Sept. 1, 1953 L. E. GODFRIAUX 2,650,522

TURN MILLING MACHINE

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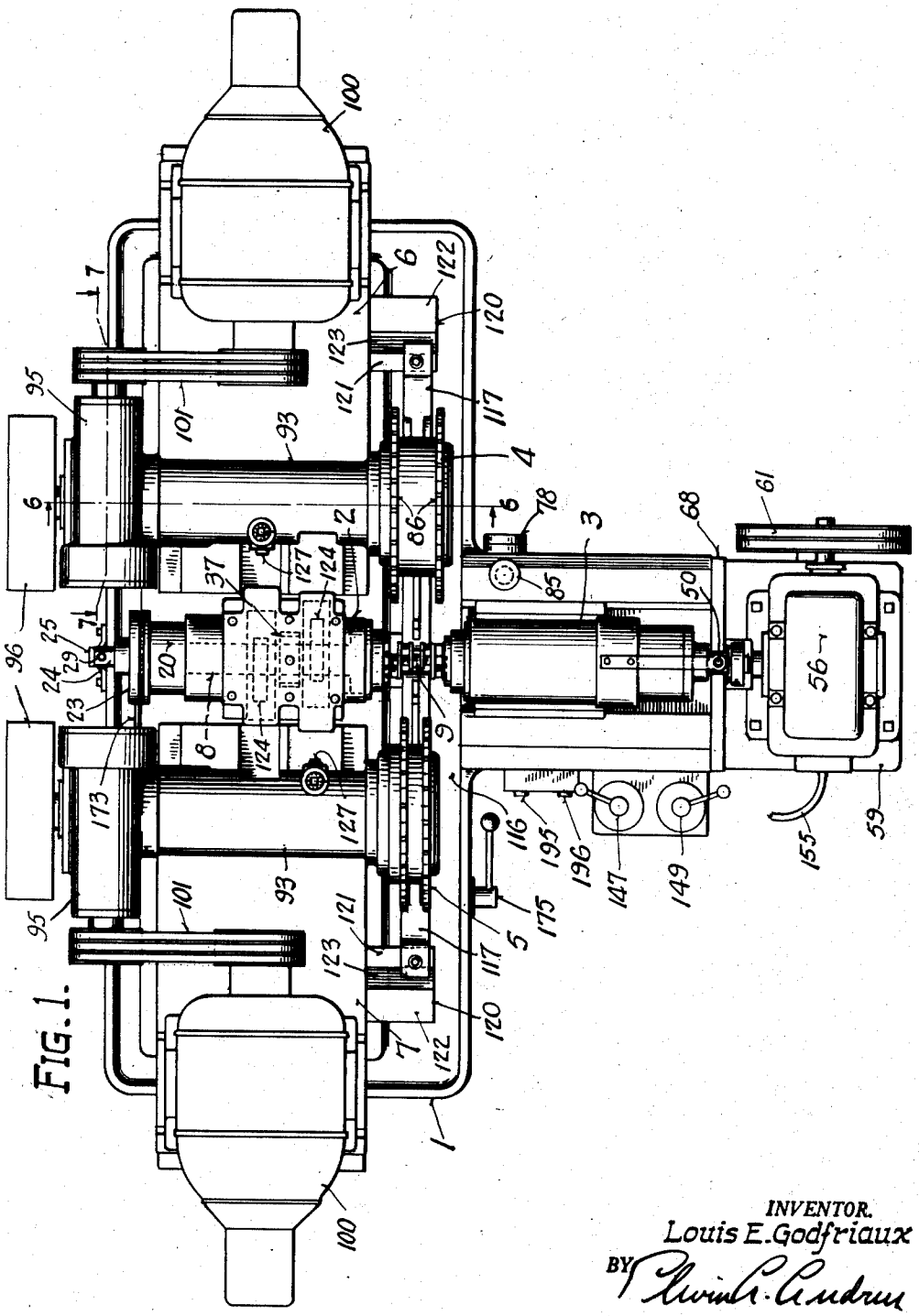


FIG. 1.

INVENTOR.
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BY Alvin C. Andrus
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Sept. 1, 1953 L. E. GODFRIAUX 2,650,522

TURN MILLING MACHINE

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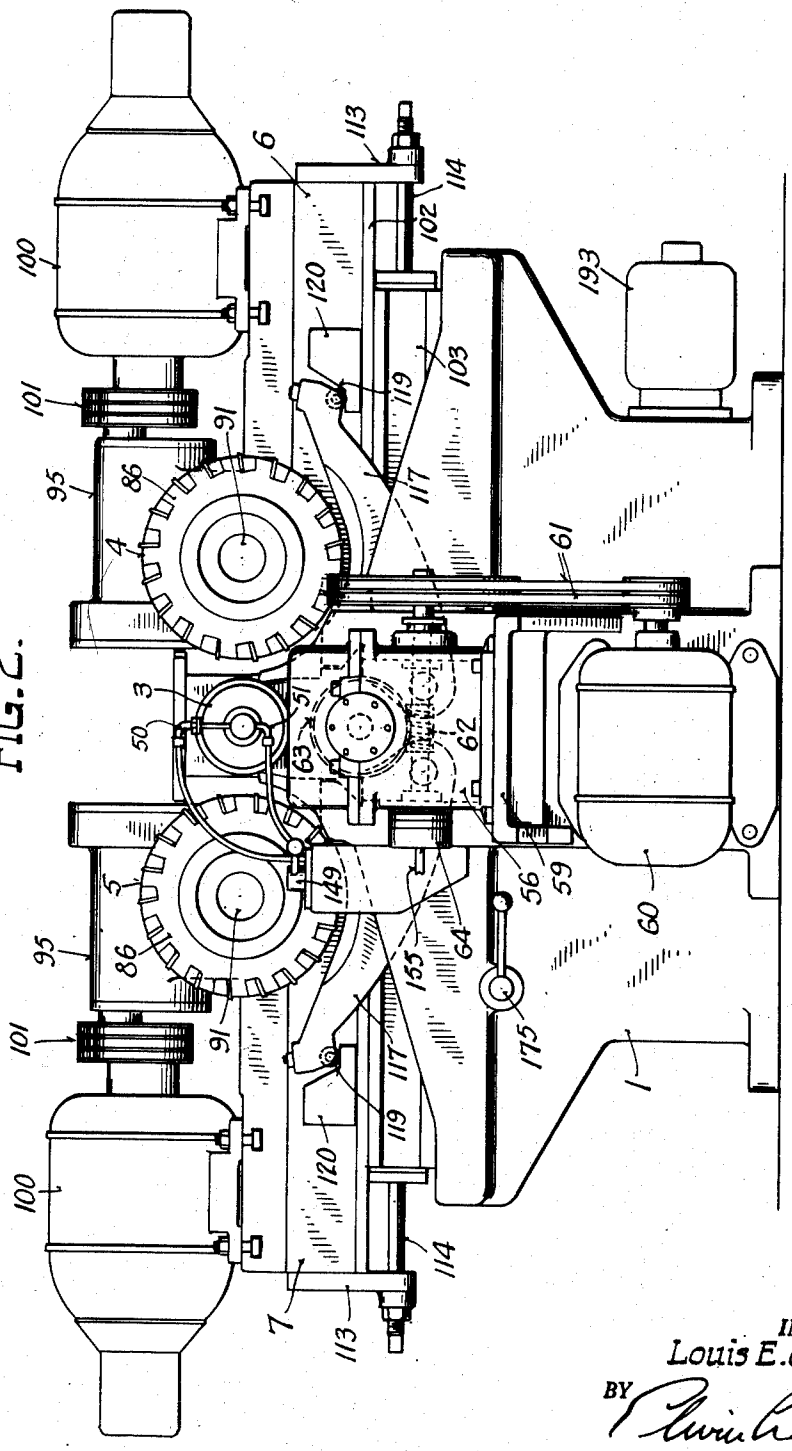


FIG. 2.

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Sept. 1, 1953 L. E. GODFRIAUX 2,650,522

TURN MILLING MACHINE

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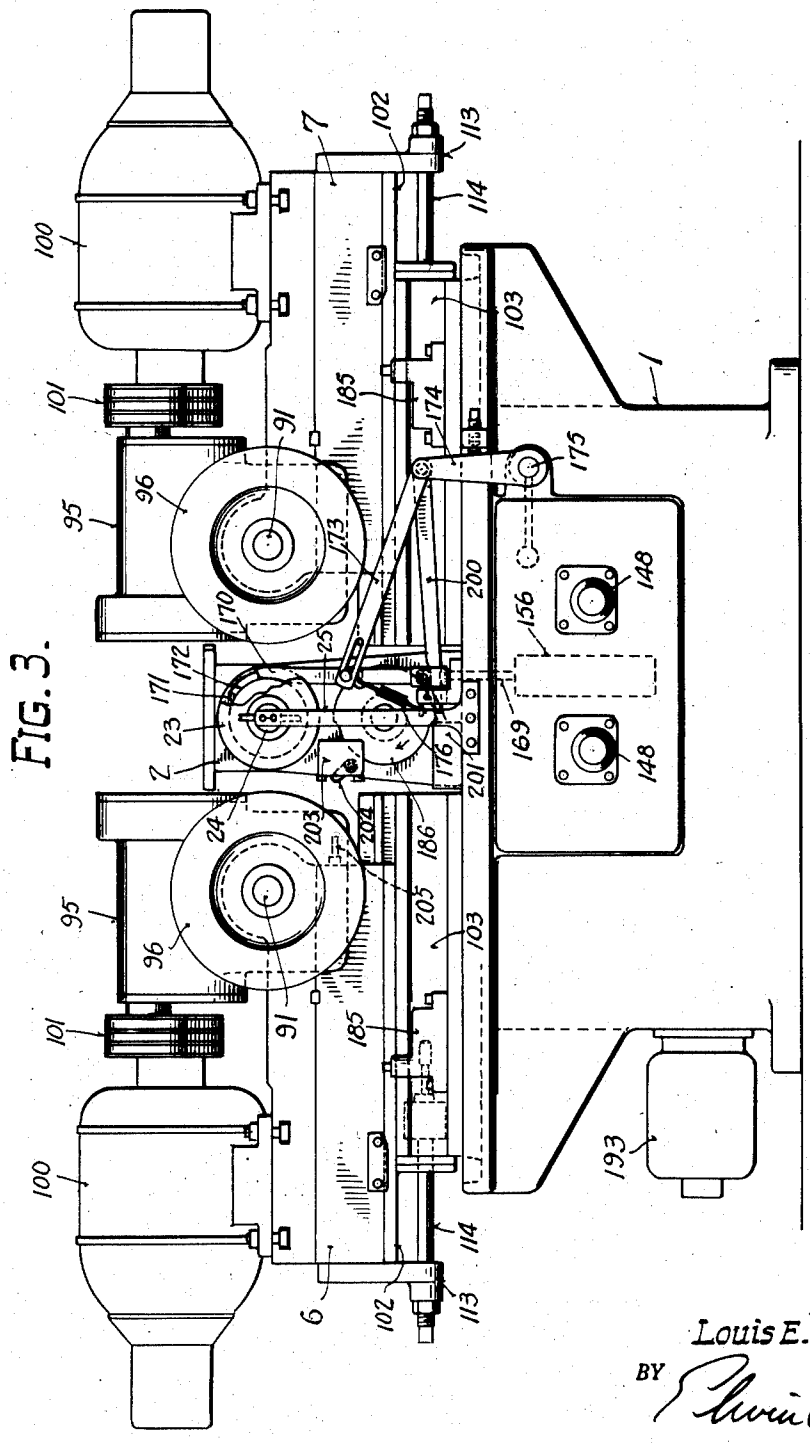


FIG. 3.

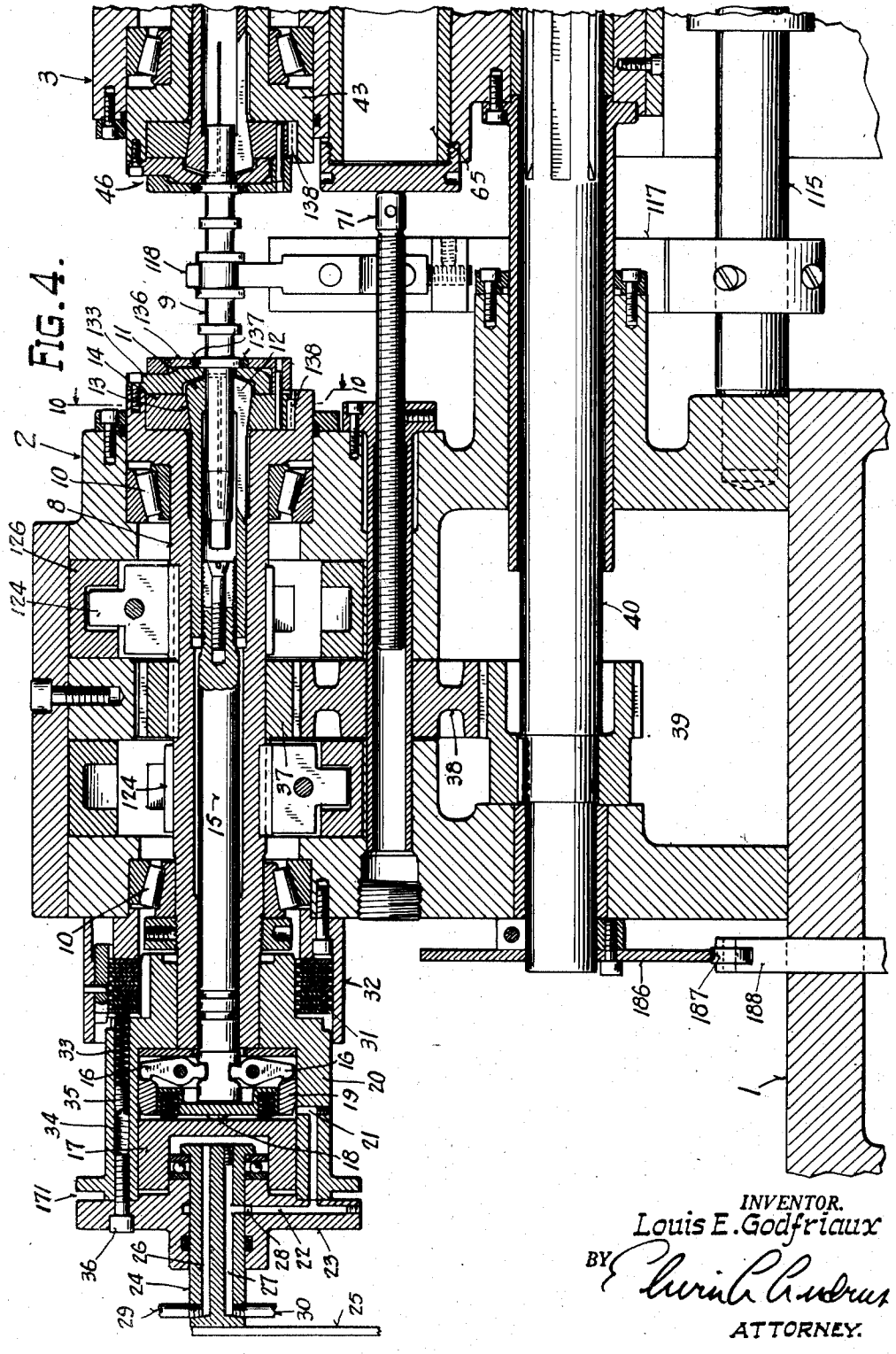
INVENTOR.
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Sept. 1, 1953 L. E. GODFRIAUX 2,650,522

TURN MILLING MACHINE

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FIG. 4.



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Sept. 1, 1953 L. E. GODFRIAUX 2,650,522

TURN MILLING MACHINE

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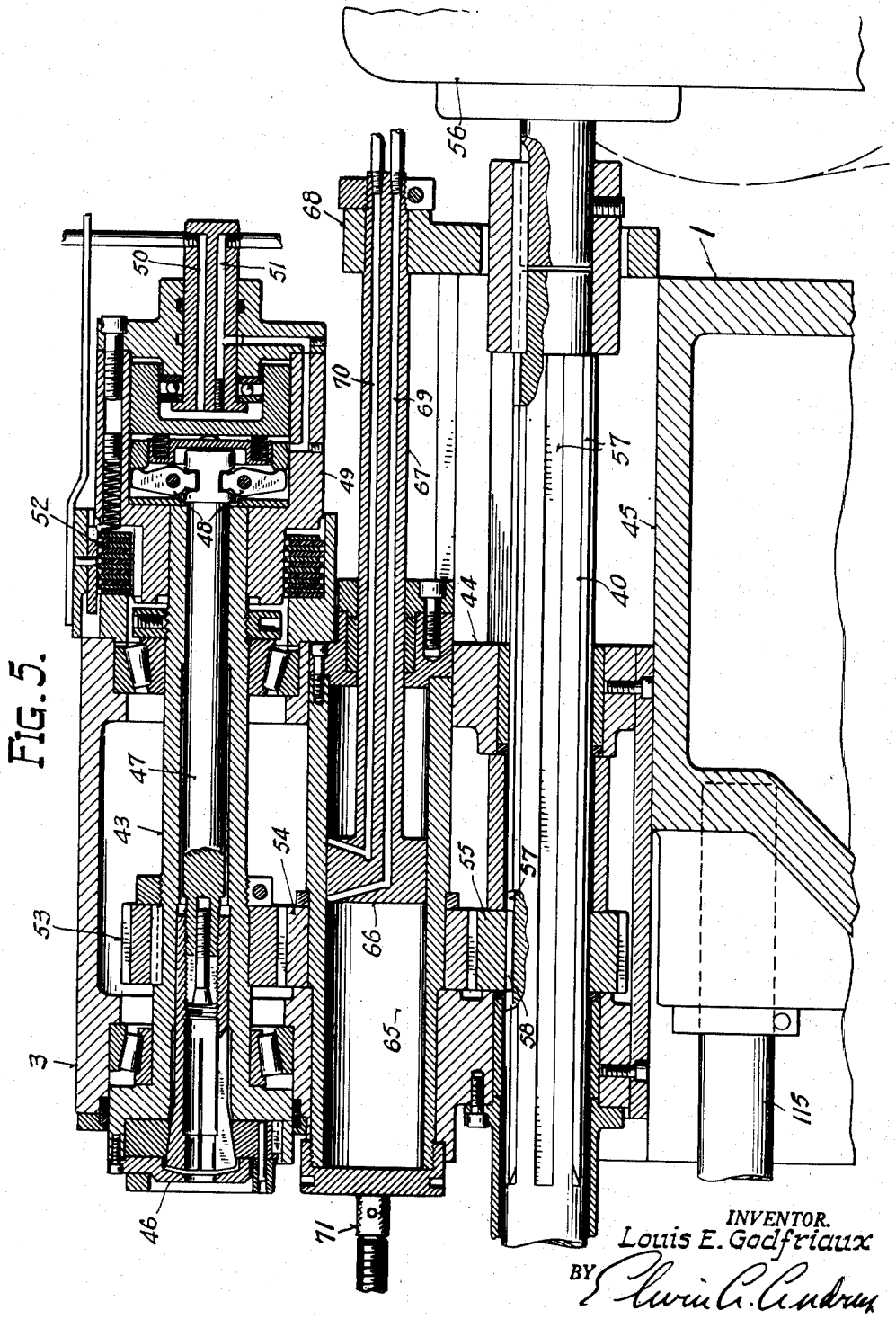


FIG. 5.

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Sept. 1, 1953 L. E. GODFRIAUX 2,650,522

TURN MILLING MACHINE

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FIG. 6.

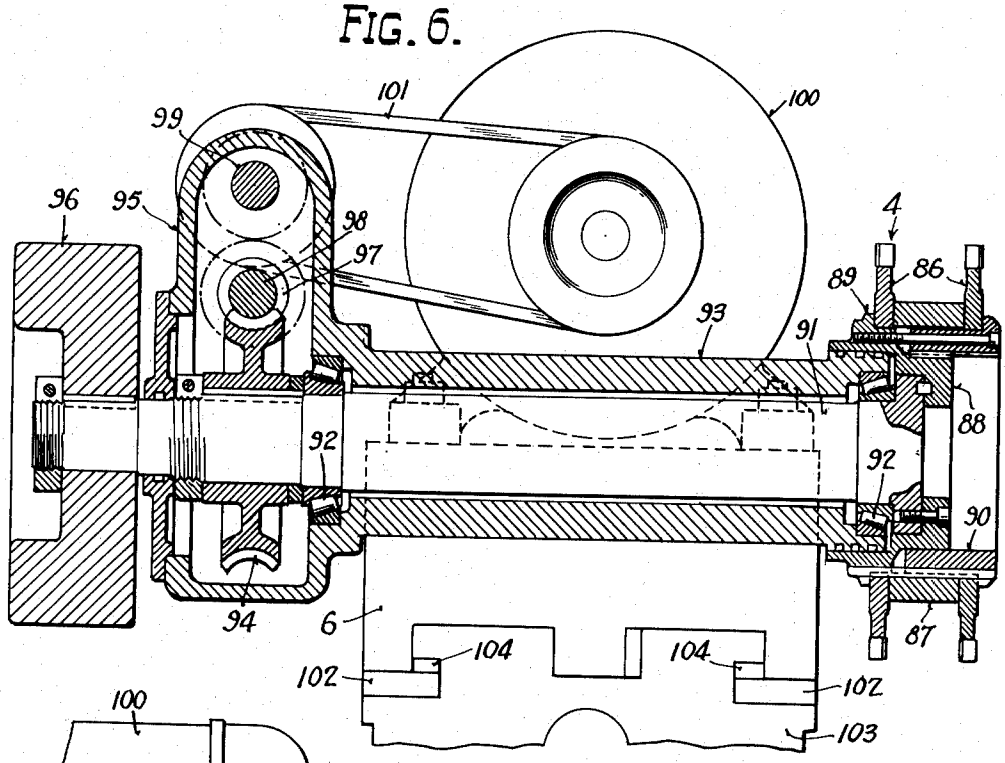
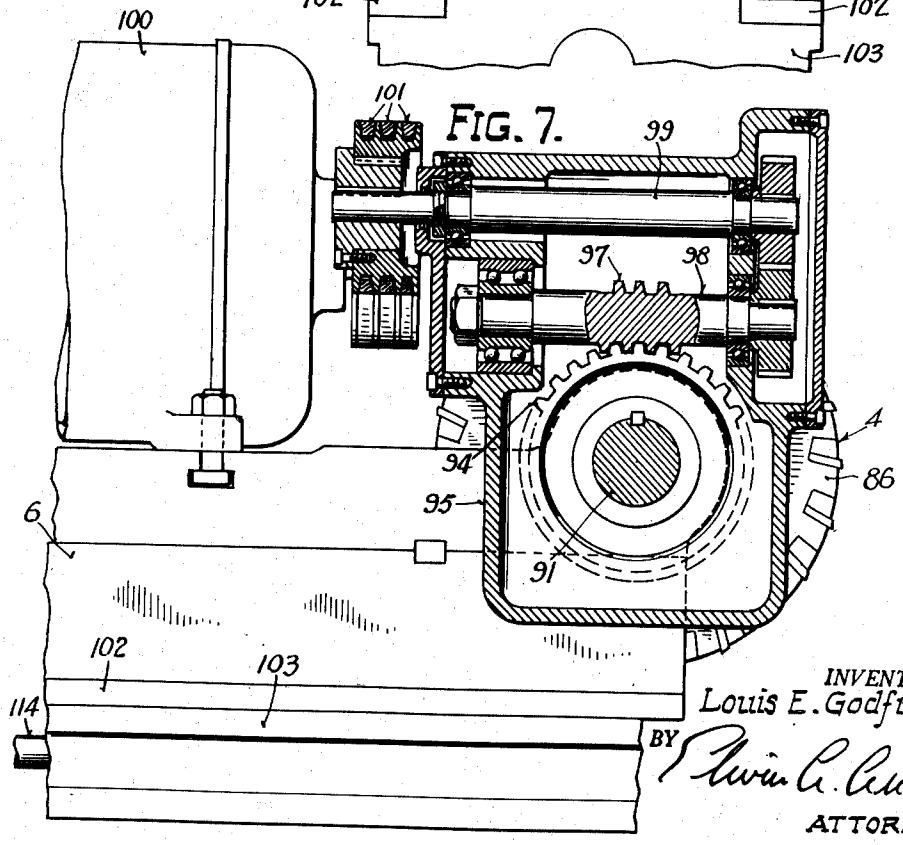


FIG. 7.



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Sept. 1, 1953 L. E. GODFRIAUX 2,650,522

TURN MILLING MACHINE

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FIG. 8.

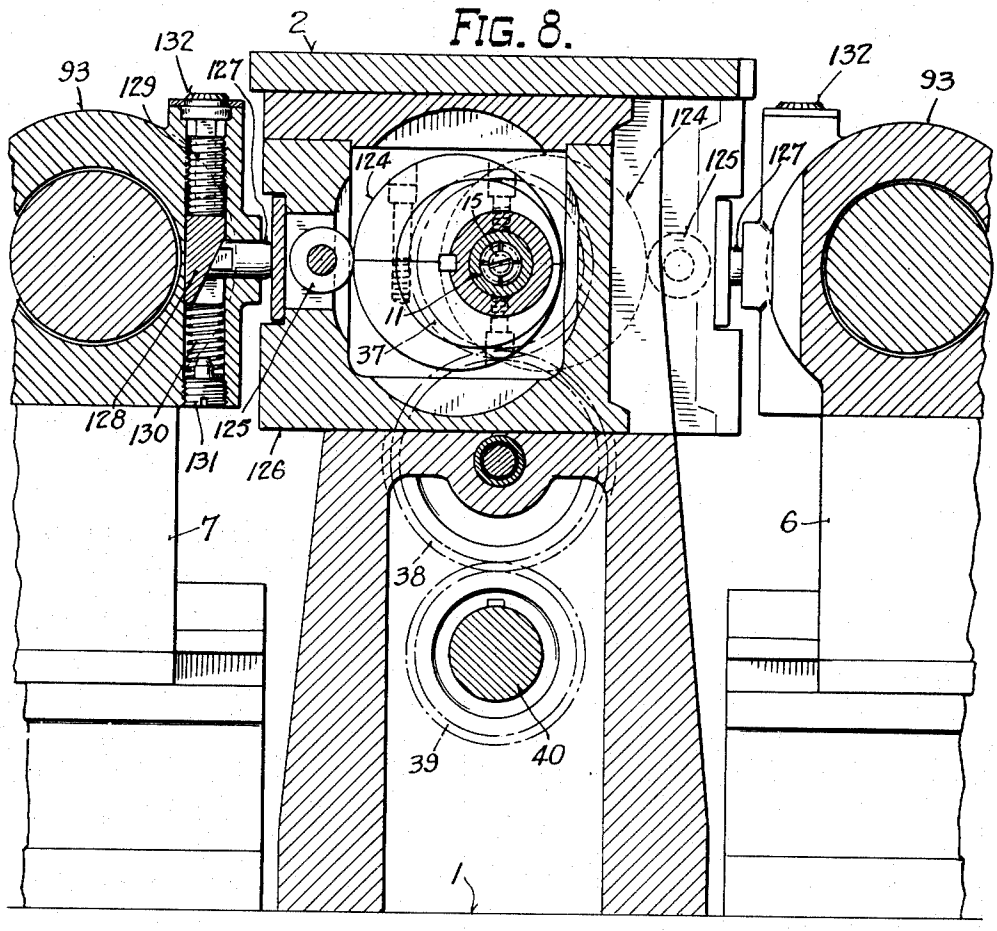


FIG. 9.

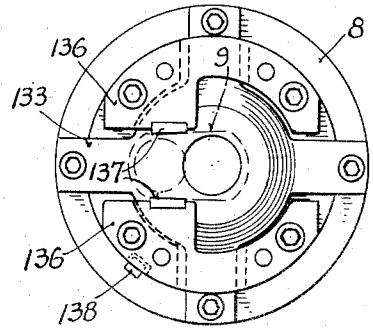
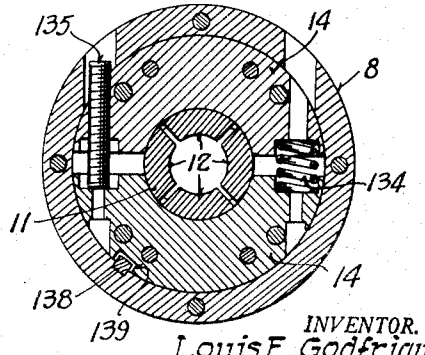


FIG. 10.



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Sept. 1, 1953 L. E. GODFRIAUX 2,650,522

TURN MILLING MACHINE

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FIG. 11.

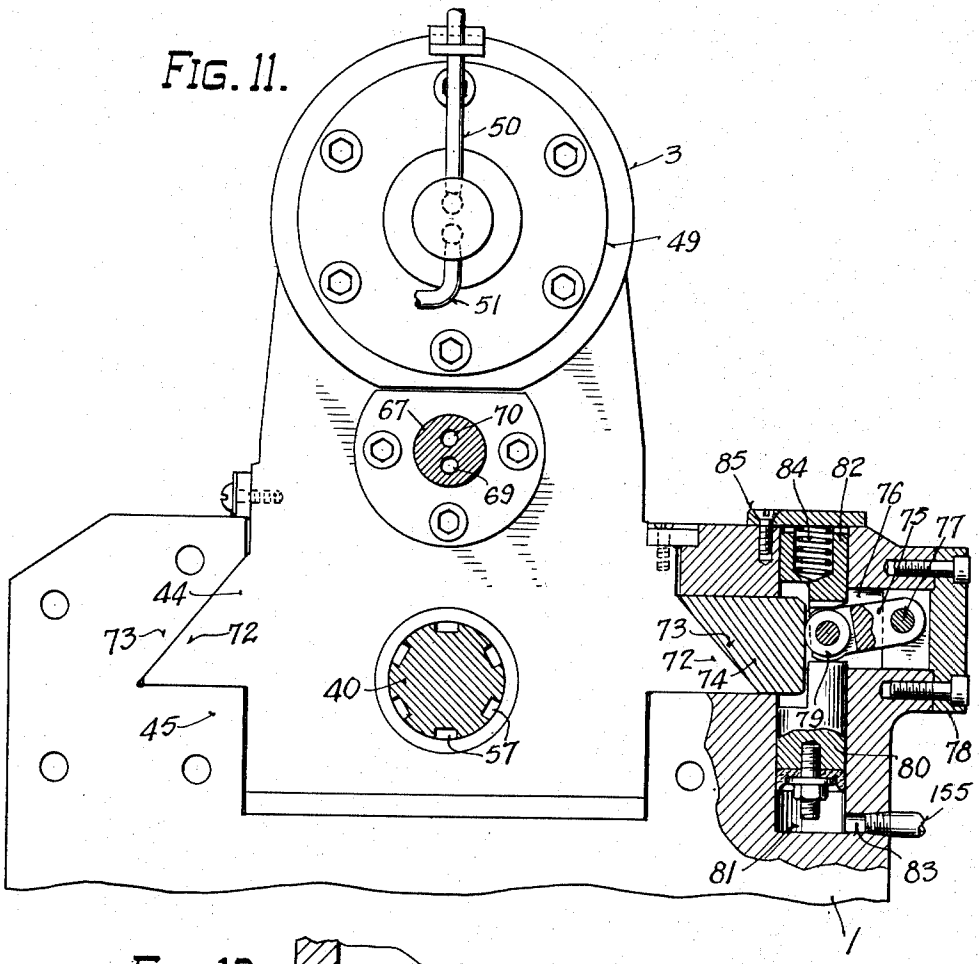
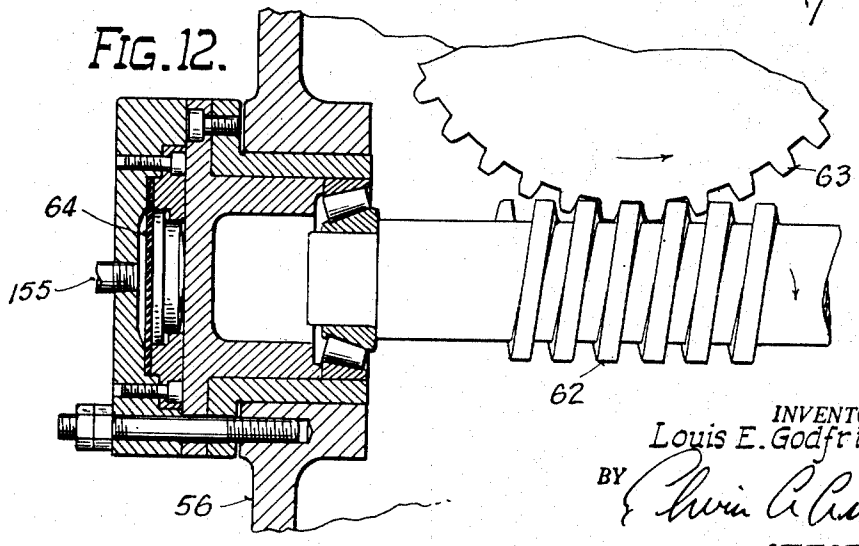


FIG. 12.



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TURN MILLING MACHINE

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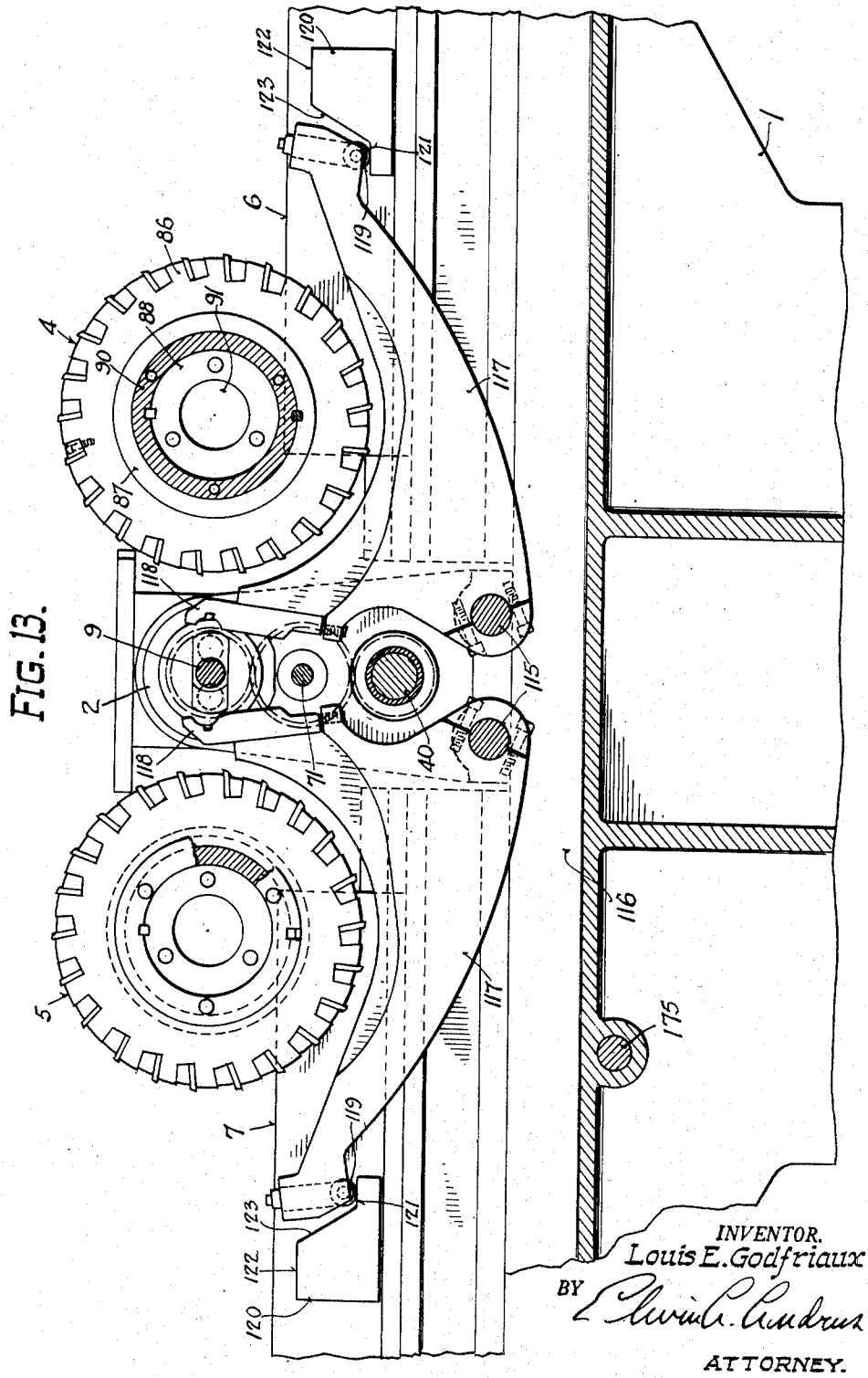


FIG. 13.

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Sept. 1, 1953 L. E. GODFRIAUX 2,650,522

TURN MILLING MACHINE

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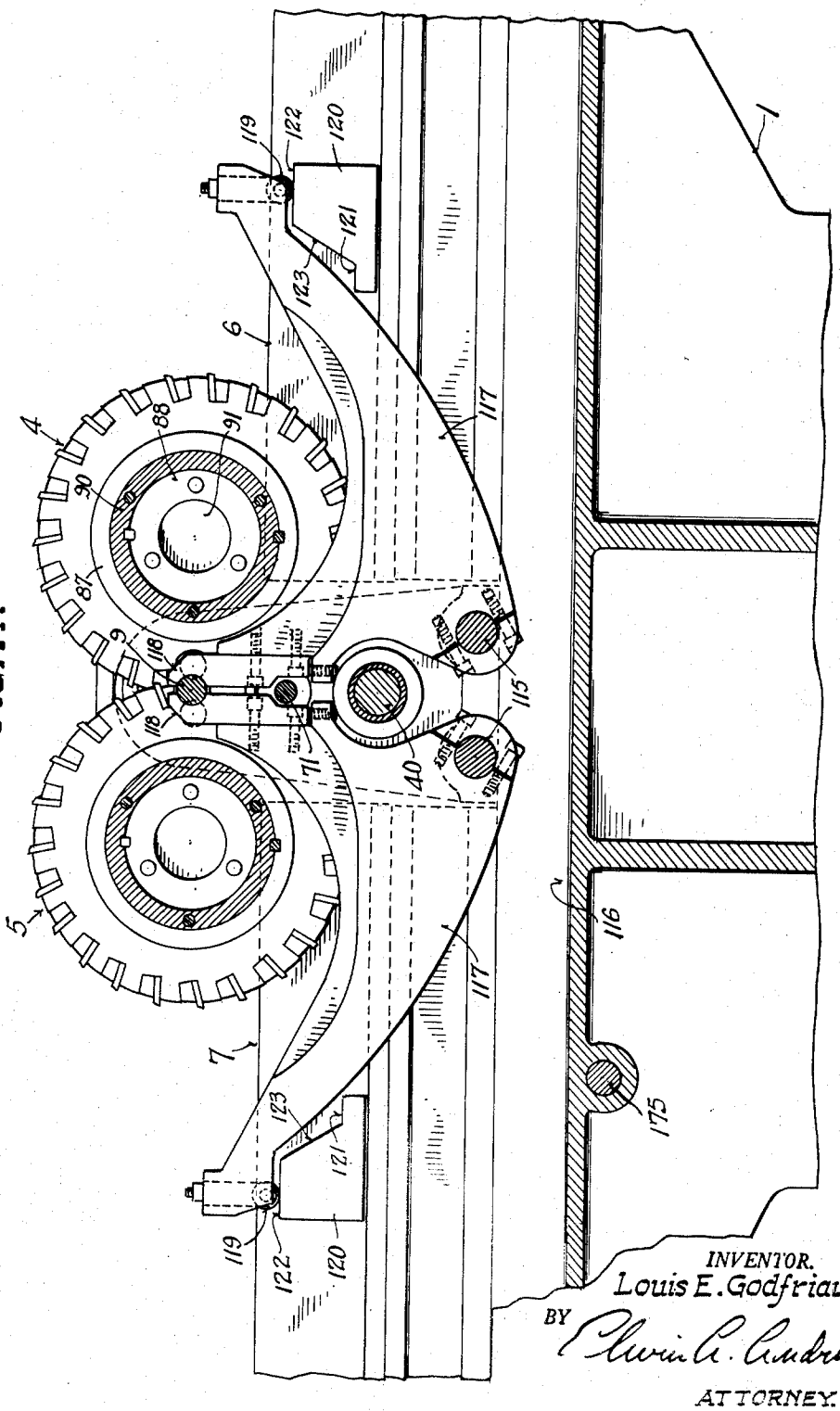


FIG. 14.

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TURN MILLING MACHINE

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FIG. 15.

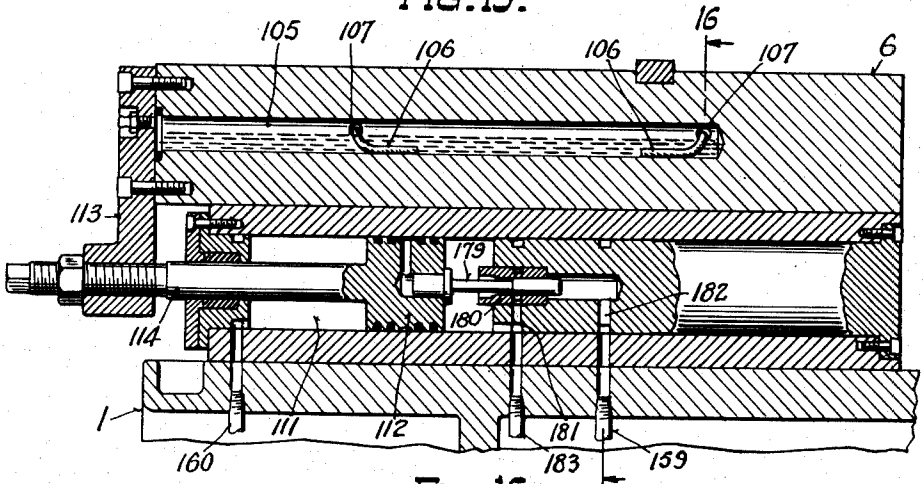
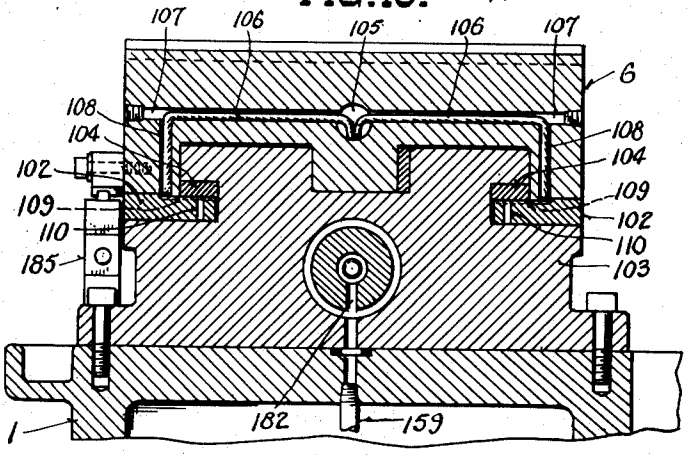


FIG. 16.



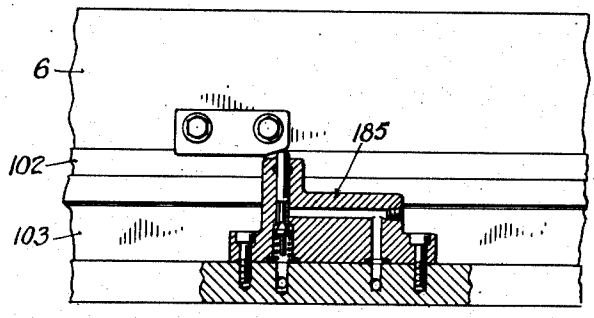


FIG. 17.

INVENTOR.
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TURN MILLING MACHINE

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FIG. 18.

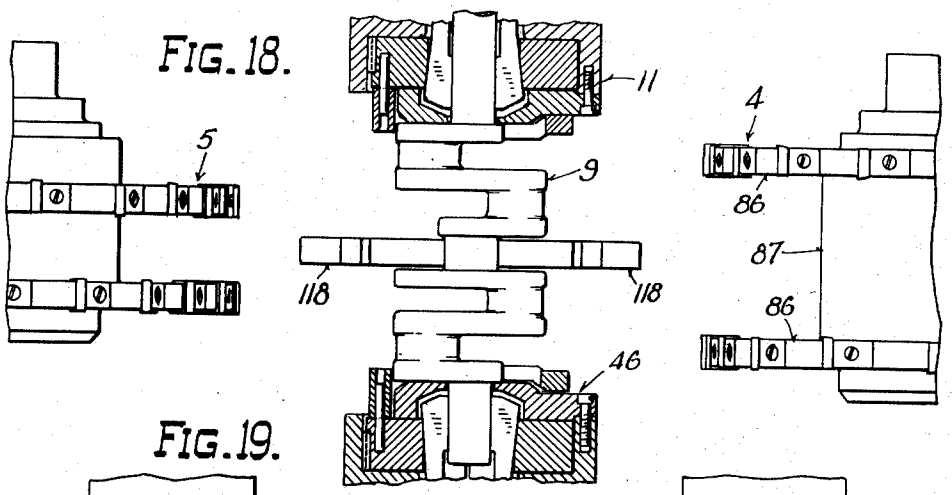


FIG. 19.

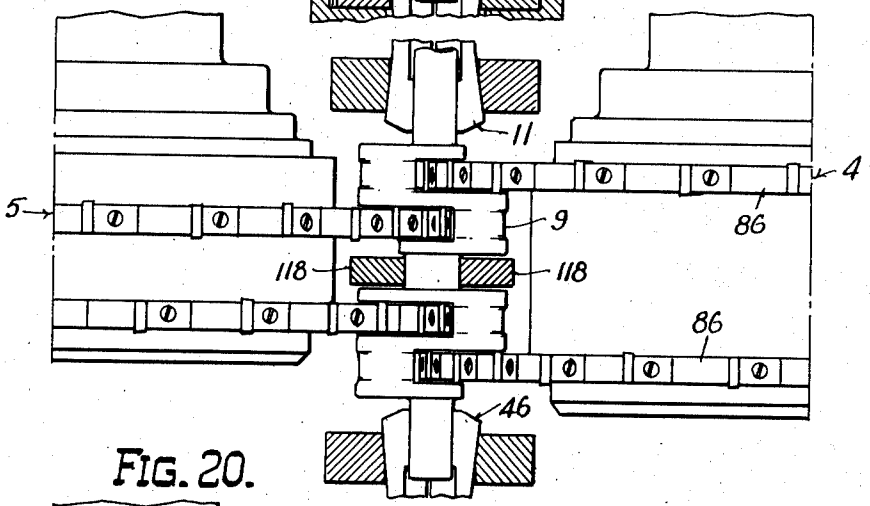
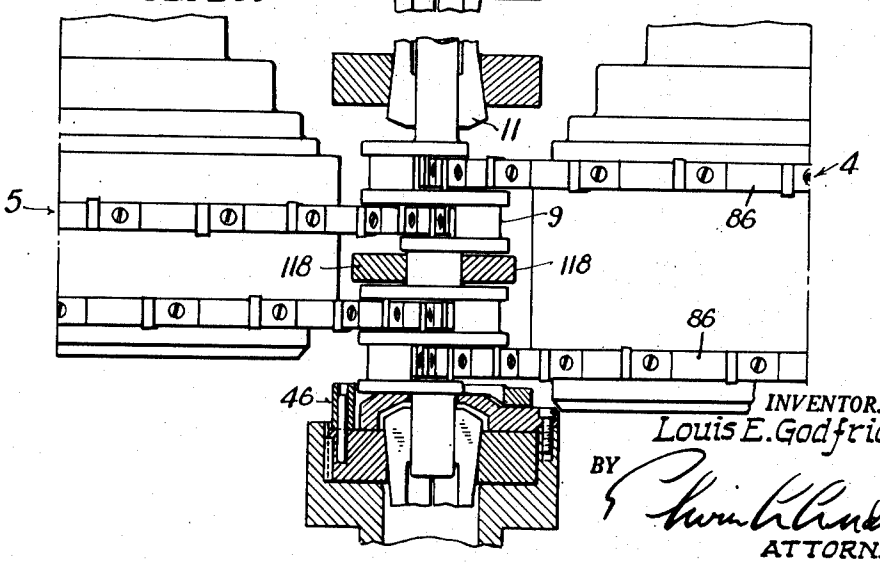


FIG. 20.



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Sept. 1, 1953 L. E. GODFRIAUX 2,650,522

TURN MILLING MACHINE

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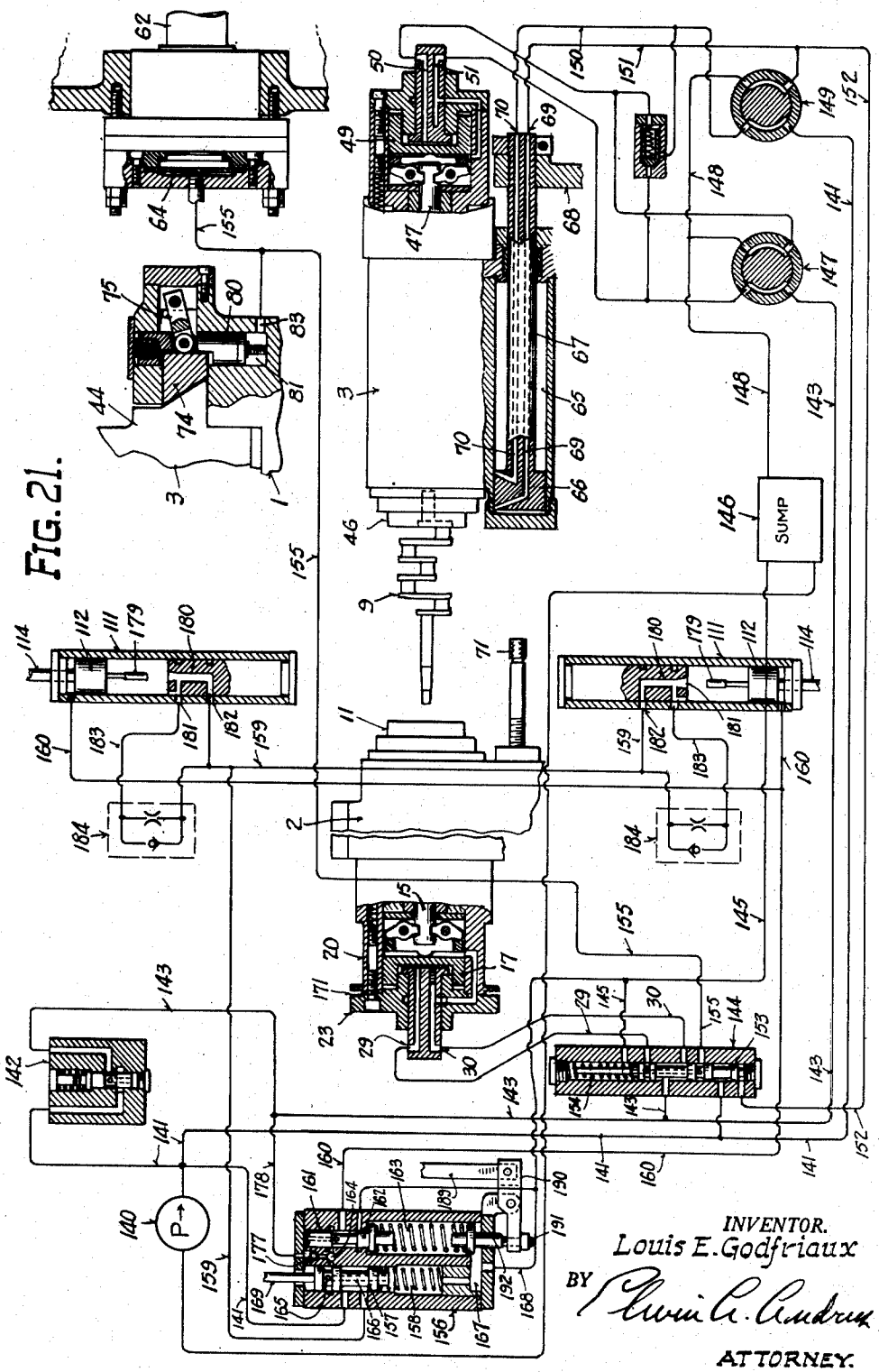


FIG. 21.

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TURN MILLING MACHINE

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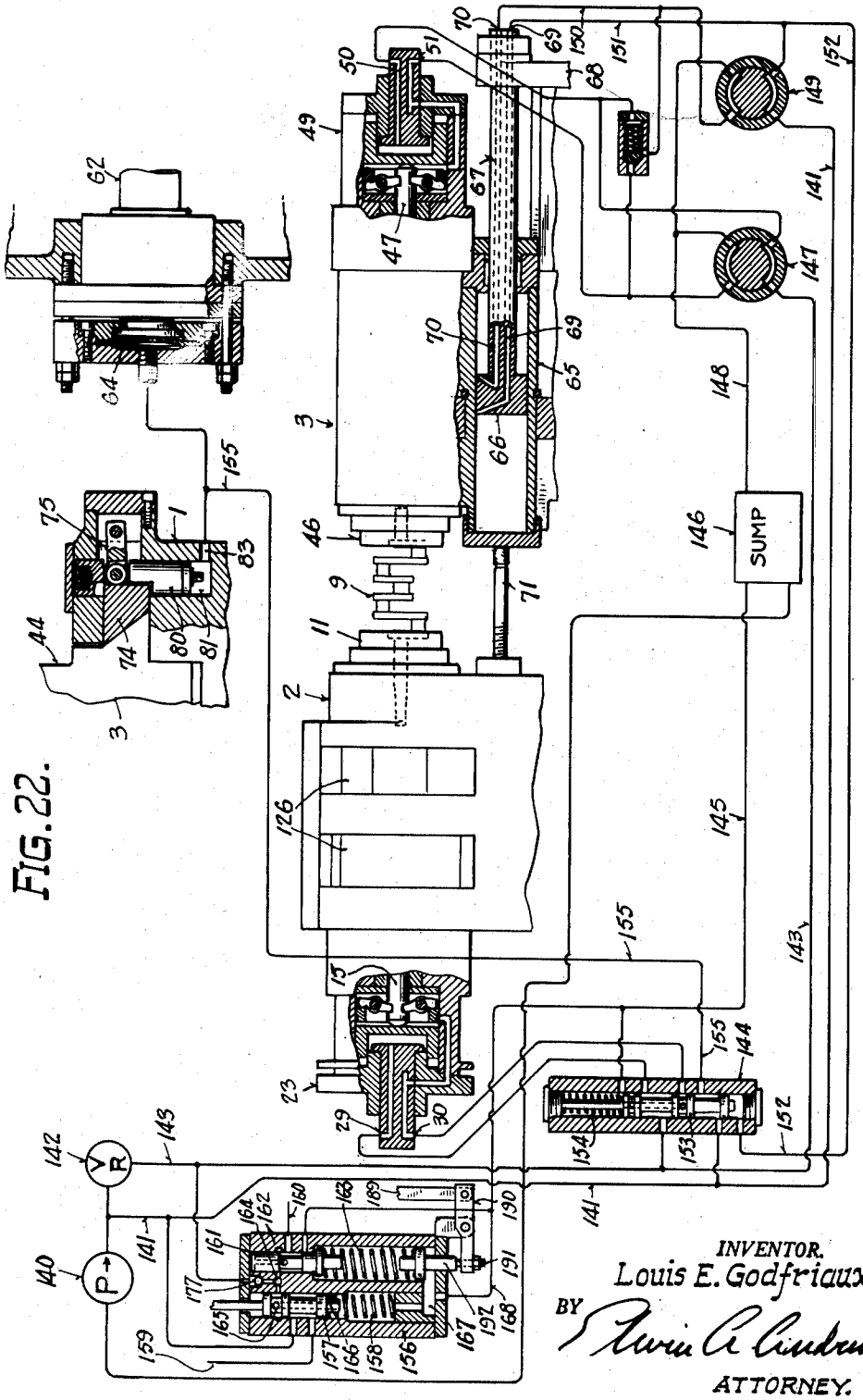


FIG. 22.

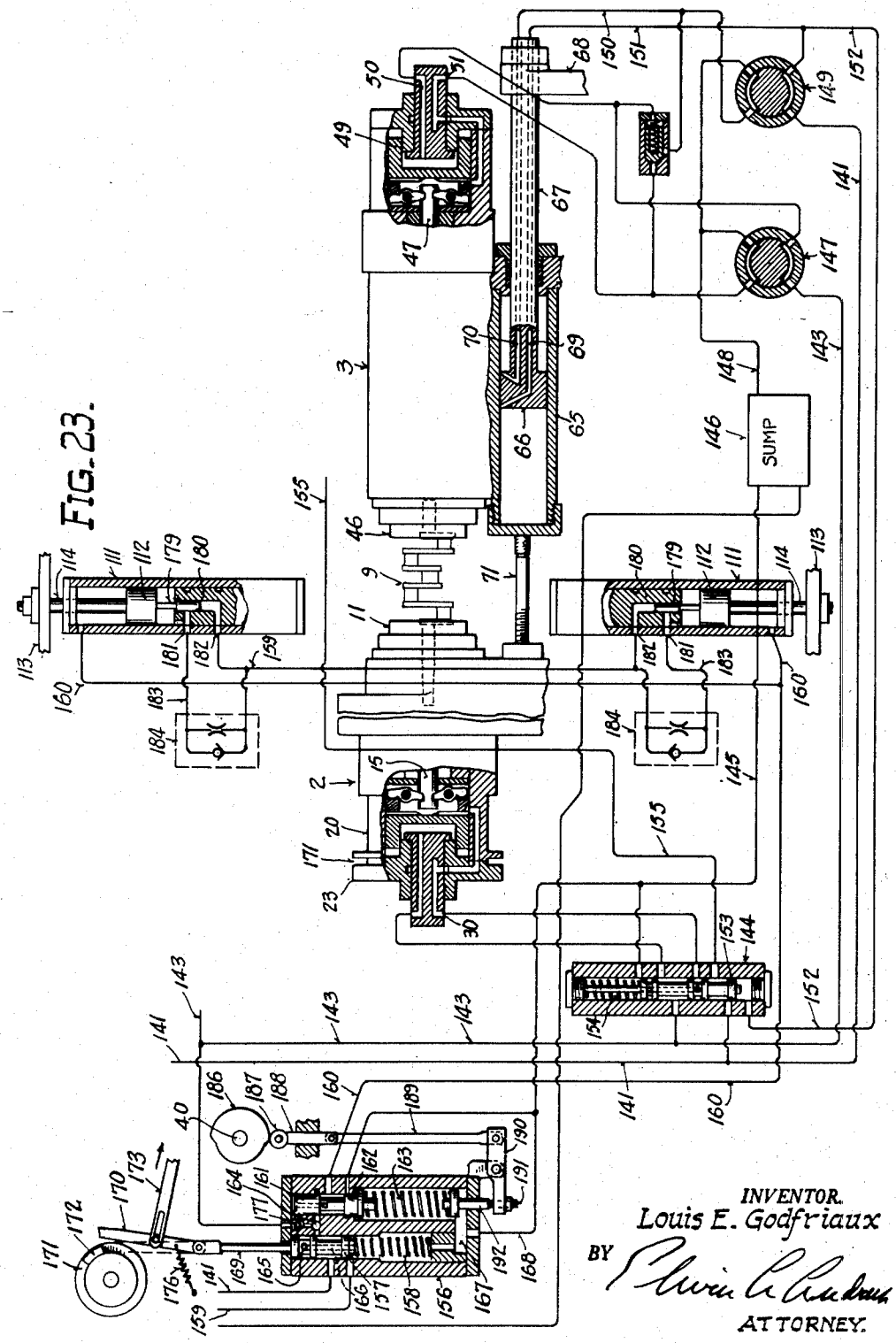
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Sept. 1, 1953 L. E. GODFRIAUX 2,650,522

TURN MILLING MACHINE

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FIG. 23.



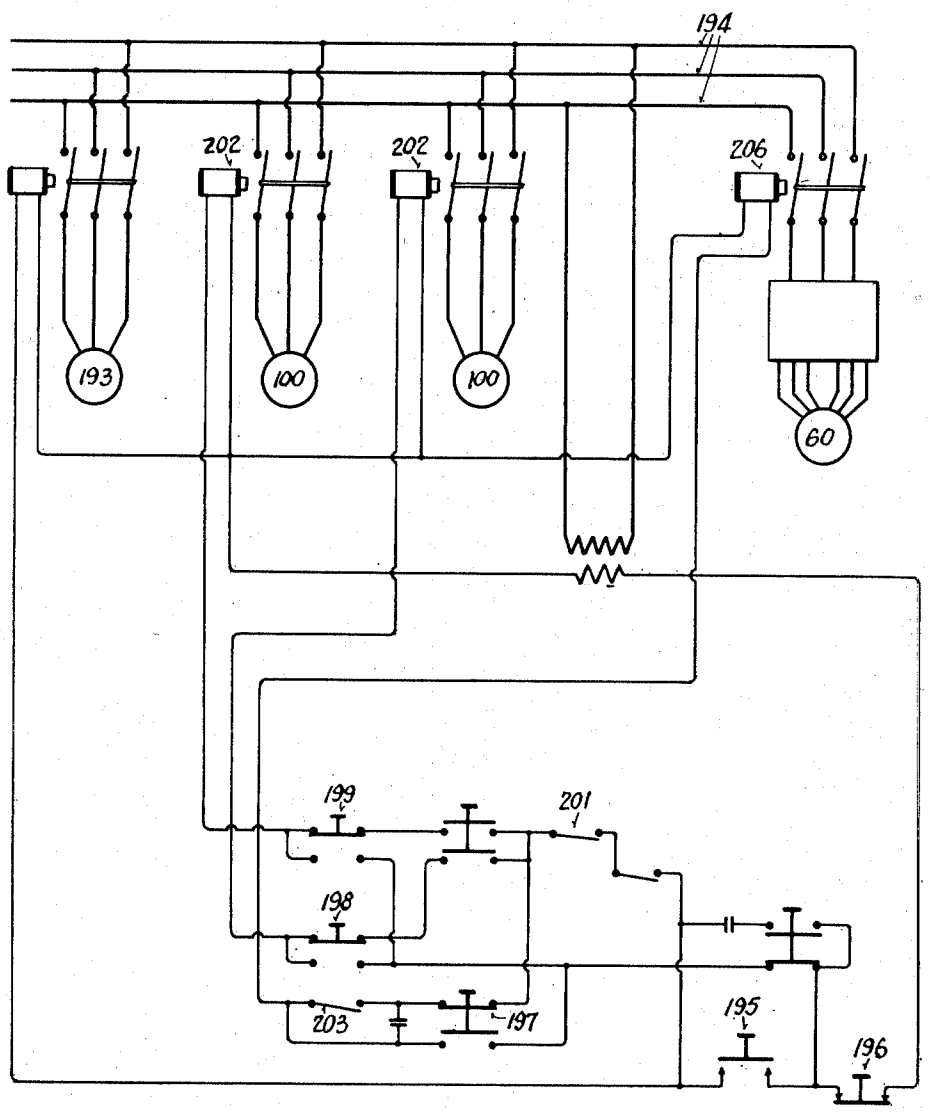
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TURN MILLING MACHINE

Filed Oct. 21, 1946 16 Sheets-Sheet 16

FIG. 24.



INVENTOR.
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Patented Sept. 1, 1953

2,650,522

UNITED STATES PATENT OFFICE

2,650,522

TURN MILLING MACHINE

Louis E. Godfriaux, Madison, Wis., assignor to Gisholt Machine Company, Madison, Wis., a corporation of Wisconsin

Application October 21, 1946, Serial No. 704,629

29 Claims. (Cl. 90—15)

1

This invention relates to a turn milling machine which has been constructed for the accurate machining of crankshafts and the like wherein the crank pins are eccentric to the axis of the shaft.

One of the principal objects of the invention is to provide a machine capable of milling the eccentric crank pin while rotating the shaft on its axis.

Another object of the invention is to provide a machine that will mill the cheeks and the crank pins in a single operation.

Another object is to provide for the turning of a workpiece in a milling machine simultaneously with the advance and retraction of the milling cutter according to a given pattern to provide a predetermined shape for the workpiece.

Another object is to provide a machine for milling crankshafts and the like and which will mill more than one crank pin at a time.

Another object is to provide an automatic machine for milling crankshafts and the like.

Another object is to provide for the accurate chucking of a crankshaft at both ends in a machine for milling the crank pins thereof.

Another object is to provide a simple and accurate feed for the milling cutters.

Another object is to provide a machine of the type referred to with a wide range of adjustment to enable the machining of crankshafts of various sizes in a single machine.

Another object is to provide a machine in which the rotary milling cutter is made to follow the orbit of an eccentrically rotating workpiece, such as the crank pin of a crankshaft.

Another object is to provide a more accurate mounting and support for the milling cutter.

Another object is to prevent chatter of the gib plate and provide a locked hold-down therefor during operation of the milling cutter.

Another object is to provide a machine in which both the headstock spindle and the tailstock spindle are driven to provide for greater rigidity without distortion of the crankshaft during milling.

An embodiment of the invention consisting of a machine adapted to mill a four throw crankshaft for a two cycle engine is illustrated in the accompanying drawings in which:

Figure 1 is a top plan view of the machine;

Fig. 2 is a front elevation of the machine with parts broken away and sectioned;

Fig. 3 is a rear elevation of the machine;

Fig. 4 is an enlarged vertical section of the machine taken along the axis of the headstock spindle;

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Fig. 5 is an enlarged vertical section of the machine taken axially of the tailstock spindle;

Fig. 6 is an enlarged vertical section of the machine taken on line 6—6 of Fig. 1 through the axis of one of the milling cutters;

Fig. 7 is an enlarged vertical section of the machine taken on line 7—7 of Fig. 1 showing the drive for one of the milling cutters;

Fig. 8 is an enlarged vertical section of the machine taken across the pattern control for the cutters showing the same at the position of outermost movement in milling the crank pins;

Fig. 9 is an enlarged front elevation of the headstock spindle chuck;

Fig. 10 is an enlarged transverse section of the chuck taken on line 10—10 of Fig. 4;

Fig. 11 is an enlarged transverse detail sectional view showing the clamping of the tailstock;

Fig. 12 is an enlarged detail section showing the worm gear drive for the spline shaft spindle drive;

Fig. 13 is an enlarged detail view showing the center support for the crankshafts when the cutters are in retracted position;

Fig. 14 is a similar view showing the center support in clamping position during operation of the cutters;

Fig. 15 is an enlarged detail vertical longitudinal section taken through the center of the base of one of the cutter slides and showing the drive therefor;

Fig. 16 is a transverse section taken on line 16—16 of Fig. 15;

Fig. 17 is a detail section showing the construction of dumping valve usable with certain types of operation;

Fig. 18 is an enlarged detail plan view showing the cutters in retracted position with a crankshaft chucked and in position for milling;

Fig. 19 is a similar view showing the cutters in operation as they mill the cheeks and approach the crank pins;

Fig. 20 is a similar view showing the cutters upon completion of the milling of the crank pins;

Fig. 21 is an enlarged detail view of the controls, partially schematic, showing the controls just prior to chucking of a workpiece;

Fig. 22 is a similar detail view taken after chucking and prior to starting the cutters;

Fig. 23 is a similar detail view taken during milling of the cheeks and prior to milling of the pins; and

Fig. 24 is a wiring diagram for the automatic control of the machine.

The machine comprises a bed 1 on which is

supported a headstock 2, a longitudinally movable tailstock 3 aligned with the headstock, and a pair of opposed rotary milling cutter heads 4 and 5 mounted on corresponding slides 6 and 7 on opposite sides of the headstock.

The bed 1 is of T shape with the headstock 2 mounted centrally on the upper cross member, the tailstock 3 mounted on the lower stem, and the slides 6 and 7 mounted on the upper side branches of the T.

The headstock 2 comprises a housing containing the spindle 8 for driving one end of a crankshaft 9 or other workpiece.

The spindle 8 is mounted for rotation in suitable roller bearings 10, and has a chuck 11 at its forward end for receiving and gripping the end of crankshaft 9.

The chuck 11 comprises a sleeve having its forward end slit longitudinally to provide a number of jaws 12 with an outer conical surface 13 bearing against a complementary inner conical surface of an adjustable split ring collet closer member 14 so that longitudinal movement of the sleeve rearwardly in spindle 8 compels the jaws to contract inwardly upon the shaft 9. Forward movement of the sleeve permits the jaws to expand outwardly under the resilience of the metal, and to release the shaft 9.

The rear end of the chuck sleeve is cylindrical and fits in spindle 8 to positively center the chuck at all times.

Movement of the sleeve of chuck 11 is effected by a drawbar 15 extending rearwardly axially of spindle 8 and which is in turn moved axially by a set of pivotal radially disposed levers 16 operated by a piston 17 engaging a pair of diametrically opposed projections 18 on a ring member 19 which in turn presses against the outer ends of the levers 16 in the cylindrical housing 20.

The ring member 19 is of maximum outside diameter to fit the inside wall of the housing 20 near the levers 16 and is of progressively less diameter towards its outer end to keep uncovered a port 21 leading to a passage 22 in the end plate 23 for housing 20.

A non-rotating header 24 is secured axially in the end plate 23 and is held by an upstanding post 25 from base 1. The header 24 has a pair of longitudinal passages 26 and 27 therein for supplying pressure fluid to the cylinder 20.

Passage 26 extends to the inner end of header 24 and supplies pressure fluid to the outer end of cylinder 20 between piston 17 and end plate 23 to effect chucking of a workpiece.

Passage 27 extends to the center of header 24 where it connects with a circumferential groove 28 connecting with passage 22 to drain fluid from the inner side of piston 17.

Reversal of the functions of passages 26 and 27 by valve means effects release of the chuck 11. Conduits 29 and 30 connect the corresponding passages 26 and 27 to a suitable valve control to be described hereinafter.

The spindle 8 is provided with a disc brake 31 disposed between housing 20 and a fixed casing 32 on the headstock housing. Alternate discs, starting with the innermost disc are keyed to the casing 32 and thereby prevented from rotation, while the intermediate discs and outermost disc are keyed to cylinder housing 20 to rotate therewith.

The brake 31 provides a constant drag for spindle 8 determined by the springs 33 which are disposed in corresponding circumferentially spaced longitudinal bores 34 in housing 20, with their inner ends engaging the outermost disc of the brake to bias the latter inwardly and with their outer ends engaged by the corresponding adjusting screws 35 threaded into the bores 34.

Cap screws 36, also threaded into the bores 34, serve to secure end plate 23 to cylinder housing 20.

The spindle 8 is driven by a ring gear 37 keyed thereto centrally thereof and driven through intermediate gear 38 from the drive gear 39 on spline shaft 40.

The spindle 8 also has keyed thereto, on opposite sides of ring gear 37, a pair of master cams which are used to control the movement of the corresponding cutters 4 and 5 in following the orbits of the corresponding crank pins, in the manner described hereinafter.

The tailstock 3 comprises a housing containing a tailstock spindle 43 for driving the outer end of the crankshaft 9. The housing of tailstock 3 is mounted on a gib plate 44 adapted to slide longitudinally of the spindle on the way 45.

The construction of spindle 43 is the same as that of spindle 8. A chuck 46 at the rear end of the spindle is operated by a drawbar 47 and levers 48 in a housing 49 at the front end of the spindle. Fluid pressure is admitted to housing 49 to operate the chuck 46, by means of conduits 50 and 51, respectively, corresponding to conduits 29 and 30 for chuck 11.

A brake 52 provides a constant drag on spindle 43 and is constructed the same as brake 31.

The spindle 43 is driven by a ring gear 53 keyed thereto in the tailstock housing and which is driven by intermediate gear 54 from the drive gear 55 on spline shaft 40.

The spline shaft 40 is journaled at its rear end in the rear end of headstock housing 2 and at its forward end it is coupled to a short shaft journaled in a gear reducing housing 56. The shaft 40 has spline grooves 57 longitudinally thereof in the region of the tailstock housing 3, and drive gear 55 has inward projections 58 fitting in the spline grooves 57 and adapted to drive the gear splined on shaft 40.

The gear reducer housing 56 is mounted on a bracket 59 on the front end of base 1. A drive motor 60 is secured to the base 1 below bracket 59 and is connected by a belt 61 to drive a worm gear 62 in housing 56. The worm gear 62 in the reducer housing meshes with a drive gear 63 on a shaft in the reducer coupled to the forward end of shaft 40 to drive the latter at a reduced speed.

The shaft 40 driven by motor 60 drives both the headstock spindle 8 and the tailstock spindle 43 at the same predetermined speed.

The splines of shaft 40 are relieved of pressure from the worm gear 62 by means of a hydraulic cylinder 64 disposed at the end of the shaft of gear 62, and having a diaphragm piston engaging the end thrust bearing for the shaft to provide a slight limited longitudinal movement in the worm when the rotational cycle has ended, and thereby facilitate retraction of the tailstock.

The sliding of the tailstock 3 longitudinally on way 45 is effected by means of a hydraulic cylinder 65 in the tailstock housing, disposed parallel to the spindle, beneath the same, and having a double acting piston 66 therein secured by rod 67 extending outwardly of the end of the cylinder to a bracket 68 on the base 1.

A fluid passage 69 extends through rod 67 to the rear side of piston 66 to supply fluid pres-

sure to the rear end of cylinder 65 and effect rearward movement or advance of tailstock 3 toward headstock 2.

A fluid passage 70 extends through rod 67 to the forward side of piston 66 to supply fluid pressure to the forward end of cylinder 65 and effect forward movement or retraction of tailstock 3.

An adjustable stop 71 is threaded into a sleeve in headstock housing 2 in alignment with the rear end of cylinder 65 to be engaged thereby and limit the rearward movement of the tailstock by fluid pressure in cylinder 65.

The stailstock 3 is clamped in position during operation of the milling cutters. For this purpose the housing for the tailstock has tapered gibs 72 on each side extending longitudinally in complementary corresponding tapered ways 73 in the base 1.

The lower side of each gib 72 is preferably horizontal while the upper side of each gib 72 is inclined.

The inclined wall of the way 73 on one side is comprised of a movable block 74 disposed in a recess in the base 1.

A toggle arm 75 is disposed in an opening 76 in base 1 and has its outer end pivoted on a fixed pin 77 in a cap 78 secured over the opening 76.

The inner end of toggle arm 75 has a roller 79 bearing against block 74.

The inner end of toggle arm 75 is supported on a plunger 80 operable in a vertical hydraulic cylinder 81, and is pressed downwardly by the vertically movable plunger 82.

A fluid passage and conduit 83 supplies fluid pressure to the bottom end of cylinder 81 to raise plunger 80 and the toggle arm 75 for pushing block 74 inwardly and thereby clamping the tailstock in place.

When the fluid pressure in cylinder 81 is released a spring 84 biases plunger 82 downwardly to release toggle arm 75 of pressure. A cap 85 is secured over the top of plunger 82 and serves as a stop for the upward movement of the plunger. The coil spring 84 is disposed in a vertical bore in plunger 82 and is pressed downwardly therein by cap 85.

The rotary milling cutter head 4 and its slide 6 are similar in construction to the milling cutter head 5 and its slide 7, and the description of the former will serve generally for describing both.

The rotary milling cutter head 4 may comprise any suitable number of discs 86, each having a plurality of cutting blades mounted in recesses in its perimeter. The cutter head 4 shown has two discs 86, corresponding to the two crank pins to be milled by head 4, the discs being spaced apart by a spacer ring 87 to register properly with the crank pins.

The two discs 86 with the spacer ring 87 therebetween are clamped as a unit upon hub 88, with the inner disc 86 bearing against a flange 89 on the hub, and with a flanged sleeve 90 supporting the outer disc 86 and bolted to the hub. The sleeve 90 is keyed to the outer end of hub 88, and the assembled unit of discs 86 and ring 87 is keyed to the hub 88 and the sleeve 90.

The hub 88 is bolted to the end of a cutter spindle 91 which is mounted in husky end roller bearings 92 in a spindle housing 93 on the slide 6.

The forward bearing 92 is large and is disposed within the hub 87 so that there is substantially no overhang of the cutters tending to result in inaccuracies in cutting.

The rear end of spindle 91 has a gear 94 keyed thereto within a gear housing 95, and a flywheel 96 outside the housing and which rotates with the cutter head to provide for smooth operation of the cutters.

The gear 94 is driven by a worm gear 97 on a horizontal transverse shaft 98 mounted in housing 95 above the spindle.

Shaft 98 is driven by suitable gears from drive shaft 99 disposed above the same in housing 95. The drive shaft 99 is driven from motor 100 by means of the belts 101.

The spindle housing 93, gear housing 95 and motor 100 are mounted on the slide 6 to move horizontally toward and away from the headstock 2.

The slide 6 is supported by gib plates 102 on a slide base 103 on top of bed 1. Adjustable tapered gibs 104 between plates 102 and overhanging parts of the way 103 provide hold-down means for the slide 6.

The gib and slide surfaces are oiled by means of a large longitudinal tubular passage 105 extending centrally longitudinally of slide 6 from the outer end and which is partially filled with oil at all times. A wick 106 lies in the passage 105 and extends out through transverse passages 107 disposed across the slide at about one quarter of its length from each end, and thence to vertical passages 108 which feed oil directly to the two side gibs 102. Grooves 109 feed the oil between the gib surfaces 102 and 104 and from thence the oil drops through passages 110 in gibs 102 to the lower slide surfaces of the latter on slide way 103.

The slide base 103 contains a powder cylinder 111 for moving slide 6 in and out, the piston 112 in the cylinder being attached to the rear end of the slide 6 by a bracket 113 and piston rod 114. Supply of pressure fluid to the opposite ends of cylinder 111 determines the movement of the slide 6.

The crank shaft 9 being a four throw shaft with a central bearing pin in alignment with the ends of the shaft, it is desirable to support the shaft at the center against the cutting and turning forces applied. This is accomplished by a support operated from the movement of slides 6 and 7.

For this purpose a pair of laterally spaced pivot shafts 115 extend across a depression 116 in the upper face of the bed 1 between the headstock 2 and tailstock 3.

Each shaft 115 is rotatable in its end bearings and has clamped thereto a bell crank lever 117.

The short vertical arm of lever 117 carries a shoe 118 adapted to bear against the center of shaft 9 on one side of the latter. There being a similar lever and shoe for each shaft 115, the shoes 118 are adapted to cooperate in supporting the center bearing pin of shaft 9 against distortion of the shaft during milling.

The long lateral arm of each lever 117 is provided at its outer end with a supporting roller 119 which rides on a cam block 120 bolted to the front side of the corresponding slides 6 and 7.

The cam block 120 has two horizontal cam surfaces 121 and 122 joined by an inclined cam surface 123. When the slides 6 and 7 are in outward retracted position the rollers 119 rest on the lower cam surfaces 121 thereby supporting the bell crank levers 117 in their down position wherein the shoes 118 are separated and the shaft 9 is free from the center bearing support.

When slides 6 and 7 move inwardly to start

milling operations the rollers 119 ride up inclined cam surfaces 123 to the upper cam surface 122 where the levers 117 are disposed to effect support of the center bearing pin of shaft 9 by the shoes 118.

The levers 117 may be clamped upon pivot shafts 115 in any position to meet the requirements of the center pin of crankshaft 9, and where no center pin is present in the shaft, the levers 117 may be removed entirely.

The slides 6 and 7 are adapted to move the milling cutter heads 4 and 5 in and out in a predetermined manner to enable the cutters to follow the orbit of the eccentric crank pins on shaft 9 as the latter is rotated by spindles 8 and 43.

For this purpose the movement of the corresponding slide is in conformance to a master cam 124 on spindle 8 patterned to correspond with the orbit movement required. There are two cams 124 on spindle 8, one for controlling each of the slides 6 and 7.

A roller cam follower 125 bears against each cam 124 in the horizontal plane of the axis of spindle 9, and is rotatably mounted in a horizontally movable frame in the headstock housing. The cam follower 125 and frame 126 for cutter head 4 are disposed facing the inner end of slide 6, and the cam follower 125 and frame 126 for cutter head 5 are disposed facing the inner end of slide 7.

Each of the slides 6 and 7 has an adjustable stop button 127, disposed on the advance side of the housing 93 for the cutter spindle, and which is adapted to engage the corresponding cam follower frame 126 when the slide carrying the button reaches the position where the cutter has substantially completed milling of the cheeks of workpiece 9 and starts to mill the eccentric pins on the workpiece.

The stop button 127 has an inclined rear end pressing against a complementarily inclined block 128 in a vertical boss-like housing on housing 93.

The block 128 is biased upwardly to fixed adjusted position against a threaded screw 129 by a spring 130 supported in the lower end of the housing by a plug 131. The threaded screw 129 has a graduated dial 132 at its upper end for facilitating adjustment of the position of screw 129 and correspondingly of stop button 127.

The machine is adapted to traverse the cutter heads 6 and 7 toward the work 9 from the position illustrated in Fig. 18 until they start to mill the crank. Thereupon when the crank is initially positioned, the cutter heads 6 and 7 are moved at a feed rate for milling the cheeks which is determined by the practical capacity of the milling cutters for the rotational cutter speed selected and the size of the crankshaft cheeks to be milled.

When the milling cutters reach the crank pins as shown in Fig. 19, and slides 6 and 7 abut their stops 127 on the corresponding frames 126 controlled by the position of cams 124, the spindles 8 and 43 start to rotate, thereby rotating crankshaft 9 and cams 124 in unison.

For one-half of this revoluion, which may be the first half as illustrated, the cams 124 push the corresponding slides 6 and 7 outwardly thereby effecting a retraction of the cutter heads 4 and 5 corresponding to the horizontal linear movement of the working contact of the respective cutters normal to the corresponding crank pins. During this outward movement of slides 6 and 7 the fluid pressure in the outer end of cylinder 111 is relieved by a pressure regulating valve to be described later.

For the other half of the revolution of crankshaft 9, which may be the last half as illustrated, the cams 124 control the forward feeding movement of slides 6 and 7 under the influence of fluid pressure in the outer ends of cylinders 111.

Where the crank is initially indexed in the chucks with the crank pins positioned opposite to that illustrated, the cutters 4 and 5 approach the crank pins first, and milling of the cheek is accomplished during turning of the crankshaft 9 and simultaneously with milling of the pins.

The crank pins are fully milled during one revolution of the crankshaft 9 and the cutters are then retracted fully from the workpiece.

The crankshaft 9 should be positioned and indexed in the spindles 8 and 43 with the axis of each eccentric pin of the shaft disposed in the corresponding axial plane of the shaft containing the center line for the corresponding cam 124.

For this purpose the spindles 8 and 43 are each provided with a spindle cross member 133 which has a circular central body with a bore through which the shaft 9 extends into the chuck, and four radiating arms therefrom in the form of a cross and which are bolted to the end of the corresponding spindle.

The collet closure 14 is formed in two semicircular halves set into a recess in the end of the spindle and around the conical end of the jaws 12, and is held in place by the cross member 133. The two halves of collet closure 14 float relative to each other and are biased apart and into engagement with the spindle by means of a coil spring 134 disposed in recesses in the opposed faces thereof near the circumference on one side of the parting line. An adjustable stop 135 separates the faces of the two halves of the closure 14 on the side opposite the spring 134.

A driver plate 136 formed in two halves corresponding with the halves of closure member 14, and slotted centrally to receive corresponding arms of the spindle cross 133, is bolted to the corresponding closure halves 14 over the front of member 133. The two halves of driver plate 136 are spaced apart sufficient to receive the corresponding intermediate arms of cross 133 therebetween. In addition, one or both of the driver plate halves is recessed centrally and provided with a hardened abutment 137 for receiving and locating the end cheek of the shaft 9.

Various shapes of replaceable driver plates may be employed to accommodate crankshafts and workpieces of different size and shape.

The driver plate 136 with its abutments 137 serve to locate and index the crankshaft in the spindle chuck.

One of the halves of collet closure 14 is keyed to the spindle at 138, and in order to prevent any strain on the crankshaft due to tolerances when indexing the same with the driver plate 136 at each end, the closure 14 and its driver plate parts for the headstock chuck are made capable of limited floating movement relative to those for the tailstock chuck by providing a wider groove 139 in the closure member 14 for the key 138 in the headstock chuck referred to which keys the member 14 for rotation with the spindle. The corresponding groove 139 in the tailstock chuck may be reasonably tight on key 138 so that only the headstock chuck floats to sufficiently relieve stress on shaft 9 when inserting the latter therein.

The crankshaft 9 shown in the drawing has

its two end eccentric pins lying on one side of the axis of the shaft and its two central eccentric pins lying on the opposite side of the axis of the shaft.

The cutter head 4 has its discs 86 spaced to correspond with the spacing of the end pins of shaft 9 and the cutter head 5 has its discs 86 spaced to correspond with the spacing of the central eccentric pins of shaft 9.

The hydraulic control circuit for the machine is illustrated in Figs. 21 to 23, inclusive, with the several parts in different operative positions.

Fig. 21 shows the valves and operative parts in position upon insertion of a crankshaft 9 to be milled into the chuck 46 of the tailstock.

A constant pressure variable volume pump 140 supplies oil or other suitable power fluid under a primary pressure of about five hundred pounds per square inch to supply line 141.

Line 141 supplies primary fluid pressure to a pressure reducing valve 142 which transmits fluid at about eighty pounds per square inch to line 143 to initially operate chucks 11 and 46.

For this purpose conduits 29 and 30 leading from cylinder 20 for operating chuck 11 are connected alternatively to line 143 by means of the piston valve 144, the opposite conduit being at the same time connected through valve 144 to a drain line 145 leading to a sump 146 in base 1 and from which pump 140 obtains its supply of fluid.

Likewise, conduits 50 and 51 leading from cylinder 49 for operating chuck 46 are connected alternatively to line 143 by means of the manual pilot valve 147, the opposite conduit being at the same time connected through valve 147 to a drain line 148 leading to sump 146.

In Fig. 21 the valve 144 connects line 143 to conduit 30 for supplying pressure fluid to the inner end of cylinder 20 to hold the piston 17 outwardly and the chuck 11 open. Conduit 29 is connected by valve 144 to drain line 145.

Likewise, valve 147 connects line 143 to conduit 51 for supplying pressure fluid to the inner end of cylinder 49 to hold its piston outwardly and the chuck 46 open. At the same time, valve 147 connects conduit 50 to drain line 148.

Primary line 141 also supplies high pressure fluid to a manual pilot valve 149 which controls the supply of pressure fluid to passages 69 and 70 for operation of the tailstock advance and return.

In Fig. 21 valve 149 is shown as connecting line 141 to conduit 150 leading to passage 70 and supplying pressure fluid to the forward end of cylinder 65 to hold the tailstock 3 in retracted forward position. At the same time, passage 69 leading from the rear end of cylinder 65 is connected by conduit 151 through valve 149 to drain line 148.

A line 152 leads from conduit 151 to the end of valve 144 for operating the plunger 153 therein in opposition to the spring 154 in the opposite end of the valve. As shown in Fig. 21, the power chamber of valve 144 is connected through line 152, conduit 151 and valve 149 to drain line 148. The spring 154 holds plunger 153 in valve 144 against its stop where the connections to the headstock chuck operating cylinder are as previously described.

The connections through valve 149 hold the tailstock in its right hand position where it is adapted to be unloaded and to receive a new workpiece to commence the cycle.

In Fig. 22 a workpiece 9 has been inserted and initially gripped with light pressure by chuck 46 by operation of manual valve 147, and pilot valve 149 has been turned to advance the tailstock 3. When the tailstock hits its stop 71, as shown, pressure builds up in conduit 151 and line 152 sufficient to operate cross-over valve 144 in which initial chucking pressure is supplied from line 143 to operate chuck 11 to grip the workpiece.

Valve 144 also controls the passage of primary pressure fluid from line 141 to conduit 155 leading to passage 83 and cylinder 81 for operating the tailstock clamp and hold-down and to cylinder 84 for operating the diaphragm therein to position the worm gear shaft for driving the spindles. In the position of plunger 153 in valve 144 shown in Fig. 21 the branch to pressure line 141 reaches a dead end in the valve and the conduit 155 leading to the tailstock clamp and diaphragm cylinder is connected to drain through internal passages in the valve plunger.

Primary pressure line 141 supplies high pressure fluid to the cross-over valve 156 which operates the slides 6 and 7 to traverse and feed the milling cutters to the work and apply primary pressure to line 143 for final chucking, clamping of the tailstock and operating the diaphragm cylinder.

As shown in Fig. 21, the plunger 157 of valve 156 is pushed inwardly against its spring 158 and connects the branch supply conduit from primary line 141 to a conduit 159 having two branches, each branch leading to the inner end of one of the slide cylinders 111 to hold its piston 112 outwardly, and thereby hold the slides 6 and 7 and the corresponding cutters 4 and 5 in retracted position.

The opposite outer ends of cylinders 111 are connected by conduit 160 to a cam-operated pressure reducing valve 161 in the same body as valve 156.

The valve plunger 162 of valve 161 is shown in Fig. 21 as pressed by its spring 163 to a position where it connects conduit 160 through the valve chamber of 161 around plunger 162 to a passage 164 leading to valve 156 and thence through a port 165 and passage 166 through plunger 157 to the common chamber 167 at the lower end of valves 156 and 161, which in turn is connected by drain conduit 168 to sump 146.

The valve 156 is disposed vertically at the rear of the machine with the control rod 169 of plunger 157 protruding upwardly into abutment with a vertical stop latch 170 which extends upwardly into a circumferential slot 171 between end plate 23 and cylinder housing 20 where its upper end abuts a stop 172 which normally holds latch 170 and the control rod 169 downwardly against spring 158, as shown in Figs. 21 and 22.

The latch 170 is manually released by a pull rod 173 operated by a lever 174 on a shaft 175 extending through bed 1 to the front of the machine and turned by a manual operating lever shown in Figs. 1 and 2.

Latch 170 is biased constantly into slot 171 by the tension spring 176 so that the latch serves like a one revolution clutch, its release effecting operation of cross-over valve 156 to start the traverse and feeding of cutters 4 and 5, and then the latch finally tripping the cross-over valve 156 to stop the slide feeding when the spindle 8 has turned one revolution to complete the milling of the eccentric pins on workpiece 9, as will be more fully described hereinafter.

During this cycle of operation the cross-over valve 156 is in the position shown in Fig. 23

where it supplies primary pressure through passage 164 to the pressure reducing valve 161 which in turn supplies traverse and feeding pressure to the outer ends of slide cylinders 111 through conduit 160, to effect inward movement of pistons 112 and the corresponding cutters 4 and 5. At the same time valve 156 connects conduit 159 leading from the inner ends of cylinders 111 directly to chamber 167 and drain conduit 168 to sump 146.

Passage 164 between valves 156 and 161 supplies high pressure fluid to the chucks 11 and 46 through a check valve 177 and conduit 178 to conduit 143 supplying the chuck operating cylinders 20 and 49. The final chucking is with high fluid pressure which is maintained during the milling operations.

Each piston 112 is constructed with a plunger control valve on its inner end comprising a central plunger 179 adapted to reciprocate in a valve body 180 which has a central radial passage 181 leading to the chamber of cylinder 111 at the inner end of the same. When the piston 112 is at the outer end of cylinder 111, the plunger 179 uncovers the central port to passage 181 and thereby opens the latter to a passage 182 leading from the inner end of valve body 180 to conduit 159 and thence through cross-over valve 156 to sump 146.

The piston 112 traverses forward fast upon entrance of pressure fluid to the outer end of cylinder 111 until the cutters 4 or 5, as the case may be, reach their working position where they start to mill the cheeks of workpiece 9. At this point the plunger 179 closes the connection between passages 181 and 182 and the feed for milling the cheeks is then governed by the escape of fluid from the inner end of cylinder 111 through the conduit 183 to a flow control valve 184, shown in Fig. 21, for each cylinder and from thence to drain line 159. Valve 184 is set to provide the desired inward feed for piston 112 during milling of the cheeks of workpiece 9.

Where the setting of valve 184 may not allow the escape of fluid from the inner end of cylinder 111 at a rate sufficient to effect a continuous follow-up of cam 124 by the stop 127 and a proper feeding of the cutters in accordance with the cam, an auxiliary dumping valve 185, shown only in Figs. 16 and 17, may be provided and connected to by-pass the fluid from the inner end of the corresponding cylinder 111 around feed control valve 184 and to drain line 159, thereby releasing the pressure on the fluid in the inner end of cylinder 111 during the follow-up movement.

The dumping valve 185 may be tripped or actuated by the movement of the corresponding cutter slide, as shown, when the shaft 9 is initially indexed with the crank pins nearest the corresponding cutters, or it may be tripped by a suitable cam on the spline shaft 40 to operate in direct synchronism with the rotation of crankshaft 9.

The pressure in the outer end of cylinders 111 is automatically reduced, at the point in the cycle where the cutters reach the pins and the crankshaft rotation is initiated, to a pressure a little in excess of that required to keep the slides 6 and 7 with their stops 127 engaging the corresponding follower frames 126 of cams 124. As the spindles 8 and 43 rotate the workpiece the cams 124 first push the slides 6 and 7 outwardly to enable the cutter to follow the eccentric pins in their orbits and when the rotation of workpiece 9 has passed the dead center of the half way mark, the pressure in the outer ends of cylinders 111 is maintained sufficient to cause the cutters to again move inwardly following the control pattern of cams 124.

For this purpose the cams 124 should be constructed to compensate for the diameter of the pins being milled so that the cutters 4 and 5 are always applied to the near side of the corresponding pins as the latter travel in their orbit. The cams 124 should also be constructed to compensate for the vertical movement of the pins as they travel in their individual orbits so that any change required in horizontal distance between the near side of any pin, as determined by its radial distance from the axis of the cutter, and the vertical axial plane of the corresponding cutter, because of the raising or lowering of the pin on the circumference of the cutter, will be taken care of to produce a pin that is uniform in diameter.

The automatic control of pressure in the outer ends of cylinders 111 is effected by valve 161 which, during the initial feeding of the cutters passed the full primary pressure through to conduit 160 and the cylinders. For this purpose, a second cam disc 186 is secured on the rear end of spline shaft 40 to rotate therewith. A cam roller 187 is disposed on the upper end of vertical rod 188 in a bore in the top of base 1, with the cam roller in engagement with the cam disc 186. The rod 188 is supported on a vertical link 189 joining it to one end of a horizontal centrally pivoted lever 190. The other end of lever 190 contains an adjustable threaded pin 191 which supports a floating plunger 192 in chamber 167 beneath and supporting spring 163.

The cam 186 is recessed in that part of the cycle requiring reduced pressure for the outer ends of cylinders 111, and thereby functions to relieve spring 163 and allow valve plunger 162 to be forced downwardly by fluid pressure at the top end until a balance is reached providing the desired pressure reduction.

The valve 161 functions as a pressure regulating valve which allows escape of fluid at a reduced pressure from the outer ends of cylinders 111 to chamber 167 and drain pipe 168 during retraction of the slides 6 and 7 by cams 124, and supplies power fluid at an increased pressure to the cylinders 111 to feed the slides 6 and 7 forward during the last half of the rotary cycle of spindle 8.

When the rotation of spindle 8 through one revolution causes stop 172 to engage the end of latch 170 and force plunger 157 of valve 156 against its spring, the valve 156 is reversed to connect the primary line 141 to supply fluid through conduit 159 to the inner ends of cylinders 111 and to connect the outer ends of cylinders 111 through conduit 160 to valve 161 and thence to drain pipe 168. The cutters 4 and 5 are thereby retracted and the workpiece 9 may be removed by first turning pilot valve 147 to reverse the flow of fluid to cylinder 49 for releasing chuck 46, then turning pilot valve 149 to reverse the flow of fluid to cylinder 65 to retract the tailstock and release chuck 11.

The hydraulic circuit controls all straight line movements of the machine, whereas the electrical circuit controls all rotational movements. The two circuits are interlocked to operate their several controls in synchronism.

There are four motors to be operated. These

are motor 60 for rotating the work 9, motor 100 for rotating cutter head 4, another motor 100 for rotating cutter head 5 and a motor 193 for driving pump 140. All of the motors are connected to the power lines 194 by the main switch push button 195 mounted on the side of the base 1 for the tailstock 3. A similar stop push button 196 operates the switch to disconnect all of the motor circuits from line 194.

Motors 60 and 100 may be separately operated to inch the work 9 and the cutter heads 4 and 5 independently of each other for adjusting the machine, by means of three corresponding inching switch push buttons 197, 198 and 199, respectively, which function when the main switch push button 195 is open.

When the workpiece 9 has been initially chucked and the operator lifts the hand lever on shaft 175 to release latch 170 a horizontal cam arm 200 is pulled by lever 174 to a position where its upper cam surface allows a switch button 201 to drop and close the circuit of relays 202 which in turn closes the circuit for motors 100 to start both cutter heads 4 and 5 rotating for milling the cheeks of workpiece 9.

A micro-switch 203 is disposed with its lever arm 204 in the path of an abutment 205 on the inner end of slide 6 so that the switch 203 closes momentarily and energizes the holding circuit of contactor 206 which starts motor 60 to rotate the workpiece 9 when slide 6 reaches its innermost position.

The spring 176 between latch 170 and base 1 pulls the latch into the groove 171 to engage stop 172 as the spindle 8 reaches the end of its rotation, and the same movement returns the hand lever on shaft 175 and also switch operating arm 200 to normal position wherein arm 200 raises switch 201 opening the relays 202, opening the circuits for motors 100, and also opening the holding circuit for contactor 206, stopping work motor 60.

The electrical circuit may include many additional elements for adjusting and varying speeds of the rotating parts to suit the work.

The machine is adapted to mill the major part of the cheeks of the crankshaft 9 while the latter is not rotating and with the maximum cuts in a direction straight across the axis of the shaft and near thereto. The eccentric pins and a minor part of the cheeks are milled while rotating the crankshaft, and the smallest amount of cut is taken on the outside of the pin farthest from the axis of the shaft. In this way the power input for the different operations is maintained more uniform through the cycle of the machine.

The cutter preferably approaches the corresponding eccentric pin across the axis of the crankshaft along a line intersecting the axis of the pin and the axis of the shaft. For this purpose the crankshaft is indexed with the axis of the pin lying in a common plane with the axis of the shaft and the axis of the cutter, and with the axis of the shaft disposed between the axis of the pin and the axis of the cutter.

The cutters may be caused to approach the corresponding pins at any location on the circumference of the pins, and it is possible to mill the pins and cheeks simultaneously.

Where the crankshaft is initially positioned with its pins nearest to the corresponding cutters, the milling of the pins and of the cheeks is accomplished during rotation of the crankshaft and there is substantially no straight line milling of the cheeks while the spindles and crankshaft are stationary.

For any given setting of approach, the cams 124 are constructed to provide the desired pattern of movement for the cutters to correspond with the orbit movement of the crank pins. The cams 124 are constructed in halves removably secured on the spindle 8 so that they may be replaced readily to adapt the machine to different work.

Where the crank pins lie in different radial planes of the crankshaft, the cutters may approach the corresponding pins from different directions relative to the pins.

As many cutters may be provided as needed for any given crankshaft, and the number of cutters will depend upon the number of throws to be milled.

Various embodiments of the invention may be employed within the scope of the accompanying claims.

The invention is claimed as follows:

1. In a turn milling machine adapted to mill crankshafts and the like wherein a plurality of eccentric pins to be milled travel in an orbit around the axis of the shaft as the spindle and workpiece rotate, a rotary milling cutter for each pin to be milled, the cutters for oppositely disposed pins being disposed on opposite sides of the workpiece, slides supporting said cutters for reciprocating movement toward and away from the workpiece in a direction in a plane substantially normal to the axis of rotation of the workpiece, means to traverse and feed said slides, cam means rotated in unison with the spindle for controlling the feed of said slides to cause said cutters to follow the orbits of the corresponding pins and mill the pins on substantially all sides thereof, and means responsive to the completion of a single revolution of said spindle to cause said traverse and feed means to retract the slides and cutters from the workpiece without further rotation of the spindle.

2. In a turn milling machine adapted to mill crankshafts and the like wherein one or more eccentric pins to be milled travel in an orbit around the axis of the shaft as the spindle and workpiece rotate, a rotary milling cutter, a slide supporting said cutter for reciprocating movement toward and away from the workpiece in a direction in a plane substantially normal to the axis of rotation of the workpiece, hydraulic means for moving said slide toward the workpiece to thereby move the cutter toward the work, a cam rotated in unison with said spindle and disposed as a stop for the forward feed of said slide, said cam being adapted to retract the slide against said hydraulic means and to control the advance of the slide to cause said cutter to follow the orbit of the eccentric pin and mill the pin on substantially all sides thereof, and means actuated by the rotation of said cam and the movement of said slide to change the flow and pressure of fluid in said hydraulic means to effect traverse and feed rates for said slide.

3. In a turn milling machine adapted to mill crankshafts and the like wherein a plurality of eccentric pins to be milled travel in an orbit around the axis of the shaft as the spindle and workpiece rotate, a rotary milling cutter for each pin to be milled, the cutters for oppositely disposed pins being disposed on opposite sides of the workpiece, slides supporting said cutters for reciprocating movement toward and away from the workpiece in a direction in a plane substantially

normal to the axis of rotation of the workpiece, hydraulic means for moving said slides toward the workpiece to thereby move the cutters toward the work, cam means rotated in unison with said spindle and disposed as stops for the forward feed of the corresponding slides, said cam means being adapted to retract the slides against said hydraulic feeding means and to control the advance of the slides to cause said cutters to follow the orbits of the corresponding eccentric pins and mill the pins on substantially all sides thereof, and means actuated by the rotation of said cam and the movement of said slide to change the flow and pressure of fluid in said hydraulic means to effect traverse and feed rates for said slide.

4. In a machine of the class described, a rotary milling cutter, a rotary spindle adapted to hold a workpiece having a cylindrical part to be milled eccentric to the axis of rotation of the workpiece, hydraulic means for moving said cutter toward the eccentric part of the work, a cam rotated in unison with said spindle and disposed as a stop for the forward movement of said cutter, said cam being adapted to retract said cutter against said means during at least a part of the milling cycle to compensate for the movement of said eccentric part in its orbit of rotation, and means to reduce the pressure in said hydraulic means during retraction thereof by said cam.

5. In a machine of the class described, a rotary milling cutter, a rotary spindle adapted to hold a workpiece having a cylindrical part to be milled eccentric to the axis of rotation of the workpiece, means for moving said cutter toward the work, a movable abutment adapted to stop the movement of said cutter and to reciprocate in line with said cutter movement to control said movement during the milling of said eccentric part, and a cam rotated in unison with said spindle and disposed to move said abutment in line with the feeding movement of said cutter to retract the latter against said means during at least a part of the milling cycle to compensate for the movement of said eccentric part in its orbit of rotation.

6. In a machine of the class described, a rotary spindle adapted to hold a crankshaft having an eccentric crank throw to be milled, a rotary milling cutter disposed in lateral alignment with said crank throw and having side and circumferential cutters adapted to mill the cheek and eccentric pin of said throw, means to feed said milling cutter in a line substantially radial to the axis of rotation of the workpiece, means to index the workpiece to initially position the crank pin farthest from the cutter to effect milling of a substantial part of the cheeks of the throw while the crankshaft is held stationary by said spindle during the approach of said cutter to the eccentric pin, and means operative thereafter to modify the feed of said cutter and to retract and control the advance of the cutter for milling of the eccentric pin during rotation of the crankshaft to compensate for the movement of the crank pin in its orbit during milling of the pin.

7. In a machine of the class described, a rotary spindle adapted to hold a crankshaft having at least two eccentric crank throws extending in substantially opposite directions from the axis of the shaft and presenting cheeks and eccentric pins to be milled, a rotary milling cutter disposed in lateral alignment with each of said crank throws and having side and circumferential cutters for milling the cheeks and eccentric pin of the corresponding throw, means to index the crankshaft initially to dispose the throws thereof opposite to the corresponding cutters, means to feed said cutters towards the crankshaft from substantially opposite sides thereof while the latter is held stationary to mill the major parts of the corresponding cheeks by cutting movements near to the axis of support of the crankshaft, and means to feed said cutters thereafter in a reciprocating movement while the crankshaft is rotated to compensate for the movement of the corresponding crank pin in their orbits and effect milling of the pins on all sides to a substantially uniform diameter.

8. In a machine of the class described, a rotary spindle adapted to hold a crankshaft having an eccentric crank throw to be milled, a rotary milling cutter disposed in lateral alignment with said crank throw and having side and circumferential cutters adapted to mill the cheek and eccentric pin of said throw, means to feed said milling cutter in a line substantially radial to the axis of rotation of the workpiece, means to index the workpiece to initially position the crank pin farthest from the cutter to effect milling of a part of the cheeks of the throw while the crankshaft is held stationary by said spindle during the approach of said cutter to the eccentric pin, means automatically initiated to start the rotation of said spindle upon said cutter reaching the pin, and a cam rotated in unison with said spindle and disposed as a stop for the forward feed of said cutter, said cam being adapted to retract and control the advance of said cutter against said first named feeding means during part of the milling cycle to compensate for the movement of said crank pin in its orbit and effect milling of the pin on all sides to a substantially uniform diameter.

9. In a machine of the class described, a rotary spindle adapted to hold a crankshaft having an eccentric crank throw to be milled, a rotary milling cutter disposed in lateral alignment with said crank throw and having side and circumferential cutters adapted to mill the cheek and eccentric pin of said throw, hydraulic means to feed said milling cutter in a line substantially radial to the axis of rotation of the workpiece, means to locate the workpiece to initially position the crank pin thereof opposite to the cutter to effect milling a part of the cheeks of the throw while the crankshaft is held stationary by said spindle during the approach of said cutter to the eccentric pin, means automatically initiated to start the rotation of said spindle upon said cutter reaching the pin, a cam rotated in unison with said spindle and disposed as a stop for the forward feed of said cutter, said cam being adapted to retract said cutter against said hydraulic feeding means during part of the milling cycle and to control the advance of the cutter during the remainder of the cycle to compensate for the movement of said crank pin in its orbit and effect milling of the pin on all sides to a substantially uniform diameter, means to supply power fluid at a relatively high pressure to said feed means during approach of the cutter to the pin, and means synchronized with the rotation of said spindle and automatically regulating the pressure of the power fluid for said feed means during operation of said cam thereagainst.

10. In a machine of the class described, a rotary spindle adapted to hold a crankshaft hav-

ing at least two eccentric crank throws extending in substantially opposite directions from the axis of the shaft and presenting cheeks and eccentric pins to be milled, a rotary milling cutter disposed in lateral alignment with each of said crank throws and having side and circumferential cutters for milling the cheeks and eccentric pin of the corresponding throw, means to index the crankshaft initially to dispose the throws thereof in a predetermined position relative to the corresponding cutters, hydraulic means disposed to feed said cutters toward the crankshaft from substantially opposite sides thereof while the latter is held stationary, means automatically initiated to start the rotation of said spindle upon said cutters reaching the pins, a plurality of cams rotated in unison with said spindle, each cam being disposed as a stop in the path of feed for a corresponding cutter and being adapted to retract said cutter against the hydraulic means feeding the same during part of the milling cycle and to control the advance of the cutter during the remainder of the cycle to compensate for the movement of the corresponding crank pin in its orbit and effect milling of the pin on all sides to a substantially uniform diameter, means to supply power fluid at a relatively high pressure to said hydraulic feed means during the approach of the cutters to the crank pins, and means synchronized with the rotation of said spindle and automatically regulating the pressure of the power fluid for said feed means during operation of said cams thereagainst.

11. In a machine of the class described, a rotary spindle adapted to hold a crankshaft having an eccentric crank throw to be milled, a rotary milling cutter having a diameter substantially greater than the maximum diameter of the crankshaft and disposed in lateral alignment with said crank throw with its axis parallel to the axis of said spindle and having side and circumferential cutters adapted to mill the cheek and eccentric pin of said throw, means to feed said milling cutter in a line substantially radial to the axis of rotation of the workpiece, means to locate the workpiece initially to dispose the crank pin in a predetermined position relative to the cutter, means automatically initiated to start the rotation of said spindle upon said cutter reaching the pin and to feed said cutter in a reciprocating movement in accordance with the movement of the pin in its orbit to effect milling of the pin on all sides to a substantially uniform diameter, and means to retract said cutter from the crankshaft automatically upon completion of the cut and to stop the spindle rotation to provide for unloading and loading operations free from interference by said milling cutter.

12. In a machine of the class described, a rotary spindle adapted to hold a crankshaft having an eccentric crank throw to be milled, a rotary milling cutter disposed in lateral alignment with said crank throw and having side and circumferential cutters adapted to mill the cheek and eccentric pin of said throw, hydraulic means to feed said milling cutter in a line substantially radial to the axis of rotation of the workpiece, means to locate the workpiece to dispose the crank pin opposite initially in a predetermined position relative to the cutter, means automatically initiated to start the rotation of said spindle upon said cutter reaching the pin, a cam rotated in unison with said spindle and disposed as a stop for the forward feed of said cutter, said cam being adapted to retract said cutter against said hydraulic feeding means during part of the milling cycle and to control the advance of the cutter during the remainder of the cycle to compensate for the movement of said crank pin in its orbit and effect milling of the pin on all sides to a substantially uniform diameter, and means regulating the discharge of fluid from said hydraulic feeding means in correlation to the movement of said cutter and the rotation of said work spindle.

13. In a machine of the class described, a rotary spindle adapted to hold a crankshaft having an eccentric crank throw to be milled, a rotary milling cutter disposed in lateral alignment with said crank throw and having side and circumferential cutters adapted to mill the cheek and eccentric pin of said throw, hydraulic means to feed said milling cutter in a line substantially radial to the axis of rotation of the workpiece, means to locate the workpiece to dispose the crank pin initially in a predetermined position relative to the cutter, means automatically initiated to start the rotation of said spindle upon said cutter reaching the pin, a cam rotated in unison with said spindle and disposed as a stop for the forward feed of said cutter, said cam being adapted to retract said cutter against said hydraulic feeding means during part of the milling cycle and to control the advance of the cutter during the remainder of the cycle to compensate for the movement of said crank pin in its orbit and effect milling of the pin on all sides to a substantially uniform diameter, means regulating the discharge of fluid from said hydraulic means, and cam means operated in synchronism with said spindle for automatically controlling said regulating means and controlling the supply of pressure fluid to said hydraulic means during rotation of the spindle and workpiece.

14. In a machine of the class described for milling crankshafts and the like in which the work cycle is completed in a single revolution and each successive workpiece is indexed in the same predetermined rotational position, means to index a workpiece in said predetermined position, means to rotate a crankshaft on its axis and with the pin thereof following an orbital movement, a rotary milling cutter having a width corresponding approximately to the length of the crank pin to be milled, means to feed said cutter to the crank pin while the crankshaft remains stationary, means automatically initiated to start rotation of said crankshaft upon said cutter reaching the pin, means thereafter operative to move said cutter in accordance with the orbit movement of the crank pin as the crankshaft is rotated on its axis, and means to back traverse said cutter from the workpiece and stop rotation of the latter immediately upon completion of a single rotation of the workpiece..

15. In a machine of the class described for milling crankshafts and the like in which the work cycle is completed in a single revolution and each successive workpiece is indexed in the same predetermined rotational position, means to index a workpiece in said predetermined position, means to hold the crankshaft against rotation during initial milling operations and to rotate said crankshaft thereafter, a rotary milling cutter having a width corresponding approximately to the length of the crank pin to be milled, means to feed said cutter to the crank pin while the latter is held against turning, means thereafter

operative to move said cutter in accordance with the orbit movement of the crank pin as the crankshaft is rotated on its axis, and means to back traverse said cutter from the workpiece and stop rotation of the latter immediately upon completion of a single rotation of the workpiece.

16. In a machine of the class described for milling crankshafts and the like, means to hold the crankshaft against rotation during initial milling operations and to rotate said crankshaft thereafter, a rotary milling cutter having a width corresponding approximately to the length of the crank pin to be milled and having side and peripheral cutter members to simultaneously mill cheek and crank pin elements of the crankshaft, means to feed said cutter to the crank pin while the latter is held against turning, and means thereafter operative to move said cutter in accordance with the orbit movement of the crank pin as the crankshaft is rotated on its axis.

17. In a machine of the class described, a headstock, a rotary spindle in said headstock for supporting and rotating one end of a workpiece, a tailstock, a rotary spindle in said tailstock aligned with said headstock spindle for supporting and rotating the other end of the workpiece, a slide supporting said tailstock for axial movement toward and away from said headstock, a common drive for said spindles, a rotary milling cutter having its axis substantially parallel to the rotary axis of said spindles and workpiece, means disposed to move said milling cutter toward and away from the axis of rotation of said spindles in synchronism with the rotation of the spindles, a chuck carried by each spindle for gripping the corresponding end of the workpiece, and a replaceable driver abutment carried by each chuck to rotationally engage the workpiece for indexing and positively driving the same.

18. In a machine of the class described, a headstock, a rotary spindle in said headstock, a tailstock, a rotary spindle in said tailstock aligned with said headstock spindle, a slide supporting said tailstock for axial movement toward and away from said headstock, a separate chuck carried by each spindle and adapted to grip and support a corresponding end of a workpiece for rotating the latter, a common drive for said spindles, means to initially operate one of said chucks to lightly grip the workpiece upon insertion of the latter therein and while the headstock and tailstock are apart, means to initially operate the other chuck to lightly grip the workpiece and center the latter relative to said spindles upon closing of the tailstock toward the headstock and insertion of the workpiece in said other chuck, means thereafter to operate said chucks by substantial force to exert a final working grip upon the workpiece for rotating the latter with said spindles, a rotary milling cutter having its axis substantially parallel to the rotary axis provided by said chucks for the workpiece, means disposed to move said milling cutter toward and away from the workpiece in synchronism with the rotation thereof by said spindles, and means to initiate the operative movement of said milling cutter in response to said final chuck operating means.

19. In a machine of the class described, a headstock, a rotary spindle in said headstock, a tailstock, a rotary spindle in said tailstock aligned with said headstock spindle, a slide supporting said tailstock for axial movement toward and away from said headstock, a separate chuck carried by each spindle and adapted to grip and support a corresponding end of a workpiece for rotating the latter, means to initially operate one of said chucks to lightly grip the workpiece upon insertion of the latter therein and while the headstock and tailstock are apart, means to initially operate the other chuck to lightly grip the workpiece and center the latter relative to said spindles upon closing of the tailstock toward the headstock and insertion of the workpiece in said other chuck, means thereafter to operate said chucks by substantial force to exert a final working grip upon the workpiece for rotating the latter with said spindles, means to clamp said tailstock in closed position, and means for operating said last named means in synchronism with the closing of the tailstock and the initial operation of said other chuck.

20. In a machine of the class described, a headstock, a rotary spindle in said headstock, a tailstock, a rotary spindle in said tailstock aligned with said headstock spindle, a slide supporting said tailstock for axial movement toward and away from said headstock, a common drive for said spindles, a work chuck carried by each spindle, hydraulic means initially operating said chucks under a light clamping pressure, and means for thereafter applying final operating pressure thereto.

21. In a machine of the class described, a headstock, a rotary spindle in said headstock, a tailstock, a rotary spindle in said tailstock aligned with said headstock spindle, a slide supporting said tailstock for axial movement toward and away from said headstock, a spline shaft connected to rotate both spindles and carrying a drive gear movable with said tailstock to drive the same, a worm gear drive for said spline shaft, and means to release the worm of said drive to release the splines of said shaft and thereby provide for free movement of the tailstock and its drive gear along the spline shaft during loading and unloading of the machine.

22. In a machine of the class described, a headstock, a rotary spindle in said headstock, a tailstock, a rotary spindle in said tailstock aligned with said headstock spindle, a slide supporting said tailstock for axial movement toward and away from said headstock, a work chuck carried by each spindle, hydraulic means for moving said tailstock and for operating said chucks comprising means to apply a low fluid pressure to the tailstock spindle chuck, means initiated by the moving of the tailstock toward the headstock to apply a low fluid pressure to the operating means for said headstock spindle chuck, and means to apply a final operating fluid pressure simultaneously thereafter to the operating means for both chucks.

23. In a machine of the class described, a headstock, a rotary spindle in said headstock, a tailstock, a rotary spindle in said tailstock aligned with said headstock spindle, a work chuck carried by each spindle, common means for rotating said spindles, a slide supporting said tailstock for axial movement toward and away from said headstock, a clamp for securing said tailstock stationary when in operative position, hydraulic means for moving said tailstock toward said headstock to secure a workpiece therebetween, hydraulic means for operating the chuck carried by said tailstock spindle, hydraulic means for operating said clamp to secure the tailstock in position, and means responsive to the completion of the inward movement of the tailstock

toward the headstock to operate said chuck and clamp operating hydraulic means.

24. In the machine of claim 23, a bed member, a tailstock member mounted on a gib plate for longitudinal sliding movement upon said bed, complementary inwardly and upwardly inclined guideways of said tailstock and bed disposed on opposite sides of said gib plate, one of the inclined surfaces of said guideways being a part of a separate wedge block supported by one of said members, and hydraulic means for wedging said block against its supporting member and the opposed inclined surface to clamp and secure said tailstock in position.

25. In the machine of claim 23, a bed member, a tailstock member mounted on a gib plate for longitudinal sliding movement upon said bed, complementary inwardly and upwardly inclined guideways of said tailstock and bed disposed on opposite sides of said gib plate, one of the inclined surfaces of said guideways being a part of a separate wedge block supported by one of said members, a toggle member disposed between said wedge block and its supporting member and extending generally in a direction to force said block against the opposed inclined surface of the other member, and means for operating said toggle to clamp said tail stock in position.

26. A machine for milling the throws of a crankshaft, comprising a pair of rotary spindles disposed in alignment, a chuck carried by each spindle for securing the corresponding end of the crankshaft, means to drive said spindles in unison to apply rotational torque to both ends of said crankshaft, a plurality of rotary heads carrying milling cutters and disposed in circumferentially spaced relation around the crankshaft, slides supporting said cutter heads for movement toward and away from the crankshaft, means for feeding said cutter heads simultaneously toward and from the crankshaft to effect milling of the corresponding throws of the crankshaft thereby, and means operative by predetermined inward movement of said cutter slides to provide a central bearing support for said crankshaft during milling of the same, said means being retracted by retraction of said slides.

27. A machine for milling the throw of a crankshaft, comprising a pair of rotary spindles disposed in alignment, means carried by said spindles for securing a crankshaft therebetween, means to hold said spindles against rotation, means to drive said spindles in unison to apply rotational torque to both ends of said crankshaft, a rotary milling cutter disposed to be laterally aligned with the throw of the crankshaft and having circumferential and side cutter teeth thereon for milling both the pin and adjacent cheeks of the throw, means to index the crankshaft relative to said spindle and cutter to position the pin of the crankshaft farthest from the cutter, means to feed said cutter toward said crankshaft to mill the cheeks of said throw as the cutter approaches the eccentric pin of the throw and while said crankshaft is held against rotation, and means to feed said cutter in a reciprocating movement to follow the orbit of the eccentric pin and effect milling of the pin as the crankshaft is rotated through one revolution by said spindles.

28. In a machine of the class described, a rotary spindle adapted to hold a crankshaft having an eccentric crank throw to be milled, a rotary milling cutter disposed in lateral alignment with said crank throw, hydraulic means to feed said milling cutter to effect milling of the crankshaft, a cam rotated in unison with said spindle and disposed as a stop for the forward feed of said cutter, said cam being adapted to retract said cutter against said hydraulic feeding means during part of the milling cycle and to control the advance of the cutter during the remainder of the cycle to compensate for the movement of the crank pin of said throw in its orbit and thereby effect milling of the pin on all sides to a substantially uniform diameter, and means regulating the discharge of fluid from said hydraulic feeding means in correlation to the movement of said cutter and the rotation of said work spindle.

29. In a machine of the class described, a rotary spindle adapted to hold a crankshaft having an eccentric crank throw to be milled, a rotary milling cutter disposed in lateral alignment with said crank throw, hydraulic means to feed said milling cutter to effect milling of the crankshaft, a cam rotated in unison with said spindle and disposed as a stop for the forward feed of said cutter, said cam being adapted to retract said cutter against said hydraulic feeding means during part of the milling cycle and to control the advance of the cutter during the remainder of the cycle to compensate for the movement of the crank pin of said throw in its orbit and thereby effect milling of the pin on all sides to a substantially uniform diameter, means regulating the discharge of fluid from said hydraulic feeding means, and cam means operated in synchronism with said spindle for automatically controlling said regulating means and controlling the supply of pressure fluid to said hydraulic feeding means during rotation of the spindle and workpiece.

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