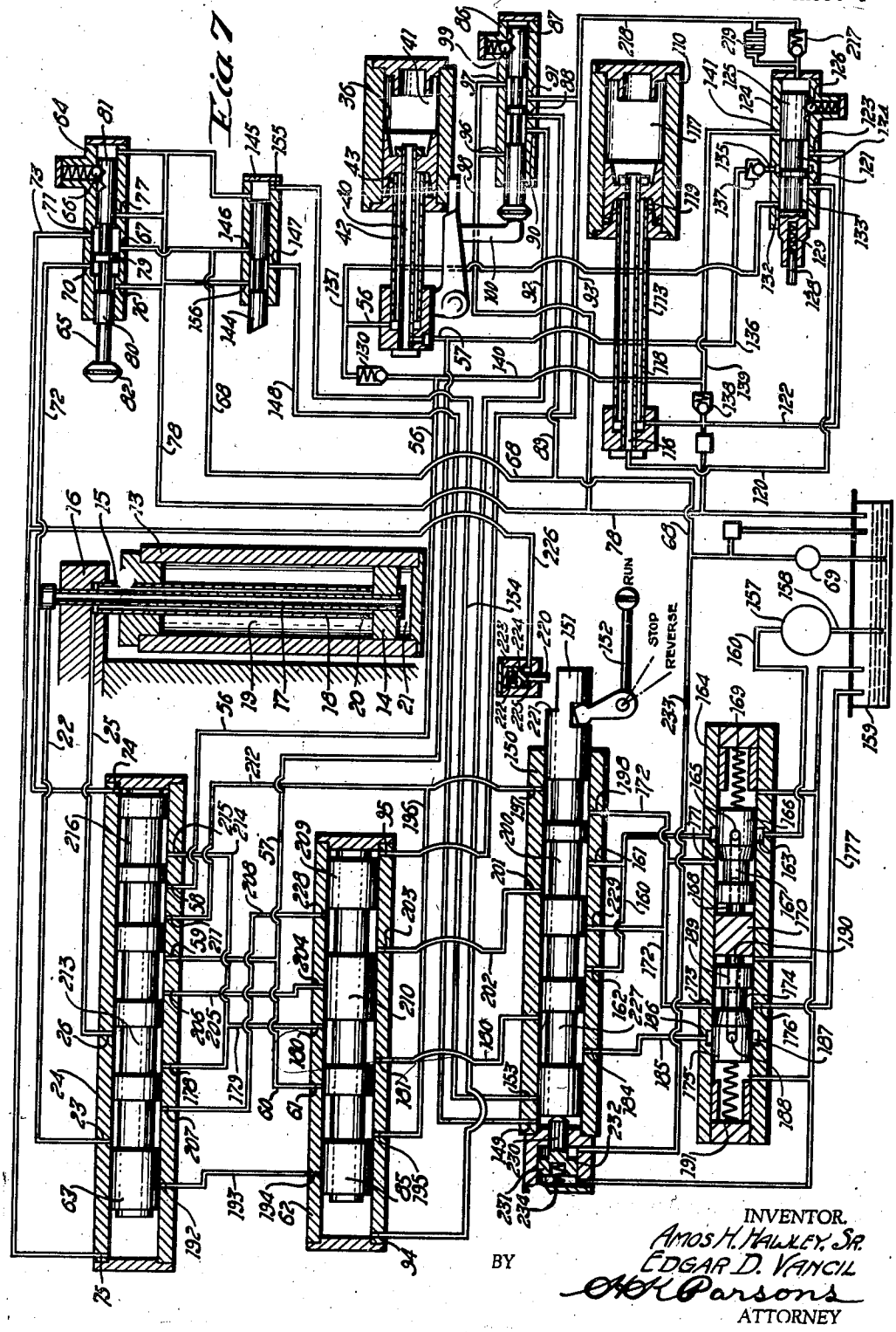
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BROACHING MACHINE

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Fig 7



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Patented Jan. 19, 1943

2,308,689

UNITED STATES PATENT OFFICE

2,308,689

BROACHING MACHINE

Amos H. Hawley, Sr., and Edgar D. Vancil, Cincinnati, Ohio, assignors to The Cincinnati Milling Machine Co., Cincinnati, Ohio, a corporation of Ohio

Application May 23, 1940, Serial No. 336,806

28 Claims. (Cl. 90—33)

This invention relates to machine tools and more particularly to improvements in automatic broaching machines.

One of the objects of this invention is to provide an improved automatic single cycle broaching machine.

Another object of this invention is to provide improvements in broaching machines which will facilitate work loading operations.

A further object of this invention is to provide improvements in automatic indexible work supports for broaching machines.

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.

Referring to the drawings in which like reference numerals indicate like or similar parts:

Figure 1 is a side elevation of a broaching machine embodying the principles of this invention.

Figure 2 is a front elevation of the machine shown in Figure 1.

Figure 3 is an enlarged section on the line 3—3 of Figure 2 showing the mechanism for shifting and indexing the work support.

Figure 4 is a section on the line 4—4 of Figure 3.

Figure 5 is a detail section on the line 5—5 of Figure 4.

Figure 6 is a detail view of one of the control dogs.

Figure 7 is a diagrammatic view of the hydraulic control circuit.

Figure 8 is a plan view showing the arrangement of the table locating stops.

Referring to Figures 1 and 2 of the drawings the reference numeral 10 indicates the column of a broaching machine upon which is slidably mounted in suitably formed guideways a broaching ram 11 which is adapted to have a series of broaching tools attached thereto for movement relative to a work supporting platen or table 12. The ram 11 has a cylinder 13 integrally formed therewith and containing a piston 14 which is connected by a double tubular piston rod 15 to a fixed part 16 of the column. By means of this arrangement the cylinder is the moving element and the piston is a fixed element.

The double tubular piston rod makes it possible to conduct fluid between the inside tube 17 and the outside tube 18 to the space 19 above the piston 14 through radial holes or passages 20 drilled in the outside tube 18 adjacent one face of the piston. The inner tube 17 serves to conduct fluid to the space 21 below the piston to effect downward movement of the ram. The upper end of the tube 17 is connected by a channel 22 to port 23 of a ram controlled valve 24. The annular space between the tubes 17 and 18 is connected by a channel 25 to port 26 of valve 24. Thus, by alternately admitting fluid to channels 22 and 25 the broaching ram may be power reciprocated.

The work supporting table 12 is indexibly supported on flat surfaces 27 of a sub-support or slide 28 and laterally guided by a tapered sleeve 29 which is connected to an upstanding stud 30 by a key 31. The tapered sleeve fits in a tapered bore 32 formed in the gear 33 which is fastened to the underside of the table 12 by bolts 34. It will be noted that the taper on the sleeve is in such a direction that it prevents upward movement of the gear and table.

The sub-support is mounted on horizontal guideways 35 as more particularly shown in Figure 4 for movement in a plane at right angles to the plane of movement of the broaching ram.

The table is provided with two work fixtures 12A and 12B as shown in Figure 1, and the table is indexible 180° whereby one fixture may be loaded during broaching of work in the other fixture.

While the broaching ram is at rest at the upper limit of its stroke, the sub-support 28 is advanced to position a work piece in the path of the broaching tools; and after the ram completes a broaching stroke, the sub-support is retracted and the table 12 indexed sequentially. The ram then returns on its idle stroke.

Automatic means are provided for advancing and retracting the slide 28 and indexing the table whereby the operator's duties are reduced to simply loading and unloading the machine and starting each automatic cycle.

The means for advancing the slide comprises a cylinder 36 which, as shown in Figure 3, is integral with the sub-support 28, and a contained piston 37 which is connected by a double tubular piston rod 38 to the knee 39 projecting from the column 10.

Referring to Figure 7, the piston rod 38 has an inside tube 40 through which fluid is conducted to the forward end 41 of the cylinder to advance the work support; and an annular space 42 be-

tween the inside and outside tube through which fluid is conducted to the other end 43 of the cylinder to retract the work support.

As shown in Figure 3 the piston rod 38 has a lost motion connection indicated at 44 with the fixed support 39. In other words, the end of the piston rod is provided with an enlarged head 45 which forms a shoulder 46 for engagement with an abutment 47 when pressure is admitted to the rear end of cylinder 36. This permits the piston 37 to move forward a sufficient distance to rotate the bell crank locking lever 48 out of engagement with the plate 49 attached to the under side of the sub-support 28 after which the pressure increases to retract the sub-support.

On the other hand when pressure is admitted to the forward end 41 of the cylinder, the piston 37 will move in the opposite direction to effect counterclockwise rotation of the bell crank lever 48 until it hits the underside of the slide 28, after which the pressure in chamber 41 builds up to advance the slide 28 to cutting position at which the bell crank will clear and move into locking position. It will be noted that the abutting surfaces 50 of the bell crank and plate are inclined the necessary amount to provide a wedging action.

This wedging action would, of course, be impossible without positive means for limiting the advance of the slide and the table. Such positive means are provided in the form of a pair of fixed abutments 501, 502, Figure 8, located on the column 10 equal distances on opposite sides of the center of the broaching ram 11; a pair of adjustable stops 503, 504 located on one end of the table, and a second pair of adjustable stops 505 and 506 located on the other end of the table. These stops are spaced equal distances on opposite sides of a predetermined radius 507 of the table.

This radius may be utilized as a reference line for locating a work fixture on the table in such position that the work will be engaged by the broaching tool. The stops will position the table so that this radius will be superimposed on the longitudinal axis 508 of the slide guideways and perpendicular to the plane of reciprocation of the broaching tool.

The indexing mechanism to be described indexes the table approximately 180 degrees or one-half of a revolution. The indexing mechanism is of such a nature that after the table has been indexed it is still free to move angularly. After the indexing operation a pair of stops will be aligned with the fixed abutments. The indexing mechanism is not intended to be accurate but reliance is placed on the stops engaging the fixed abutments to precisionally locate the table. Thus, one of the stops serves to prevent counterclockwise movement while the other prevents clockwise movement. Whichever stop hits first will cause rotation until the other stop hits and stops the rotation. Thus, each stop prevents rotation by the other stop, whereby the table is accurately positioned. In addition, since the table and the slide cannot advance any further, the stops also determine the linear position of the table as respects the distance of the work from the broaching tool. The bell crank lever thus serves to wedge the table against these abutments and clamp the table both angularly and linearly.

The arm 51 of the bell crank 48 is bifurcated for engagement with slots 52 cut in opposite sides of a block 53 which is integrally attached to the piston rod 38. This forms an operating connection between the piston rod and the bell crank, the crank being rotatably supported on a shaft 54.

The block 53 has a depending portion 55 in which is formed two channels which terminate in flexible pipes 56 and 57, these pipes being connected as shown in Figure 7 to ports 58 and 59 of the ram controlled valve 24. The channel 57 has a branch connection through channel 60 to port 61 of the work support controlled valve 62.

The plunger 63 of the ram controlled valve is shifted by hydraulic pressure under control of a pilot valve 64. This pilot valve has a shiftable plunger 65 which has two positions in which it is alternately held by a spring pressed detent ball 66. In this valve is a pressure port 67 which is supplied with pressure through channel 68 from an independent pump 69; and a pair of ports 70 and 71 which are connected by channels 72 and 73 respectively to ports 74 and 75 located on opposite ends of the valve housing 24. In addition, valve 64 has a pair of ports 76 and 77 which are connected to a common return line 78. A central spool 79 is formed on the plunger 65, larger in diameter than the end spools 80 and 81, whereby the valve becomes self-actuating after it passes a center position. The plunger 65 is provided with a double tapered head 82 which is adapted to be engaged by a trip dog 83 during downward movement of the broaching ram 11 which supports the dog, to shift the plunger 65 to the right; and by a second trip dog 84 during upward movement of the ram to shift the plunger to the left. This controls opposite shifting of the ram controlled valve plunger 63.

The plunger 85 of the work support controlled valve 62 is also hydraulically shifted under control of a second pilot valve 86, having an operating plunger 87. The pressure port 88 of this valve is supplied with fluid pressure through a branch 89 of channel 68. A pair of ports 90 and 91, which are adapted to be alternately connected to the pressure port 88, are connected by channels 92 and 93 to ports 94 and 95 located in opposite ends of the housing 62. The pilot valve 86 also has a pair of exhaust ports 96 and 97 which are connected by the common channel 98 to the return channel 78. Thus, by oppositely shifting the plunger 87 the ends of the housing 62 may be alternately connected to pressure while the other end is connected to exhaust to effect opposite shifting of the valve plunger 85.

A spring pressed detent 99 serves to hold the plunger 87 in either one of its two positions. When the work support advances to a broaching position, a dog 100 attached to the side of the bell crank 48, as more particularly shown in Figure 6, shifts plunger 87 to the position shown in Figure 7 to effect hydraulic shifting of plunger 85 of control valve 62 and thereby initiate downward movement of the broaching ram.

The slide 28 not only carries the work supporting table 12 but also part of an indexing mechanism therefor. This mechanism is more particularly shown in Figure 5, and comprises an indexing shaft 101 which has a gear 102 keyed to its upper end in mesh with the table gear 33. The lower end of the shaft 101 has an operating gear 103 supported thereon for free rotation relative to the shaft, the gear being operatively connected to the shaft through a ratchet mechanism whereby upon one direction of rotation of the gear 103 the shaft 101 will be rotated to effect indexing of the table.

The gear 103 has a ratchet wheel 104 integrally formed therewith in which is cut a series of ratchet teeth 105. A ratchet 106 is secured to the shaft 101 by a key 107 and carries a pair of spring-pressed ratchet plungers 108.

The gear 103 intermeshes with rack teeth 109 formed longitudinally on the exterior of an indexing cylinder 110. This cylinder is guided for movement on a dovetailed guideway 111 which is integral with the knee 39. The ratchet teeth 105 which are saw-tooth-shaped in section are directionally arranged so as to be effective during counterclockwise rotation of the ratchet wheel 104 to index the table, which direction of rotation is produced by movement of the cylinder 110 to the left as viewed in Figure 3. Ratcheting will, therefore, occur during the other direction of cylinder movement.

The cylinder 110 has a contained piston 112 which is connected by a double tubular piston rod 113 to the knee 39, the piston being stationary while the cylinder does the moving. To assist in guiding the parts, a second piston rod 114 is attached to the piston 112 and extends through the forward end 115 of the cylinder. As shown in Figure 7 the piston rod 113 has an inner tube 116 through which fluid is delivered to the forward end 117 of the cylinder, and an annular tube 118 through which fluid is delivered to the rear end 119 of the cylinder. The tube 116 is connected by channel 120 to port 121 and the annular tube 118 is connected by channel 122 to port 123, the ports being located in a pilot valve 124. This pilot valve has a plunger 125 which is held in either one of two positions by a spring-pressed detent 126.

The plunger 125 is shifted to the right as viewed in Figure 7 by a dog 126' mounted in a T slot 127 formed in the underside of the slide 28 as more particularly shown in Figure 4. The plunger 125 has a pin 128 supported in one end and held in an extended position by a spring 129. The spring is of sufficient strength that when the dog 126' engages the end of the pin 128 it will shift the plunger 125. Fluid operable means are provided for shifting the plunger in the opposite direction, and the spring 129 is provided so that the plunger 125 may be shifted hydraulically while the dog 126' is still in engagement with the pin 128.

On the forward stroke of the slide cylinder 36, the index cylinder 110 is caused to move substantially simultaneously therewith in the same direction, thus producing no relative movement between the rack 109 and the pinion 103. To produce this movement fluid pressure is admitted to channel 57 which flows to the forward end of cylinder 36, and movement of the cylinder causes fluid to be expelled from the other end of the cylinder into channel 56. A check valve 130 in channel 56 prevents this fluid from returning directly to valve 24, thus causing it to flow through a branch line 131 to port 132 of valve 124. When the valve plunger 125 is in the position shown, the port 132 is connected to port 121 by the annular groove 133 whereby the fluid continues through channel 120 and tube 116 in piston rod 113 to the forward end of cylinder 110. Thus, the exhaust fluid from cylinder 36 is utilized to effect forward movement of the cylinder 110.

The exhaust fluid from the chamber 119 of cylinder 110 returns through channel 122 and would continue through port 123, annular groove 134 and port 135 of valve 124 to channel 136. This channel is a branch of channel 57 which at this time is under pressure and therefore a check valve 137 in channel 136 is held closed whereby the fluid is forced through another check valve 138 located in a branch 139 of channel 122. After the fluid passes through this check valve it flows through line 140 into channel 56, but on the other side of check valve 130. Thus, the exhaust fluid from cylinder 36 is in effect bypassed around the check valve 130 to cause advance movement of the index cylinder 110. Attention is invited to the fact that the quantity of fluid exhausted from cylinder 36 in the manner just described is not sufficient, however, to complete the forward movement of cylinder 110. This movement is, therefore, completed after the broaching ram has completed its downward or cutting stroke.

The trip dog 83 on the ram slide will trip the pilot valve plunger 65 at the end of the broaching stroke, thereby interconnecting the pressure port 67 with port 70 causing fluid to flow through channel 72 and shift the valve plunger 63 to the left. This will cause admission of pressure to channel 56 which will flow through check valve 130 to the rear end of cylinder 36, causing return movement of the sub-support. It will be noted that the check valve 138 will prevent the escape of fluid at this time into channel 122. In addition, the fluid will flow through channel 131 and interconnected ports 132 and 121 of pilot valve 124 and channel 120 to the forward end of the index cylinder 110 whereby the index cylinder is caused to complete its forward or ratcheting stroke.

It will be noted that at this time the rack 109 is being moved in one direction and the intermeshing pinion 103 is being moved in an opposite direction but since this merely produces a ratcheting action the table 12 still remains in the same relative position with respect to the slide 28.

Since the ratcheting cylinder 110 is under no load at this time and has a shorter distance to move it will complete its stroke immediately. The pressure will continue to act, however, in the indexing cylinder until the slide has completed its return movement, at which time the trip dog 126' will engage the pin 128 and shift the pilot valve plunger 125 to the right. This will close port 132 and cause the pressure fluid in channel 56 to flow through channels 140, 139, and port 141 which is now open and connected to port 123. The fluid pressure will thus continue through channel 122 to the rear chamber 119 in index cylinder 110 causing return movement thereof and effecting rotation of the shaft 101 and thereby through the interconnected gearing 102—33 indexing of the work support 12. The length of movement of the cylinder and the ratio of the motion transmitting connections to the table is such that the table will be indexed substantially 180 degrees. As indexing is completed a dog 142 carried by the cylinder will operate the pilot valve 86 which, in turn, will cause hydraulic shifting of plunger 85 of the table controlled valve 62 resulting in upward movement of the broaching ram.

As the broaching ram continues on its upward stroke a latch dog 143 positioned on the ram engages plunger 144 of a stop pilot valve 145. This pilot valve has a pressure port 146 which is connected, upon shifting of plunger 144 to the right by dog 143, to port 147.

This port is connected by channel 148 to port

149 located in the end of a stop valve housing 150. This valve has a plunger 151 which is shifted to the left by the operator through the medium of the manually operable control lever 152 to start an automatic cycle of the machine. When the pressure fluid enters port 149 it acts on the left end of the plunger 151, shifting the same to the right and stopping the machine.

This shifting movement is of a sufficient amount to uncover a port 153 whereby the fluid pressure after shifting the plunger will continue through channel 154 to port 155 located in the right hand end of pilot valve 145. This will shift the plunger 144 to the left, closing port 146 and connecting port 147 to an exhaust port 156. This will immediately permit the fluid which shifted the plunger 151 to be released to reservoir and permit immediate manual actuation of the lever 152 if the machine is in condition to start another automatic cycle.

The fluid pressure for operating the broaching ram and the work support cylinders is supplied by a pump 157 which has an intake 158, through which fluid is withdrawn from a reservoir 159, and a delivery channel 160 through which fluid is delivered to ports 161 and 162 of the stop valve.

Included in the channel 160 is an annular groove 163 formed in the body of a relief valve 164. A cross bore 165 formed in the plunger 166 is always in communication with the groove. The cross bore 165 intersects an axial bore 167 in the open end of which is mounted a small headed plunger 168. A spring 169 holds the plunger parts in the position shown against a fixed block 170.

If the pressure in channel 160 rises above the setting of spring 169 the pressure in the axial bore 167 acts to shift the plunger 166 relative to plunger 168, thereby uncovering the annular groove 163 so that a portion of the fluid will escape through an exhaust port 171. This port is connected by channel means 172 to port 173 which is also formed in the relief valve body. The port 173 is continuously connected by an annular groove 174 formed in a second relief valve plunger 175 to port 176. This port is connected by channel 177 to the reservoir 159. It will thus be evident that the plunger 166 acts as a relief valve for the pump 157.

The plunger 175 acts as a back pressure relief valve to counterbalance the downward movement of the broaching ram. As previously described, the fluid in the upper chamber 19 of cylinder 13 escapes through channel 25 during downward movement of the ram. From this channel the fluid continues through interconnected ports 126 and 173 of valve 24, channel 179, interconnected ports 180 and 181 of valve 62, channel 182, interconnected ports 183 and 184 of stop valve 150 and channel 185 to port 186 of the relief valve 164. Port 186 communicates with annular groove 187 formed in the valve body and in constant communication with a cross bore 188 in plunger 175. This cross bore intersects an axial bore 189 in the open end of which is mounted a headed plunger 190.

Since a spring 191 normally holds the plunger 175 in a position to prevent escape of fluid from the annular groove 187 it is necessary that sufficient back pressure be produced in channel 185 to effect movement of plunger 175 to the left a sufficient distance to uncover the annular groove 187.

When this occurs the fluid escapes through port 176 in channel 177 to reservoir 159. Thus, a constant back pressure is maintained in the upper end of cylinder 13 during downward movement of the ram. It also acts to prevent sudden dropping of the ram in case of a failure of fluid pressure in the system. Since it is not necessary to provide back pressure during upward movement of the ram the following open path to reservoir has been provided from channel 22. This path includes interconnected ports 23 and 192 of valve 24, channel 193, interconnected ports 194 and 195 of valve 62, channel 196, interconnected ports 197 and 198 of stop valve 150 and channel 172 which is connected to reservoir in the manner previously described.

The cycle of operation of the machine will now be described, it being obvious that the starting position of the ram for any given cycle is the same as the stop position of a preceding cycle, which stop position is determined when the latch dog 143 engages the pilot valve plunger 144. In other words, the broaching ram stops during its upward movement a little distance short of its extreme upward position. The slide 28 is in a retracted position with respect to the broaching ram and the indexing movement of the table has been completed. Therefore, when the operator throws the starting lever 152 from its dash and dot stop position 199, as shown in Figure 7, to the running position in which it is shown, the ram will start upward to effect engagement of the reversing dog 82 with the reversing pilot valve plunger 65. When this valve shifts, the broaching ram stops, and the slide advances to cutting position. Completion of this movement will automatically cause downward movement of the broaching ram on a cutting stroke.

The plungers 63 and 85 of valves 24 and 62 are in a left hand position as viewed in Figure 7, while the trip plunger 65 is in a right hand position when the machine is started. Therefore, the ram actuating fluid flows from pressure port 161 of the starting valve 150 through annular groove 200, port 201, channel 202, interconnected ports 203 and 204 of valve 62, channel 205, interconnected ports 206 and 26 of valve 24, and channel 25 to the upper end of the ram cylinder 13. The exhaust fluid returns through channel 22, interconnected ports 23 and 192 of valve 24, channel 193, interconnected ports 194 and 195 of valve 62, channel 196, interconnected ports 197 and 198 of valve 150, channel 172, interconnected ports 173 and 176 of relief valve 164, and channel 177 to reservoir.

When the reversing dog 84 shifts the pilot valve plunger to the left, pressure port 67 is connected to port 66 to effect shifting of plunger 63 into its right hand position. This effects interconnection of pressure port 206 with port 59 whereby fluid flows through channel 57 to the right hand end of cylinder 36 and simultaneously through branch channel 60 to port 61 of valve 62. It will be noted that, at this time, port 61 is connected by port 181, channel 82, and interconnected ports 183 and 184 of stop valve 150 and channel 185 to port 186 of the relief valve. The relief valve spring 191 is set to a lower value than the spring 169, whereby the pump 157 works against a lower pressure during forward movement of the slide.

Attention is also invited to the fact that the shifting of plunger 63 caused the ram to stop because even although in the new position ports 23 and 26 are interconnected to ports 207 and 178, the channels 208 and 179 are blocked by spools 204 and 210 of plunger 85 in valve 62.

Thus, the ram stops and the slide advances causing fluid to exhaust from the rear end of cylinder 36 into channel 56.

Since check valve 130 will close, this exhausting fluid will by-pass through channel 131, interconnected ports 132 and 121 of valve 124 and channel 120 to the right hand end of the index cylinder 117. This cylinder will thus advance approximately simultaneously with the slide. Fluid exhausting from the other end of cylinder 117 will escape through check valve 139 and channel 140 to channel 56. This channel is now connected through ports 58 and 211 of valve 24, channel 212, interconnected ports 197 and 198 of stop valve 150, channel 172 and interconnected ports 173 and 176 of relief valve 164 to reservoir.

When the work slide has advanced sufficiently for the locking plate 49 to clear the end of bell crank 48, as shown in Figure 3, the bell crank will move into locking position, and in so doing will cause the dog 100 to shift the plunger 87 of valve 86 to its right hand position as shown in Figure 7. This will interconnect the pressure port 88 with port 90 whereby fluid will flow through channel 92 to effect shifting of plunger 85 to its right hand position. This will result in channels 208 and 179 becoming interconnected with ports 203 and 181. Since the port 203 is a pressure port, fluid will flow to the lower end 21 of ram cylinder 13, causing downward movement thereof while fluid in the upper end of cylinder 13 will exhaust to reservoir through the back pressure relief valve 175.

It will be obvious that the shifting of plunger 85 to the right disconnected pressure port 203 from pressure port 204, thus rendering the low pressure relief valve ineffective during downward movement of the ram.

After the ram completes its broaching stroke, reversing dog 83 will shift the trip plunger 65 to the right whereby the pressure port 67 is connected to port 70 and thereby to channel 72 to effect shifting of plunger 63 to the left. When this shift occurs, port 207 is the pressure port due to the position of plunger 85 of valve 62. Port 207 is thus connected to port 178 through annular groove 213 in plunger 63 and the fluid will flow through channel 179 in branch 214 thereof to port 215 which is now connected by annular groove 216 in plunger 63 to port 58. Thus, fluid will flow through channel 56 and past check valve 130 to the left end of cylinder 36 to effect retraction of the work slide. At the same time the fluid will continue through branch 131, interconnected ports 132 and 121, pilot valve 124 and channel 120 to the right hand end of cylinder 117 to complete forward movement on the index cylinder. Thus, the broaching ram stops, the slide 28 retracts, while the index cylinder 110 completes its forward or ratcheting movement. When the slide has returned, a dog 126' actuates the pilot valve 124, shifting it to its right hand position as viewed in Figure 7. The port 141 of this valve is a pressure port at this time due to its connection with channel 56 through channel 139, and fluid pressure will flow through port 123 and channel 122 to effect return movement of the indexing cylinder 117, the direction of movement being such as to effect indexing of the work supporting table.

The exhaust fluid from cylinder 117 will pass through channel 129, interconnected ports 121 and 135 of valve 124 and through the check valve 137 into channel 136 and thereby join the exhaust fluid from the slide cylinder and return to reservoir through interconnected ports 61 and 181 of valve 62 which leads to the low pressure relief valve 175. Any fluid which may be trapped in the right end of valve cylinder 124 during the shifting of its plunger 125 to the right will be forced past the check valve 217 whereby it will return to reservoir through channel 218, interconnected ports 91 and 97 of valve 86 and lines 98 and 78 which lead to reservoir 159.

When the indexing has been completed a dog 142 carried by the index cylinder slide will shift the valve plunger 87 to the left whereby pressure port 88 will be connected to port 91, causing shifting of plunger 85 to the left and admission of fluid pressure to the choke coil 219 which is connected in parallel with check valve 217 to the end of valve cylinder 124. The fluid pressure leaking through the choke coil will slowly ease the valve plunger 125 to the left, the spring 129 incidentally becoming compressed due to the fact that trip dog 126' is still in engagement with the plunger 128.

The shifting of plunger 85 to the left also disconnects pressure from channel 218 whereby the valve 124 becomes dead and therefore the plunger 125 may complete its shifting movement without producing any effect. At the same time plunger 85 connects pressure port 203 to port 204 and thereby through channel 205 and interconnected ports 206 and 26 to the upper end of the broaching ram cylinder, causing upward movement of the broaching ram. This movement continues until the latch dog 143 actuates pilot plunger 144 which admits fluid pressure to port 149 of the stop valve housing, shifting the plunger 151 to a stop position.

The parts are now in a starting position. If the operator has finished loading the idle fixture, the next cycle may be immediately started.

Two safety interlock devices are provided in connection with the starting valve, one of which is effective to shift the valve to a stop position in case of failure of the pilot pressure produced by pump 69; and the other is to prevent reversal of the starting valve during upward movement of the ram.

The latter device comprises a stop pin 220 which is normally in position to engage a shoulder 211 on plunger 151 to determine the stop position thereof as it moves to the right. The stop pin 220 is held in its normal position by a spring 222 mounted in the housing 223. The plunger has an enlarged piston head 224 which reciprocates in a cylinder 225, and the cylinder is connected by channel 226 to pilot line 73, which line is under pressure during downward movement of the broaching ram. Therefore, the stop pin is withdrawn automatically by hydraulic pressure during downward movement of the ram whereby the operator is enabled to throw the valve plunger 151 to a reverse position to effect upward movement of the ram. This is convenient for set-up purposes or in cases of emergency.

When the plunger 151 is shifted to its reverse position the following connections are established. Port 163 is connected by cannelure 227 to port 183. The fluid will then continue through channel 182, interconnected ports 181 and 180 of valve 62, channel 179, interconnected ports 17 and 26 of valve 24 and channel 25 to the upper end of the ram cylinder, causing upward movement of the ram. The return fluid will flow through channel 22, interconnected ports 23 and 207 of valve 24, channel 208, interconnected ports

228 and 203 of valve 62, channel 202, interconnected ports 201 and 229 of valve 150 and channels 172 and 177 to reservoir.

The other safety interlock comprises an interlock plunger 230 which is mounted in the end of the stop valve housing 150 as shown in Figure 7 and provided with a piston 231 which is slidably mounted in a cylinder 232. One end of the cylinder is connected by a channel 233 to the delivery line 68 of pilot pump 69 whereby the normal pressure in this line will act to hold the plunger in a retracted position against the compression of a spring 234. Should the pressure fail for any reason, such as stoppage of the pump, or a break in any of the lines of the system, the loaded spring will expand and shift the valve plunger 151 to a stop position. This will insure automatic stoppage of the machine in case of failure of pressure in the pilot control system.

There has thus been provided an improved automatic broaching machine having improved automatic work indexing means and an improved control circuit for coordinating the movements of the shiftable and indexible work supporting structure with the movements of the broaching ram.

What is claimed is:

1. In a broaching machine having a support, a broaching ram reciprocably mounted on said support, a slide, and guideways on the support for guiding said slide for movement toward and from the ram, the combination of a table rotatably mounted on the slide for rotation about an axis intersecting the longitudinal axis of the guideways, stops positioned on the table at equal distances on opposite sides of a radius of said table, fixed abutments on the support lying in a plane parallel to the plane of reciprocation of the broaching ram, and means to shift the slide and table toward the broaching ram to force the table stops into simultaneous engagement with said abutments whereby the table will be rotated to superimpose said radius in the vertical plane of said guideway axis.

2. In a broaching machine having a support, a broaching ram reciprocably mounted on the support, a slide, and guideways formed on the support for receiving and guiding the slide for movement toward and from the broaching ram, the combination of a table rotatably supported on said slide, fixed abutments located on the support on opposite sides of the ram and lying in a plane parallel thereto, stops positioned on the table on opposite sides of a radius thereof and equal distances therefrom, means for shifting the slide and table toward the broaching ram and simultaneously effect engagement of said stops with said abutments whereby the table will be positioned with said radius in a predetermined angular relation to the plane of reciprocation of the broaching ram.

3. In a broaching machine having a support, a broaching ram reciprocably mounted on said support, guideways formed on said support perpendicular to the plane of said broaching ram, and a slide mounted on said guideways, the combination of a table rotatably mounted on said slide with its axis of revolution intersecting the longitudinal axis of said guideways, a pair of stops positioned on said table equally distant from a predetermined radius thereof, fixed abutments for said stops located on the support on opposite sides of the broaching ram, and means for shifting said table until the stops are in engagement with the respective abutments whereby said table will be angularly positioned with said radius perpendicular to the plane of the broaching ram.

4. In a broaching machine having a support, a broaching ram reciprocably mounted on said support and a slide guided on said support for movement toward and from the broaching ram, the combination of a table rotatably positioned on said slide having its axis perpendicular to the plane of the slide guideways, a pair of stops located on the table equi-distant on opposite sides of a predetermined radius thereof, and a pair of abutments on the support for engaging said stops upon advance of the slide toward the broaching ram to rotatably position the table with said radius in a predetermined angular relation to the plane of the broaching ram.

5. In a broaching machine having a broaching ram and a slide movable toward and from said ram, the combination of a work supporting table indexibly mounted on said slide, clockwise and counterclockwise revolution stops mounted on the table, a support for said ram carrying fixed abutments for engagement by the respective stops upon advancement of said slide, and means to shift the slide and table toward the ram whereby irregular engagement of said stops will cause rotation of the table into a predetermined angular relation with respect to said broaching ram.

6. In a broaching machine having a broaching ram and a slide movable toward and from said ram, the combination of a table supported on said slide for free rotation relative thereto, clockwise and counterclockwise revolution stops mounted on the table, a support for the broaching ram, fixed abutments attached to the support, and means to shift the slide and table toward the ram and engage the stops with the respective abutments, whereby the table will be simultaneously positioned angularly and at a predetermined linear distance from the broaching ram.

7. In a broaching machine having a broaching ram, a slide, and a work supporting table mounted on the slide for free rotation relative thereto, the combination with means for shifting the slide and table toward the broaching ram, of means for positioning the table linearly and angularly with respect to the broaching ram including fixed abutments located on opposite sides of the ram, and clockwise and counterclockwise revolution stops on the table for engaging said abutments during advancement of the slide.

8. In a broaching machine having a broaching ram, a slide movable toward and from the ram, a work supporting table indexibly mounted on the slide, the combination of means for reciprocating said slide, a pair of abutments located at opposite sides of the broaching ram, a series of pairs of stops carried by the table, and means to index the table to align a pair of said stops with said abutments whereby upon advancement of the slide the table will be angularly and linearly positioned with respect to the broaching ram.

9. In a broaching machine having a broaching ram, a slide movable toward and from the ram, a work supporting table indexibly mounted on the slide, the combination of means for reciprocating said slide, a pair of abutments located at opposite sides of the broaching ram, a series of pairs of stops carried by the table, means to index the table to align a pair of said stops with said abutments whereby upon advancement of the slide the table will be angularly and linearly positioned

with respect to the broaching ram, and means to lock the slide to hold the table against said abutments.

10. In a broaching machine having a reciprocating broaching ram and a work supporting slide, the combination of means for advancing and retracting the slide between strokes of the ram including a piston and cylinder, an indexible table carried by the slide, a piston and cylinder for indexing the table, means to admit pressure to one end of each cylinder to advance the slide without rotation of the table at the end of one stroke of the ram, and means to admit pressure to the other ends of the cylinders sequentially to effect return of the slide and subsequent indexing of the table at the end of the next stroke of the ram.

11. In a broaching machine having a reciprocating ram and a work supporting slide, the combination of means for advancing and retracting the slide between strokes of the ram including a piston and cylinder, an indexible table carried by the slide, a piston and cylinder for indexing the table, a source of fluid pressure, control means for admitting pressure to one end of each cylinder to advance the slide without rotation of the table at the end of the idle stroke of the ram, and additional control means to effect admission of pressure to the other ends of said cylinders sequentially to effect return of the slide and subsequent indexing of the table at the end of the cutting stroke of the ram.

12. In a broaching machine having a reciprocating broaching ram and a work supporting slide, the combination with an indexible table mounted on said slide, of means for advancing and retracting the slide between strokes of the ram including a piston and cylinder for the slide, a second piston and cylinder for indexing the table, means controlled by the ram for admitting pressure to one end of each cylinder to effect advance of the slide without rotation of the table at the end of the upward stroke of the ram, and additional control means to effect admission of pressure to the other ends of said cylinders sequentially to effect return of the slide and subsequent indexing of the table at the end of the downward stroke of the ram.

13. In a broaching machine having a reciprocating ram and a work supporting slide, the combination of means for shifting the slide after each stroke of the ram including a piston and cylinder, an indexible table mounted on the slide, a piston and cylinder for indexing the table, means trip operable by the ram at the end of its cutting stroke for causing admission of pressure to one end of the slide cylinder to effect retraction of the slide, and means trip operable by the slide for causing admission of fluid pressure to one end of the indexing cylinder to effect indexing of the table after the slide has returned.

14. In a broaching machine having a reciprocating ram and a work supporting slide, the combination of means for shifting the slide after each stroke of the ram including a piston and cylinder, an indexible table mounted on the slide, a piston and cylinder for indexing the table, means trip operable by the ram at the end of its cutting stroke for causing admission of pressure to one end of the slide cylinder to effect retraction of the slide, means trip operable by the slide for causing admission of fluid pressure to one end of the indexing cylinder to effect indexing of the table after the slide has returned, and means trip operable upon completion of table indexing to effect a return stroke of the broaching ram.

15. In a broaching machine having a reciprocable broaching ram and a work supporting slide, the combination with a work table indexibly supported on the slide, of a control circuit for actuating said parts including a source of fluid pressure, manual control means for coupling said source of pressure to the circuit for initiating movement of the ram, fluid operable means for shifting the slide and table to a cutting position, means trip operable by the ram at the end of its idle stroke to connect said source of pressure to said fluid operable means, a common means effective for locking the table against rotation and bodily movement in the cutting position, and means trip operable by the slide for starting the ram on its cutting stroke after the table is locked.

16. In a broaching machine having a reciprocable broaching ram, a work supporting slide and an indexible table mounted on the slide, the combination of transmission and control means for effecting an automatic cycle of operation including an indexing shaft supported on the slide in operative connection with the table, a ratchet gear mounted on the shaft, a rack bar reciprocably supported for rotating said gear, independent fluid operable means for shifting the slide and the rack bar respectively, additional fluid operable means for reciprocating said ram, means trip operable by the ram at the end of its return stroke to connect pressure to said first-named fluid operable means to effect advance of the slide without rotation of the table, and means trip operable by the ram at the end of its cutting stroke to effect reverse actuation of said fluid operable means sequentially whereby after said slide returns, the rack bar will be actuated to effect indexing of the table through said ratchet gear.

17. In a broaching machine of the character described having a reciprocable ram, a slide movable toward and from the ram and a work supporting table mounted on the slide, the combination with means for shifting the slide and table as a unit toward the broaching ram, of means for jointly restricting the free inward movement of the slide and rotary movement of the table on the slide including a set of abutment members disposed in fixed position as respects the plane of the ram and a set of stop members carried by the table for cooperation with the abutments, said stops of a set being disposed at opposite sides of the center of rotation of the table whereby interengagement of the stops and abutments will limit the unitary advance of the slide and table in the direction of the ram and concomitantly determine the angular positioning of the table with respect to the ram.

18. In a broaching machine of the character described having a reciprocable ram, a slide movable toward and from the ram and a work supporting table mounted on the slide, the combination with means for shifting the slide and table as a unit toward the broaching ram, of means for jointly restricting the free inward movement of the slide and rotary movement of the table on the slide including a set of abutment members disposed in fixed position as respects the plane of the ram and a set of stop members carried by the table for cooperation with the abutments, said stops of a set being disposed at opposite sides of the center of rotation of the table whereby interengagement of the stops and abutments will limit the unitary advance of the slide and table in the direction of the ram and concomitantly determine the angular positioning of the table with

respect to the ram, one or more of said members being adjustable to vary the ultimate position of the slide and table elements with respect to the ram.

19. In a broaching machine of the character described including a reciprocable ram, a slide movable in a direction toward and from the ram, a work supporting table mounted on the slide for rotation with respect thereto, means for effecting rotational indexing movements of prescribed amount of the table with respect to the slide, abutment members mounted on the machine, and a plurality of sets of stop members mounted on the table and alternately positionable in alignment with the abutments upon indexing of the table, and means for moving the slide and table as a unit in the direction of abutments to an extent limited by the interengagement of the stops and abutments for definite determination of the relationship of the table to the broach.

20. In a broaching machine of the character described including a reciprocable ram, a slide movable in a direction toward and from the ram, a work supporting table mounted on the slide for rotation with respect thereto, means for effecting rotational indexing movements of prescribed amount of the table with respect to the slide, abutment members mounted on the machine, and a plurality of sets of stop members mounted on the table and alternately positionable in alignment with the abutments upon indexing of the table, means for moving the slide and table as a unit in the direction of abutments to an extent limited by the interengagement of the stops and abutments for definite determination of the relationship of the table to the broach, and means for adjustably positioning the interengageable stop and abutment elements variably to determine said relative positioning.

21. In a broaching machine of the character described including a reciprocable ram, a slide movable in a direction toward and from the ram, a work supporting table mounted on the slide for rotation with respect thereto, means for effecting rotational indexing movements of prescribed amount of the table with respect to the slide, abutment members mounted on the machine, and a plurality of sets of stop members mounted on the table and alternately positionable in alignment with the abutments upon indexing of the table, means for moving the slide and table as a unit in the direction of abutments to an extent limited by the interengagement of the stops and abutments for definite determination of the relationship of the table to the broach, means for adjustably positioning the interengageable stop and abutment elements variably to determine said relative positioning, and means for positively locking the parts in said adjusted relationship.

22. A machine of the character described, including a frame, a broach ram reciprocable on the frame, a slide on the frame movable in the direction toward and from the ram, a table rotatably mounted on the slide for presentation of work in opposition to the ram, a first hydraulic motor including a piston and cylinder having one of said parts coupled with the frame and the other with the slide for effecting reciprocation of the same, and a second hydraulic motor including a piston and cylinder having one element coupled to the table and the other to the frame for effecting rotation of the table, a source of hydraulic actuating medium, and means for controlling the coupling of said medium to the respective motors.

23. A machine of the character described, including a frame, a broach ram reciprocable on the frame, a slide on the frame movable in the direction toward and from the ram, a table rotatably mounted on the slide for presentation of work in opposition to the ram, a first hydraulic motor including a piston and cylinder having one of said parts coupled with the frame and the other with the slide for effecting reciprocation of the same, and a second hydraulic motor including a piston and cylinder having one element coupled to the table and the other to the frame for effecting rotation of the table, a source of hydraulic actuating medium, a first means for effecting a coupling of the motors in series with said medium, and additional means for effecting coupling of the hydraulic actuating medium in parallel with said hydraulic motors.

24. A machine of the character described, including a frame, a broach ram reciprocable on the frame, a slide on the frame movable in the direction toward and from the ram, a table rotatably mounted on the slide for presentation of work in opposition to the ram, a first hydraulic motor including a piston and cylinder having one of said parts coupled with the frame and the other with the slide for effecting reciprocation of the same, and a second hydraulic motor including a piston and cylinder having one element coupled to the table and the other to the frame for effecting rotation of the table, a source of hydraulic actuating medium, a first means for effecting a coupling of the motors in series with said medium, additional means for effecting coupling of the hydraulic actuating medium in parallel with said hydraulic motors, and means for effecting a reversal of pressure in one of said hydraulic motors.

25. A machine of the character described, including a frame, a broach ram reciprocable on the frame, a slide on the frame movable in the direction toward and from the ram, a table rotatably mounted on the slide for presentation of work in opposition to the ram, a first hydraulic motor including a piston and cylinder having one of said parts coupled with the frame and the other with the slide for effecting reciprocation of the same, and a second hydraulic motor including a piston and cylinder having one element coupled to the table and the other to the frame for effecting rotation of the table, a source of hydraulic actuating medium, a first means for effecting a coupling of the motors in series with said medium, additional means for effecting coupling of the hydraulic actuating medium in parallel with said hydraulic motors, means for effecting a reversal of pressure in one of said hydraulic motors, and means for effecting a subsequent reversal of pressure effect as respects the other of said hydraulic motors.

26. In a machine of the character described, the combination with a frame, a ram reciprocable thereon and a slide movable toward and from the ram, of a table rotatably mounted on the slide, a first hydraulic motor for effecting movement of the slide in a direction toward and from the ram, and a second hydraulic motor for effecting rotational movements of the table with respect to the slide, and means for controlling the actuation of said motors including a source of hydraulic actuating medium, a first means shiftable to couple the medium with the motors for joint unidirectional actuation thereof, means shiftable to maintain unidirectional movement of one of said motors while coupling the medium

to effect reversal of the other, and additional means for effecting sequential reversals of the respective motors.

27. A control mechanism for a machine of the character described which includes a reciprocable ram, a slide movable in a direction toward and away from the ram, a rotary table on the slide and means for locking the slide and table in operative position with respect to the ram, said control mechanism including a first hydraulic motor individual to the ram, a second hydraulic motor individual to the table, and an additional hydraulic motor jointly effective as respects the slide and the locking means, a source of hydraulic pressure for supply of actuating medium to the several motors, means actuable to couple the hydraulic pressure to the slide motor for effecting a movement of the slide and locking member, means actuable on a prescribed movement of said parts for coupling the hydraulic medium to the ram motor for initiating operation thereof, means actuable by the ram motor for effecting reversal of the slide motor, means actuable by the slide motor for effecting coupling of the hydraulic medium for actuation of the table motor, and means actuable by the table motor for effecting coupling of the hydraulic medium to reverse the ram motor.

28. A control mechanism for a machine of the character described which includes a reciprocable ram, a slide movable in a direction toward and away from the ram, a rotary table on the slide and means for locking the slide and table in operative position with respect to the ram, said control mechanism including a first hydraulic motor individual to the ram, a second hydraulic motor individual to the table, and an additional hydraulic motor jointly effective as respects the slide and the locking means, a source of hydraulic pressure for supply of actuating medium to the several motors, means actuable to couple the hydraulic pressure to the slide motor for effecting a movement of the slide and locking member, means actuable on a prescribed movement of said parts for coupling the hydraulic medium to the ram motor for initiating operation thereof, means actuable by the ram motor for effecting reversal of the slide motor, means actuable by the slide motor for effecting coupling of the hydraulic medium for actuation of the table motor, means actuable by the table motor for effecting coupling of the hydraulic medium to reverse the motor, and means movable with the ram for interrupting the actuation of the several motors.

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