Nov. 15, 1927. 1,649,109

A. J. GIFFORD ET AL

CONTOUR MILLING MACHINE

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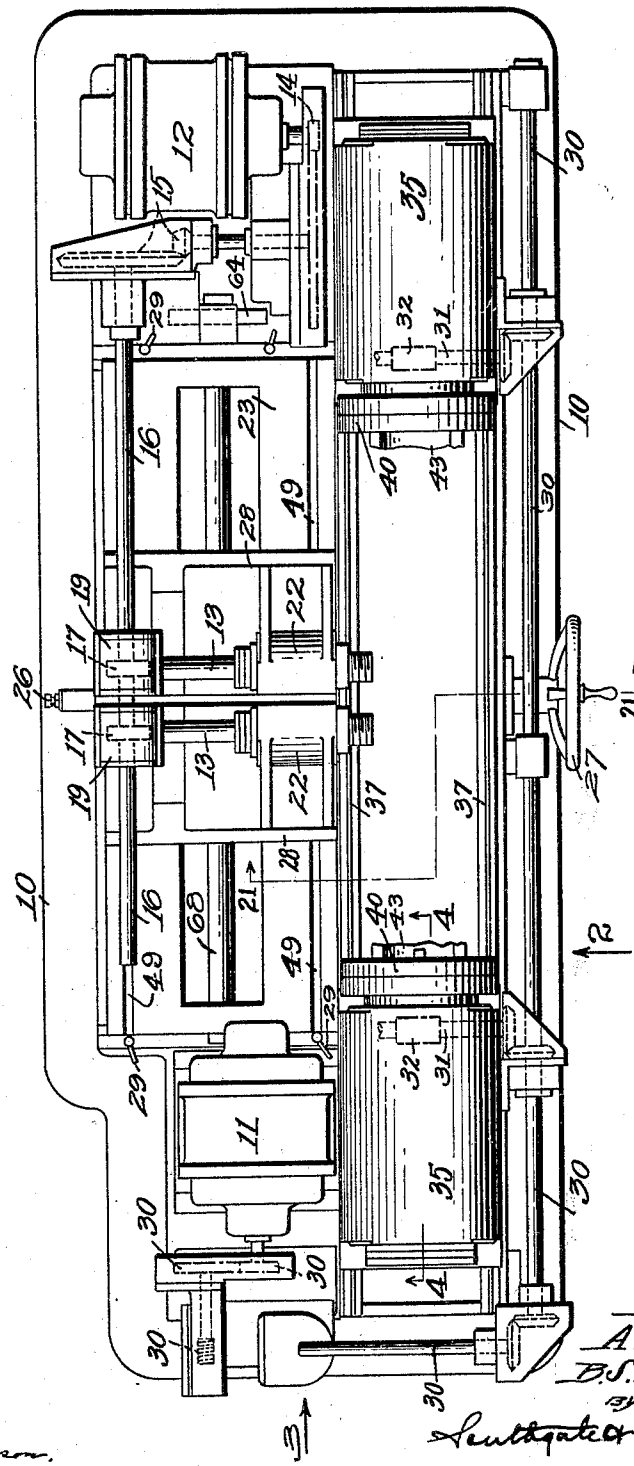


Fig. 1.

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CONTOUR MILLING MACHINE

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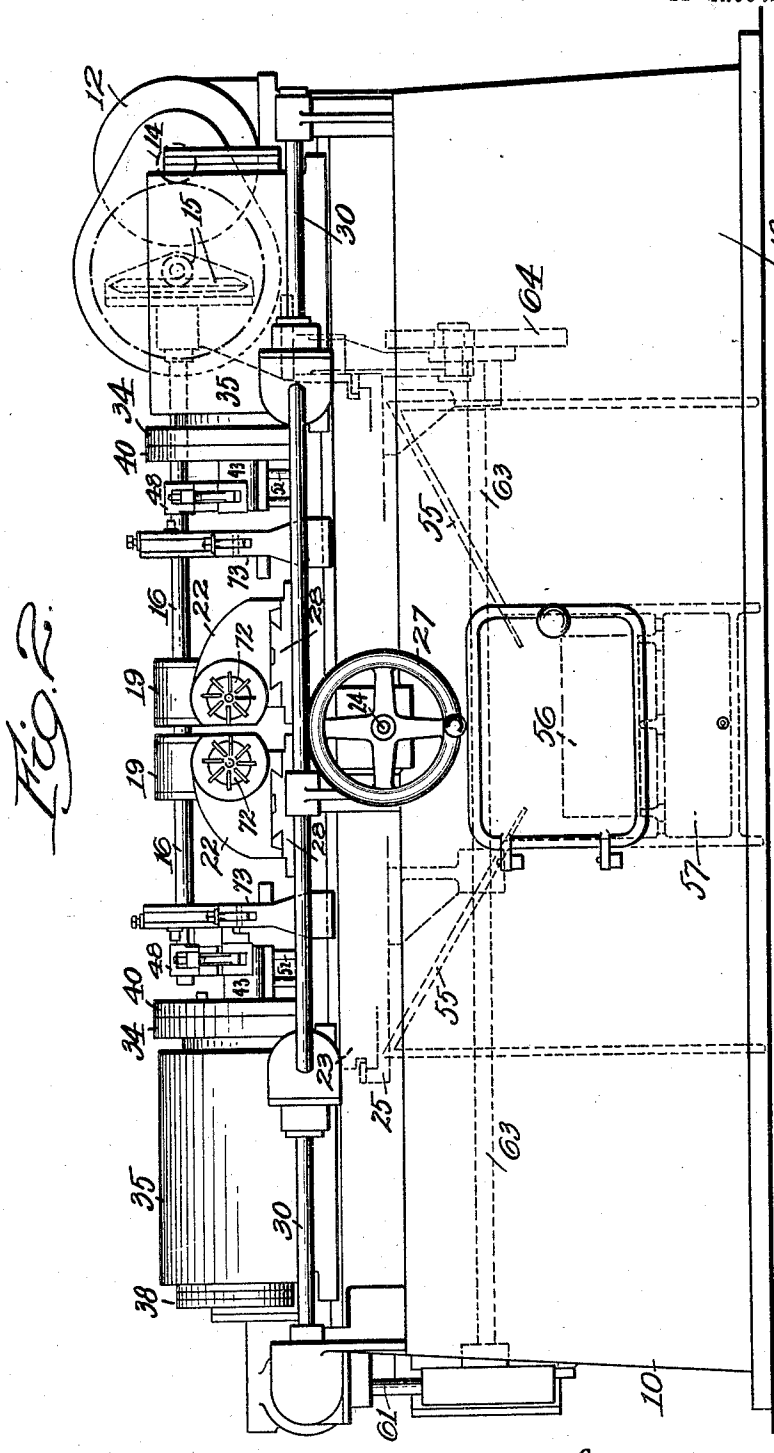


Fig. 2.

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CONTOUR MILLING MACHINE

Filed March 17, 1924 11 Sheets-Sheet 3

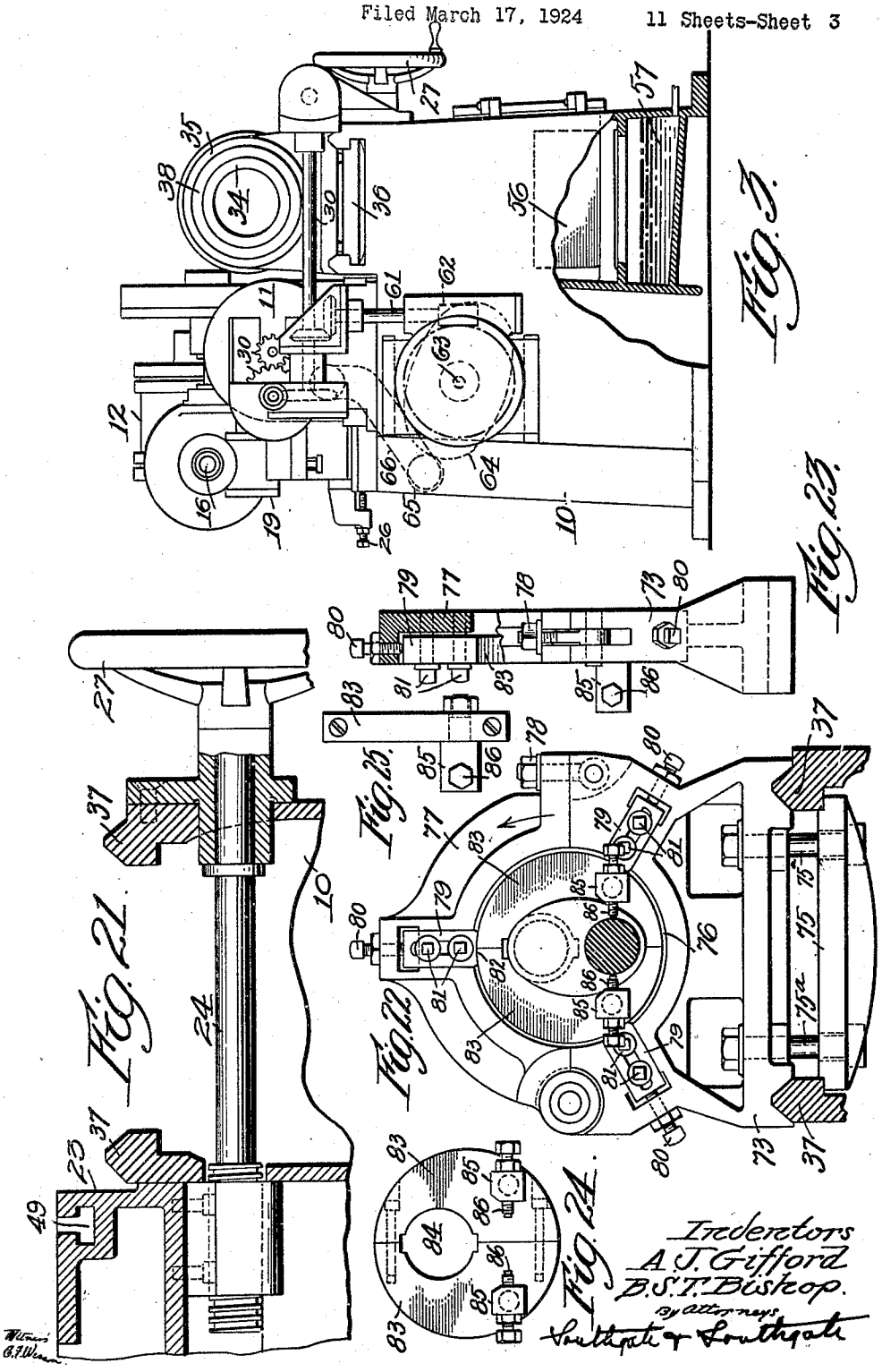


Fig. 21.

Fig. 22.

Fig. 23.

Fig. 24.

Fig. 25.

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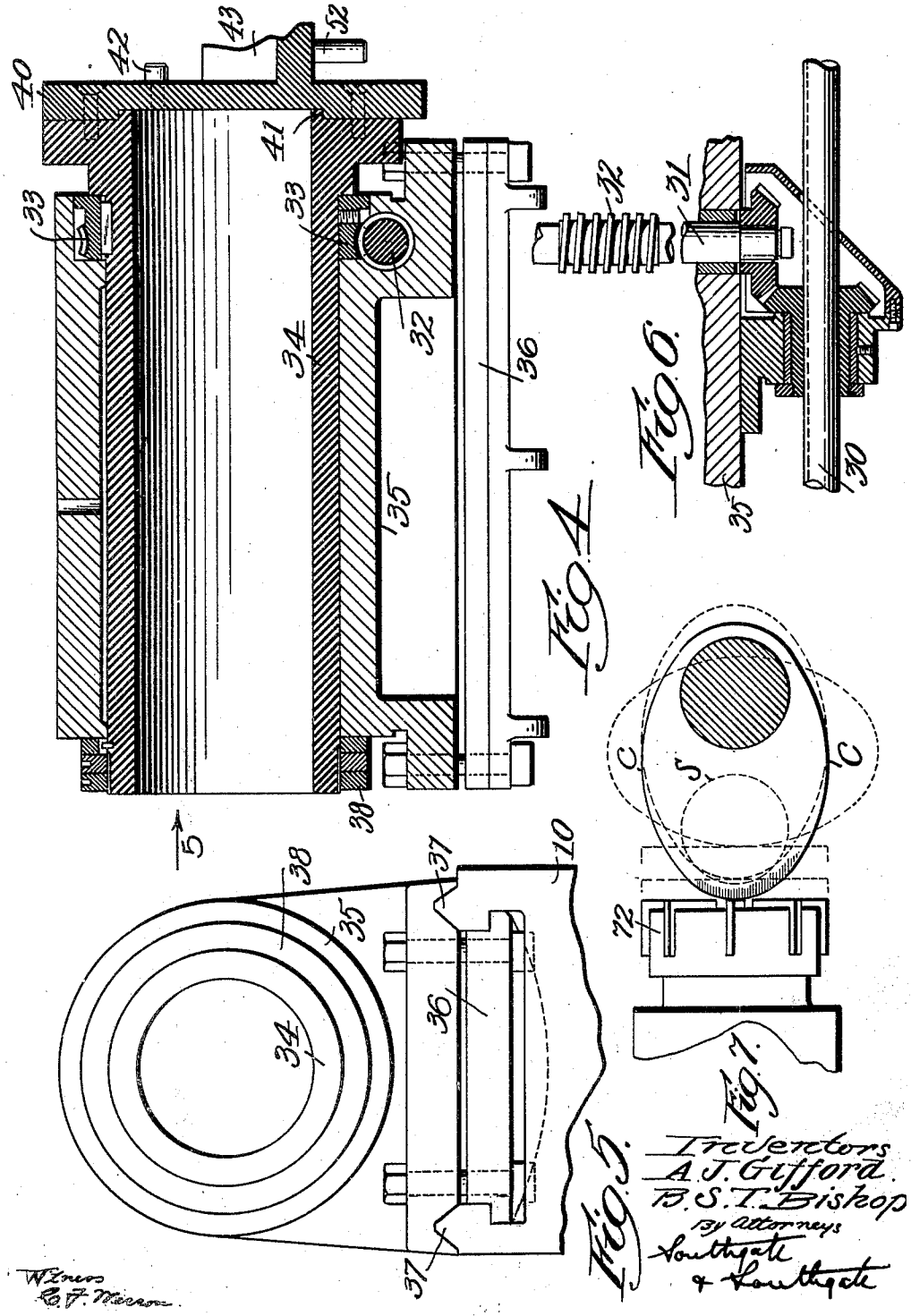
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A. J. GIFFORD ET AL

CONTOUR MILLING MACHINE

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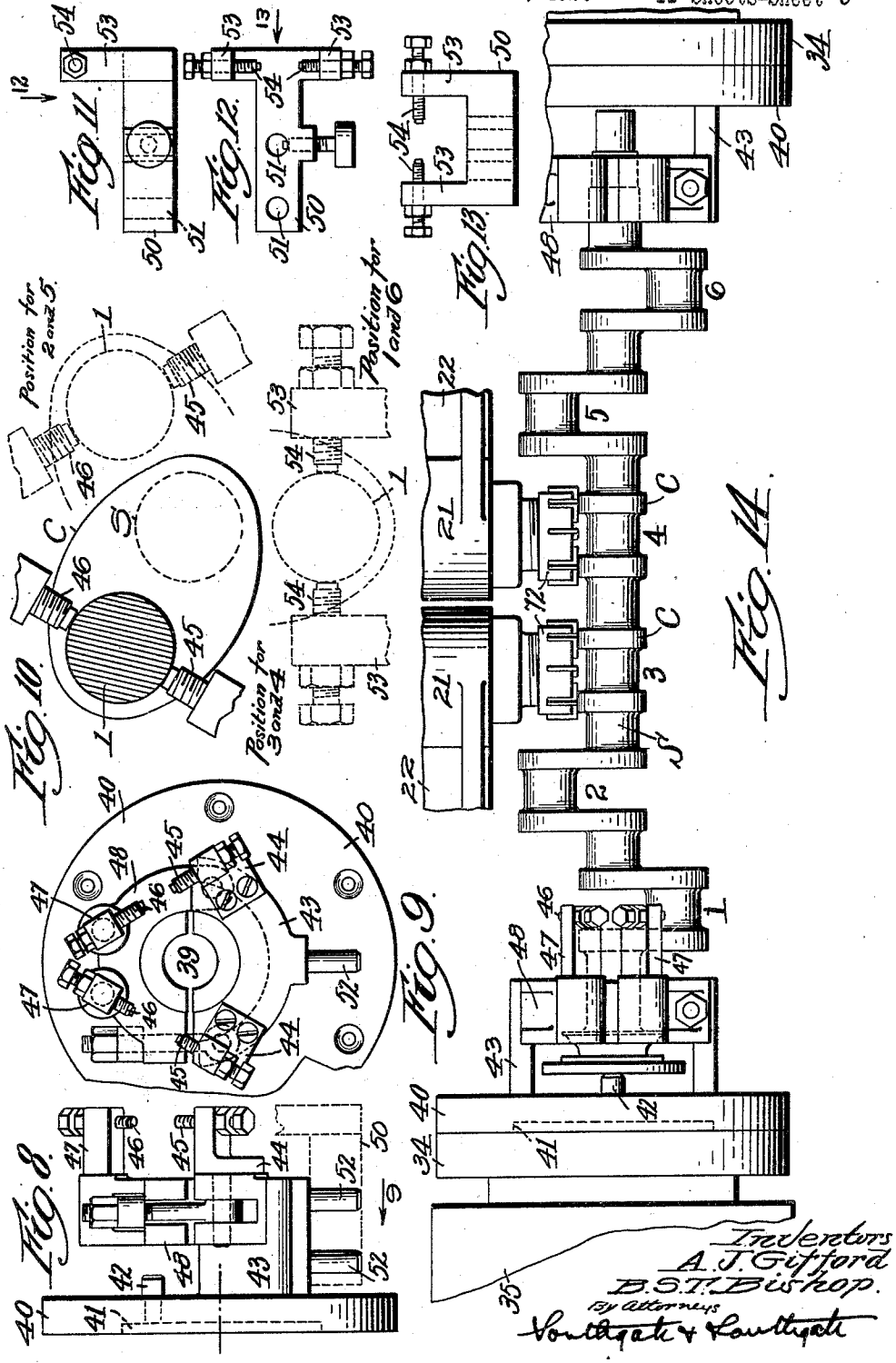
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CONTOUR MILLING MACHINE

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CONTOUR MILLING MACHINE

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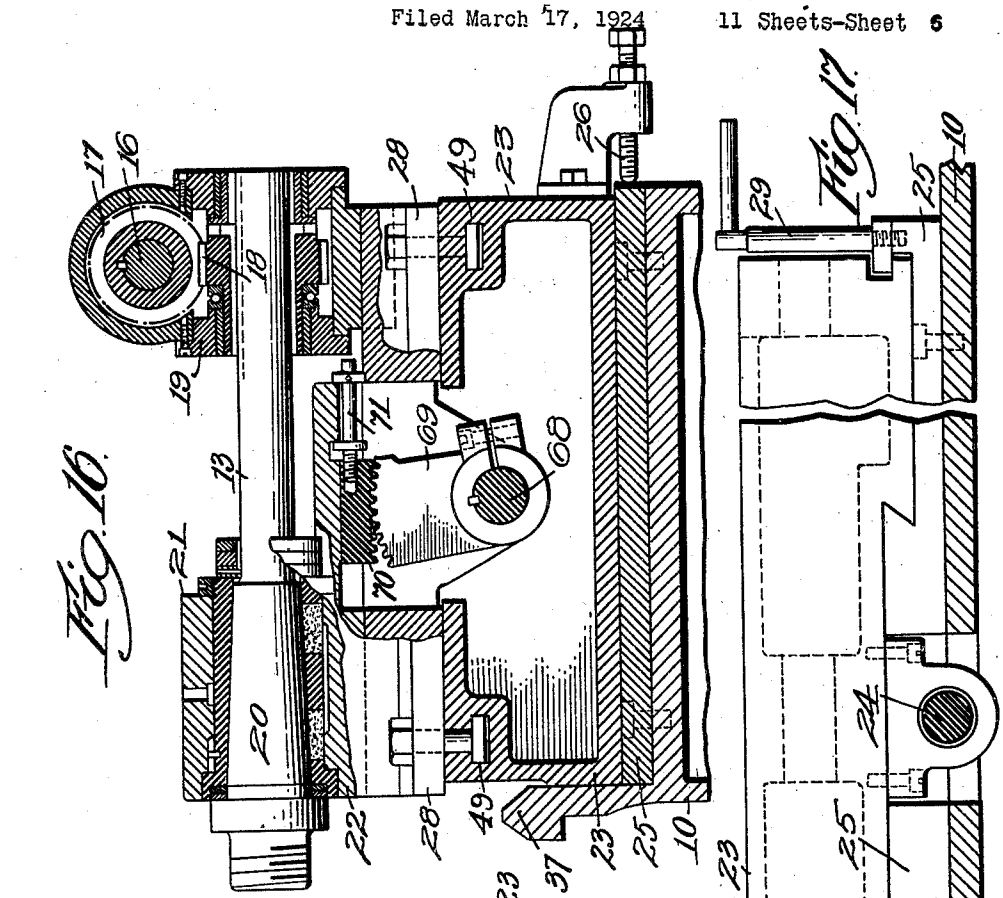


Fig. 16.

Fig. 17.

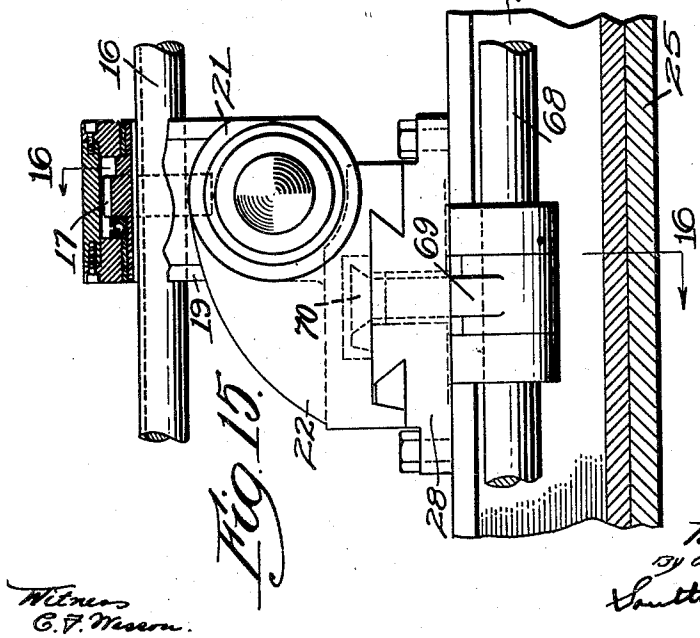


Fig. 15.

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CONTOUR MILLING MACHINE

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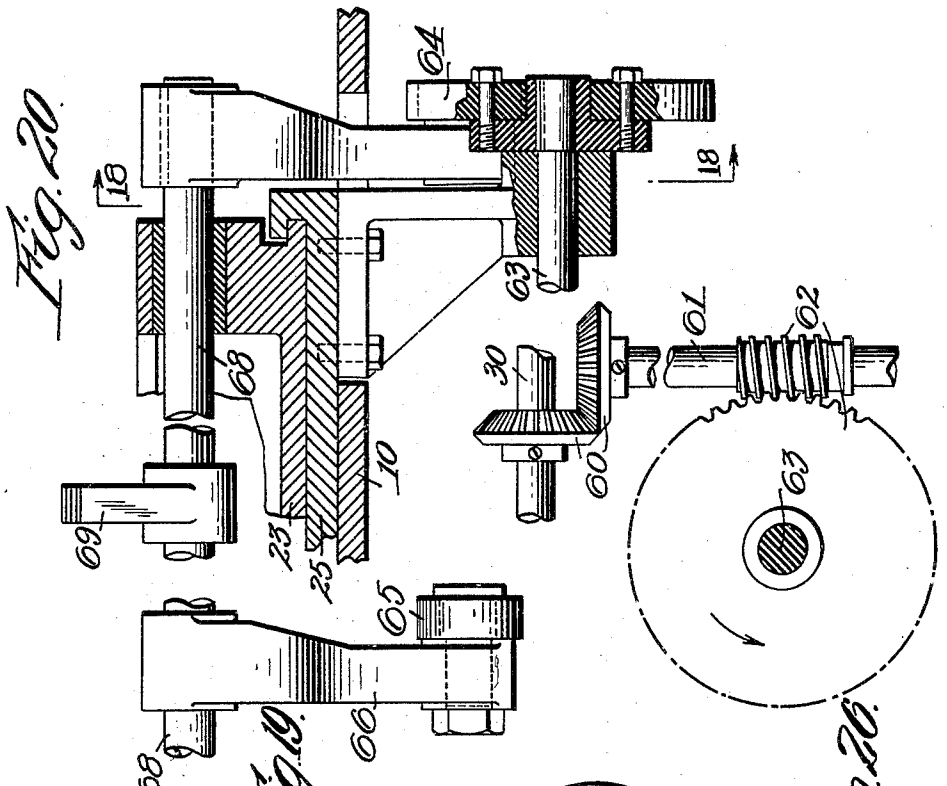


Fig. 20.

Fig. 19.

Fig. 21.

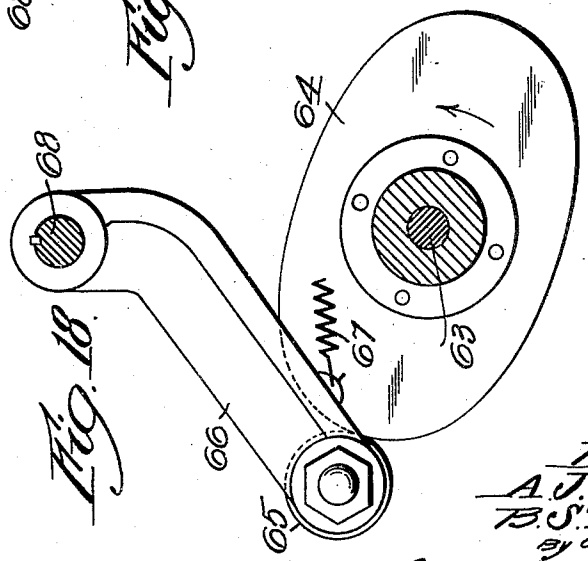


Fig. 18.

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CONTOUR MILLING MACHINE

Filed March 17, 1924 11 Sheets-Sheet 8

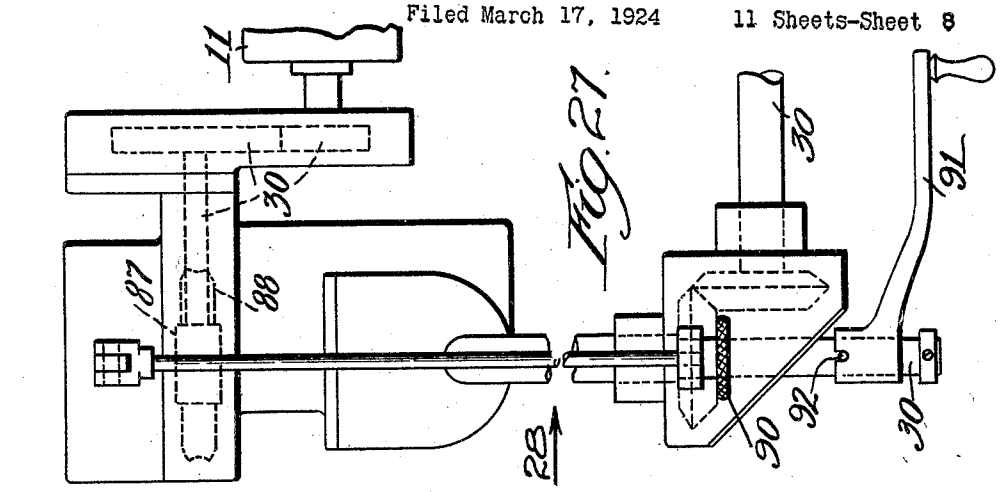


Fig. 27.

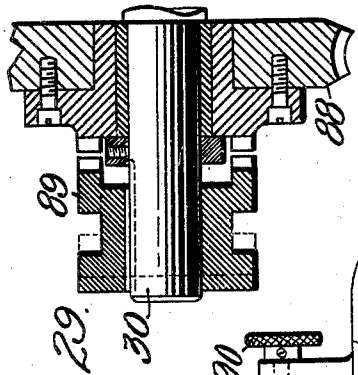


Fig. 29.

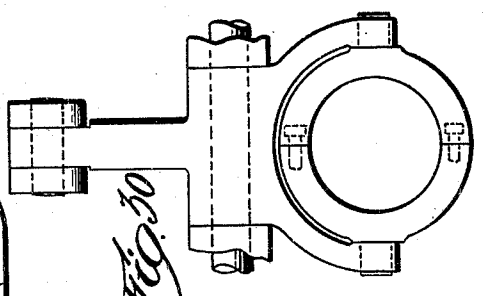


Fig. 30.

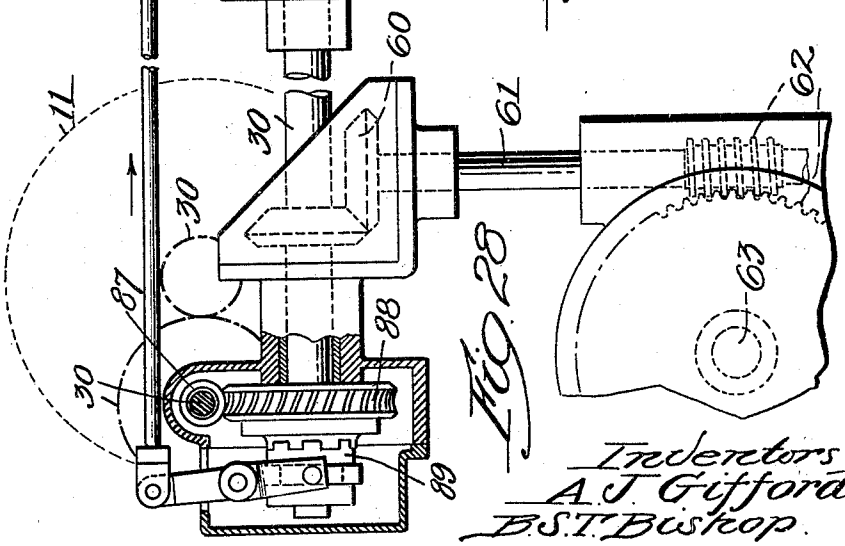


Fig. 28.

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CONTOUR MILLING MACHINE

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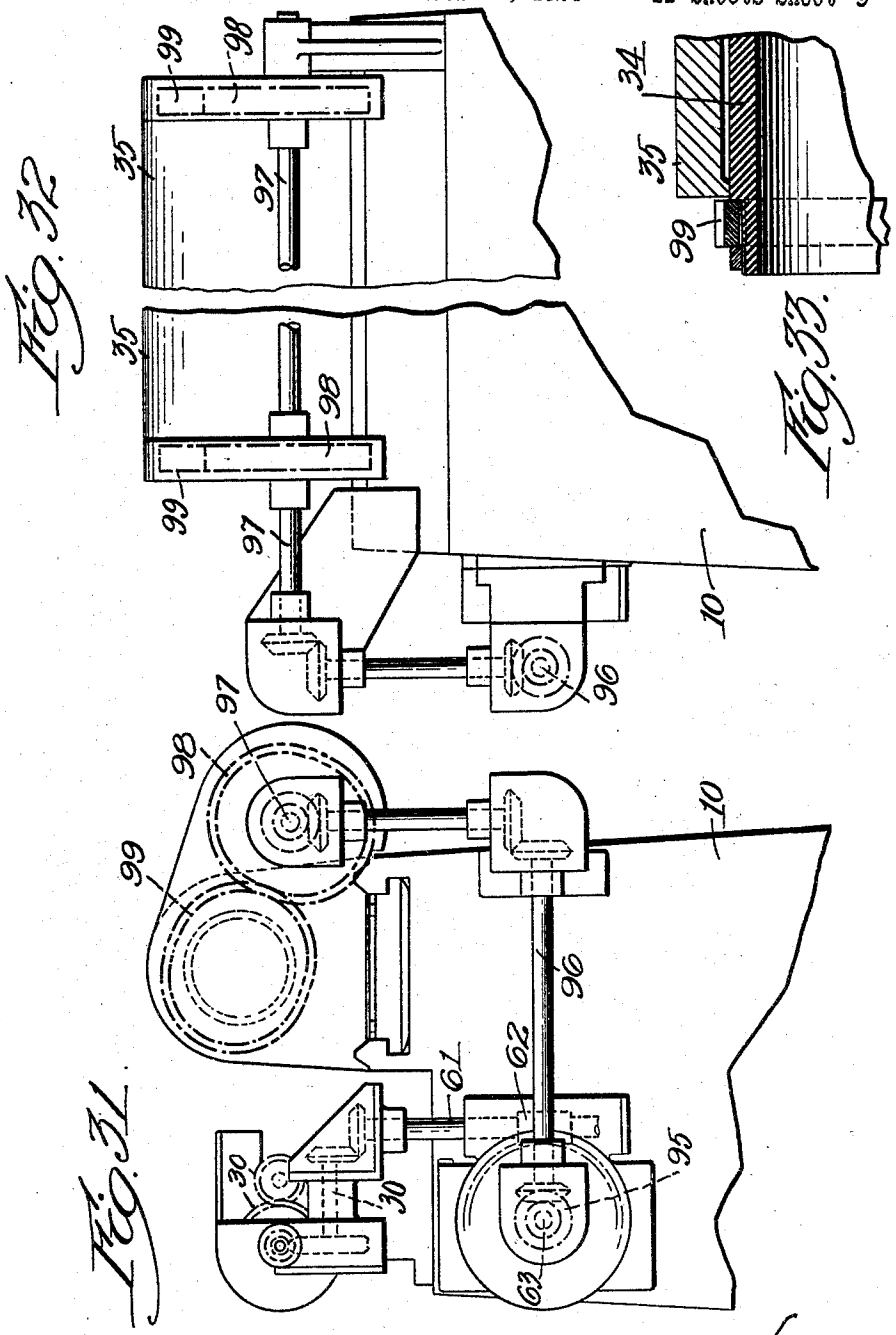


Fig. 32.

Fig. 33.

Fig. 31.

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C. F. Wesson.

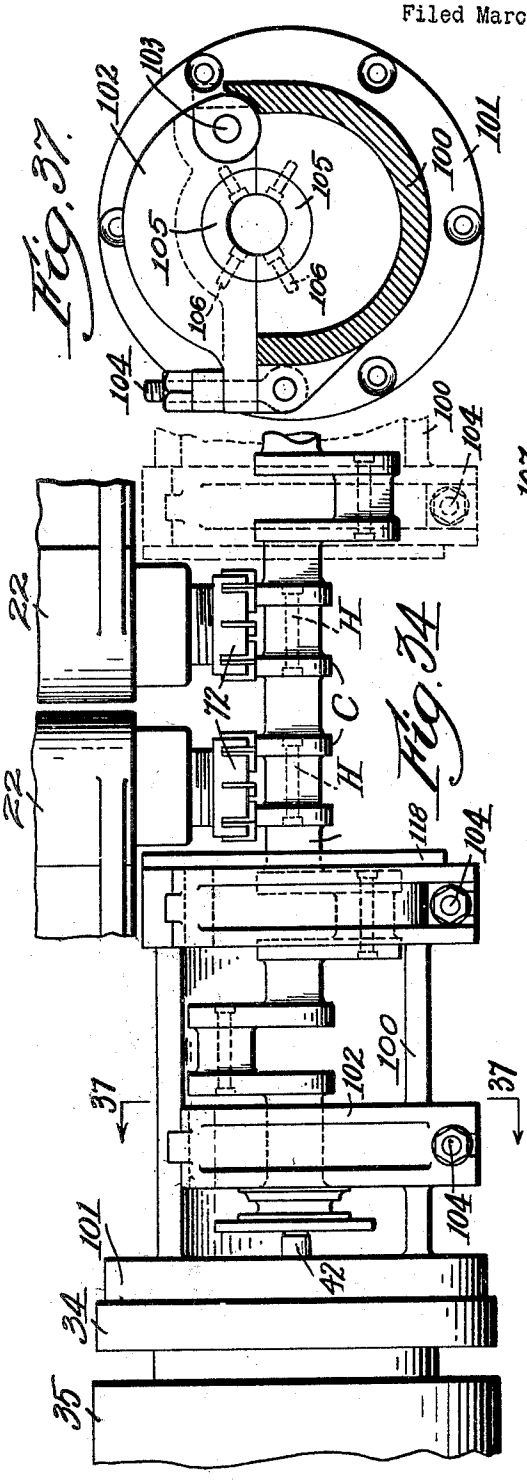
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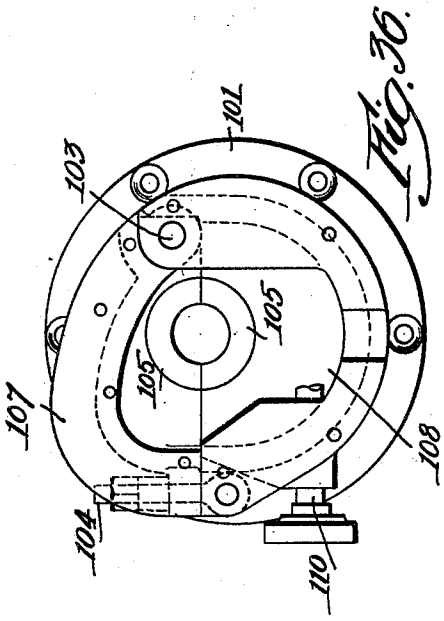
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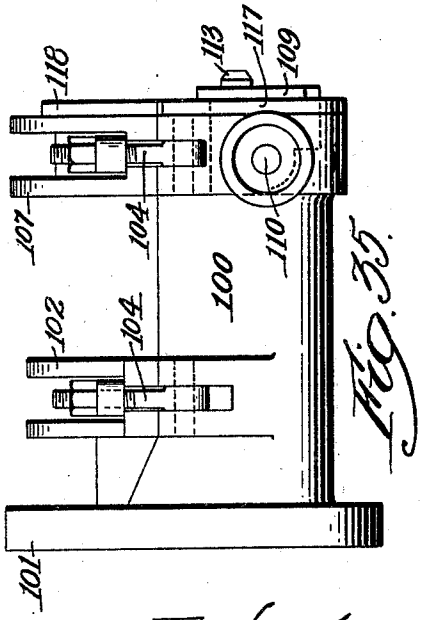
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CONTOUR MILLING MACHINE

Filed March 17, 1924 11 Sheets-Sheet 10







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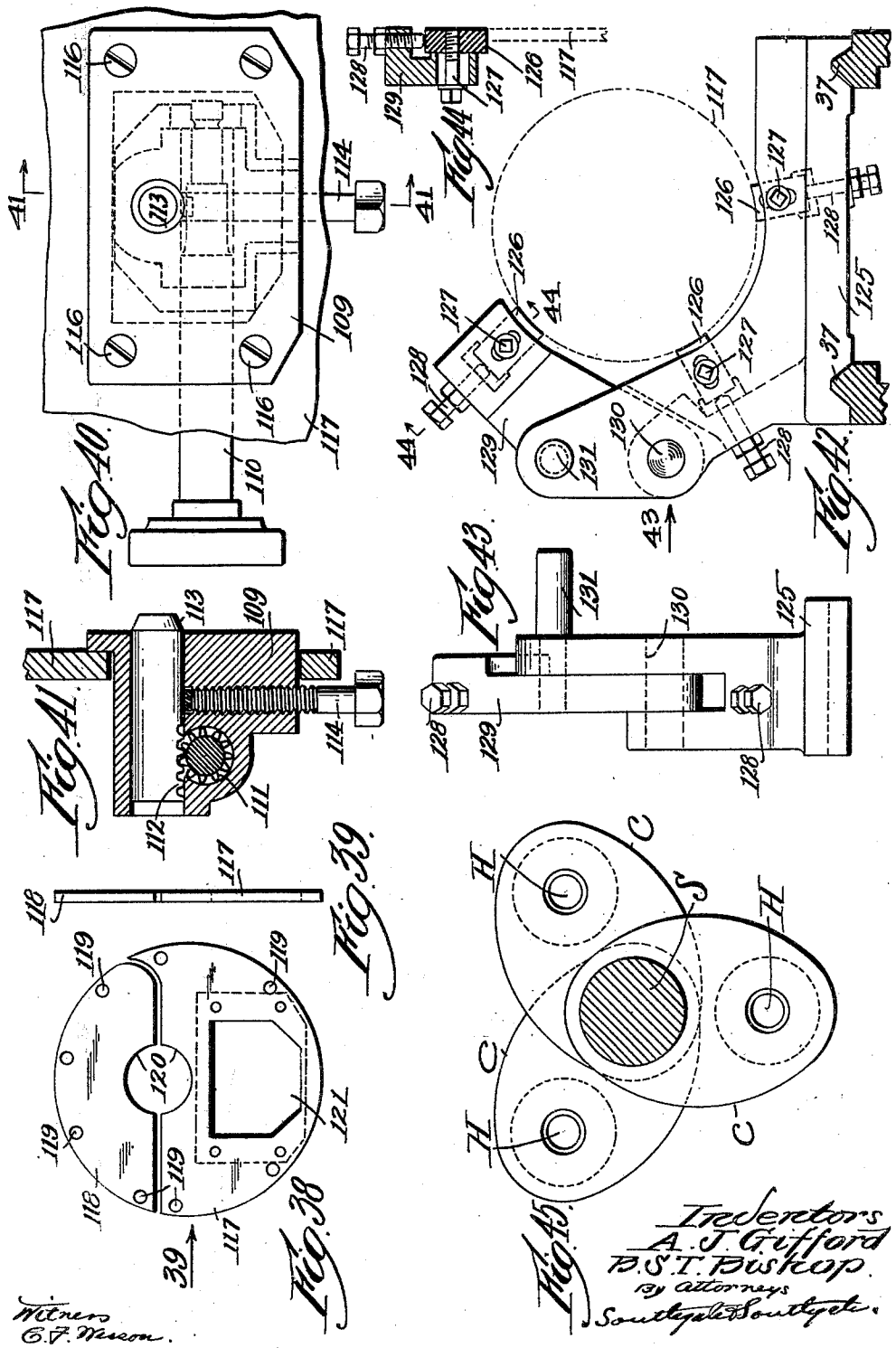
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CONTOUR MILLING MACHINE

Filed March 17, 1924 11 Sheets-Sheet 11



Patented Nov. 15, 1927. 1,649,109

UNITED STATES PATENT OFFICE.

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CONTOUR-MILLING MACHINE.

Application filed March 17, 1924. Serial No. 699,651.

This invention relates to a machine adapted especially for milling eccentric or non-circular contours and especially the cheeks of a crank shaft.

The principal objects of the invention are to provide means for axially reciprocating a pair of milling cutters to cause them to produce the desired contour on the two corresponding cheeks of the crankshaft while the shaft is being turned around; to arrange the parts to rotate the shaft about a center at such a distance from the axis of the shaft as to enable us to provide the simplest mechanism for controlling the reciprocation of the cutters in order to trace the desired contour; to provide suitable rotary supports for the ends of the crankshaft, suitable crankshaft holding crotches thereon and accurate locating means for setting the shaft at the right position on the supports; to provide simple means for causing the reciprocation of the cutter spindles and positively synchronizing the same with the rotation of the crankshaft; to provide an improved steady rest suitable for use in an eccentric position; and to provide a modified form adapted to equalize the cut around the work.

Other objects and advantages of the invention will appear hereinafter.

Reference is to be had to the accompanying drawings, in which

Fig. 1 is a plan of a contour milling machine constructed in accordance with this invention, shown as supporting two milling cutter shafts for simultaneously milling the edges of four cheeks but long enough to permit of these cutters being arranged to mill any pair of cheeks on the shaft;

Fig. 2 is a front view of the same;

Fig. 3 is an end view;

Fig. 4 is a central vertical section through one of the crankshaft supporting bearings on the line 4—4 of Fig. 1;

Fig. 5 is an end view of that bearing;

Fig. 6 is a sectional view through the driving elements for rotating the said support;

Fig. 7 is a sectional view through the crankshaft showing one of the cheeks and the operation of facing off the edge thereof;

Fig. 8 is a side view of the holding crotch on the crankshaft support;

Fig. 9 is an end view of the same;

Fig. 10 is a sectional view similar to Fig. 7 but showing the method of positioning the three pairs of cranks on the crotch shown in Fig. 9;

Fig. 11 is a side view of the locator used for positioning one of the cranks;

Fig. 12 is a plan of the same;

Fig. 13 is an end view of it;

Fig. 14 is a plan of a crankshaft and the supporting parts showing the cutters in the act of milling the edges of two of the cheeks;

Fig. 15 is an end view of the slide for supporting and operating a cutter spindle, with parts shown in section;

Fig. 16 is a sectional view of the same on the broken line 16—16 of Fig. 15;

Fig. 17 is a side view of the supporting slide therefor with the main frame illustrated in section;

Fig. 18 is an end view of the cam for controlling the reciprocation of the milling cutters;

Fig. 19 is a front view of the arm and roll operated by said cam;

Fig. 20 is a front elevation of part of the bed of the machine and the mechanism for reciprocating the cutters;

Fig. 21 is a sectional view of a part of the bed showing the hand wheel controlled mechanism for shifting the transverse tool slide;

Fig. 22 is a transverse sectional view of the crankshaft and bed of the machine showing the steady rest in elevation;

Fig. 23 is a front view of the same partly in section;

Fig. 24 is an end view of the eccentric disc constituting a part of the steady rest;

Fig. 25 is an edge view of the same;

Fig. 26 is an end view of the mechanism for driving the cam shaft shown in Fig. 18;

Figs. 27 and 28 are respectively a plan and end view of a modified construction for adjusting the work heads;

Fig. 29 is a central sectional view of the clutch;

Fig. 30 is an end view of it;

Figs. 31 and 32 are respectively an end and side view of another modified construction for equalizing the cut all around the periphery of the work;

Fig. 33 is a detail of the head and spindle construction;

Fig. 34 is a view similar to Fig. 14 showing modifications of the driving crotch;

Fig. 35 is a front view of the holding crotch thereof;

Fig. 36 is an end view of the same;

Fig. 37 is a sectional view on the line 37—37 of Fig. 34;

Fig. 38 is a face view of a centering plate;

Fig. 39 is an edge view thereof;

Fig. 40 is an enlarged face view of a driving plunger operating mechanism;

Fig. 41 is a sectional view on the line 41—41 of Fig. 40;

Fig. 42 is a side view of the center rest;

Fig. 43 is an edge view thereof;

Fig. 44 is a sectional view on the line 44—44 of Fig. 43; and

Fig. 45 is a sectional view of the crank shaft showing the cheeks.

We have shown the invention as applied to a machine long enough to mill the contours of any set of cheeks of a crank shaft, but this machine as presented herewith is intended to mill only two pairs of them. In fact, the method of operation is to mill two pairs on one machine, then take the crank shaft out and put it into another machine exactly the same, except that the milling cutters are set at a different distance apart.

In this second machine, a second set of cheek contours are milled and then, if the crank shaft has six cranks, the shaft is transferred to a third machine exactly the same, except for the distance apart of the milling cutters, and the third set of cheeks are milled off. It will be understood that this milling operation is performed around the peripheries of the cheeks and this machine is not constructed as shown for performing any other operation, although the principles set forth herein and even the details of construction are applicable for the milling of contours of other objects than crankshaft cheeks.

We have shown a bed or frame 10 for supporting all the parts. The top of this bed is divided into two regions, one extending along one side at the top for supporting the motors 11 and 12, the two spindles 13, for carrying the milling cutters 72 or other tools, and the mechanism for driving these spindles from the motor 12, as well as part of the mechanism for transmitting power from the motor 11 for driving the crank shaft to be operated upon. The other region at the top of the bed is designed for receiving the means for supporting and rotating the crank shaft to be operated upon.

The motor 12 drives the milling cutter spindles 13 through a pinion 14 on the motor shaft, suitable gearing 15 and shafts connected with and constantly driving a longitudinal shaft 16. To this shaft 16 are slidingly keyed a pair of spiral gears 17 each of which drives a gear 18 keyed slidingly to one of the cutter spindles. These spindles are supported in the following way:—On the frame 10 is fixed a slide plate 25 having ways arranged transversely. On these ways is a cross slide 23 adapted to be moved along the ways by a screw shaft 24 having a hand wheel 27 at the front of the machine. The slide is held in adjusted position by four binders 29 near its corners. The movement of the slide 23 forward is adjustably limited by an adjusting screw 26 on the slide and engaging the rear edge of the fixed slide plate 25.

In the upper surface of the cross slide 23 are a pair of longitudinal T-slots 49 having bolts extending down into them by which two supporting plates 28 are secured on the slide at any desired distance apart. These plates 28 have ways extending transversely of the machine on which are slidably mounted the two cutter slides 22. Each cutter slide has a rear hub 19 and a front hub 21 in transverse alignment in which the ends of one cutter spindle 13 are mounted. The rear end of each spindle is mounted in ball bearings in the hub 19 which carries the spiral gear 17 and which can be moved along the shaft 16 to allow for the adjustment of the spindle 13 as desired. At the front end each of the spindles is provided with a cone 20 which has a bearing in a bushing located in an upwardly extending hub 21 on the slide 22.

The motor 11 is connected by various gears, worms and shafts indicated by the numeral 30 at various points for driving two transverse shafts 31 on the front of the machine. These shafts are provided with worms 32 each meshing with a worm wheel 33 keyed to a hollow rotary spindle 34. These heads are mounted to face each other and rotate in hubs 35 which are secured to the bed by shoes 36 and bolts or the like. The bed is provided with ways 37 which support the hubs 35 resting on these ways. These hubs 35 are adjusted longitudinally along these ways and then these shoes are clamped up by the bolts to secure them firmly in their adjusted positions. A shoulder on the spindle 34 comes up against the gear 33 at one end and is provided with lock nuts and washers 38 at the other end for holding it firmly against the gear and preventing longitudinal motion.

On the end of each spindle 34 is a flat plate 40 having a recess 41 in the back for fitting over a central projection on the spindle, so that this plate is centered. It is fixed to the head by screws or the like. Mounted on the front of this flat plate is an end stop 42 and the plate is also provided with a holding crotch 43 having a recess 39 located eccentrically, for receiving the end of the crankshaft. This crotch is provided with a pair of brackets 44 in which are set a pair of

bolts 45 adapted to engage the circumference of two of the turned pins of the crankshaft S, which is to be operated upon. These bolts are arranged at an angle to each other of 60 degrees if the crank shaft has three throws as shown. This crotch has a semi-circular recess 39. Opposite these bolts 45 and in alignment with them are two bolts 46 adjustably mounted in a pair of perforated swivel studs 47 mounted on the clamp 48. The object of these four bolts is to engage the first pin of the crankshaft at diametrically opposite points as indicated in Fig. 10 for the purpose of locking the crankshaft in proper position for operation upon one of the pairs of cheeks in this machine. When the cheeks C of the pins 3 and 4 are to be operated upon as shown, the first pin #1 is held by the two screws shown in full lines in Fig. 10. If the cheeks of pins 2 and 5 are to be milled, the crankshaft is turned so that the other two screws hold pin 1 as shown in dotted lines at the right in Fig. 10.

The same pin #1 is similarly positioned by means of the locking device shown in Figs. 11, 12 and 13 when the cheeks of the pins 1 and 6 are to be milled. This positioning means comprises a plate 50 having two perforations 51 by which it is adapted to be located properly on two pins 52 extending from the bottom of the holding crotch. It has two arms 53 extending in opposite directions from one end and these are provided with bolts or screws 54 for locating the #1 pin as indicated in dotted lines at the bottom of Fig. 10. When so located, the clamp 48 is tightened up to hold the shaft in that position and the locating means is detached so that the cheeks of the pins #1 can be accessible to the cutters. This is not necessary in the case of the other cheeks.

It will be understood that the crank shaft, for example, the one shown in Fig. 14, is to be set by this crotch and locking means in such position that two pairs of cheeks, for example, those numbered 3 and 4 in Fig. 14, can be milled off around their contours.

A very important feature of this invention consists of the fact that we do not use the center or axis of the shaft S as the center on which we turn the crankshaft. On the contrary we locate it by the locating devices in such a manner that the center of rotation is somewhere between the center of the shaft S and the center of the pin which connects two of the cheeks which are to be contoured. The reason for this is to simplify the mechanism for operating or reciprocating the milling cutters. We find in practice that a center chosen about half way between the centers of the pin and shaft greatly simplifies this mechanism, particularly the cam which controls it, as will appear. This machine being designed to mill only two pairs of cheeks and those two pairs being those which have the same throw, the axis of the shaft itself will be set to rotate about the center above mentioned.

When the shaft is transferred to another machine, it is then set up so that it rotates about a center between the center of the shaft and the center of another pair of pins.

We take power from one of the shafts constituting part of the connections 30 by means of a pair of bevelled gears 60 and vertical shaft 61 and transmit it by worm and worm wheel 62 to a longitudinal shaft 63 provided with a cam 64. This is the contour cam and can be made of simple and convenient shape in accordance with this invention. Against this cam rests a roll 65 on an arm 66, and the cam forces the roll out against the resistance of a spring 67 and thus turns a shaft 68 on which the arm 66 is keyed. On this shaft 68 are fixed two gear segments 69 meshing with two racks 70 fixed to the slides 22. Each rack is connected with its slide by an adjusting screw 71 so that small adjustments can be made, but it will be obvious that whatever the adjustment, the rotation of the cam 64 through a complete revolution will move the slides back and forth once and the speed of the slides at any point is determined by the shape of the cam. As the shaft 63 and the shafts 31 are positively connected with the same driving means their relative speed of rotation is constant. Consequently the cam 64 can be designed to keep the cutters 72 always at the desired point with reference to the center on which the crankshaft turns.

It will be seen that the main slide 23 can be adjusted back and forth by hand as occasion may require by means of the hand wheel 27 and that the two parallel slides 22 can be adjusted independently by their screws 71 in the same direction. This is the direction of feed of the milling cutters 72 by the cam 64. The supporting plates can be adjusted longitudinally to bring the cutters to the positions for milling the desired cheeks.

We have shown a receiver 55 for the oil and fine pieces of metal. It has a slanting bottom to direct them into a central wire receptacle 56. From this the oil drains into the oil tank 57 from which it is pumped back into the machine.

When the crankshaft is inserted in the machine its end is butted against the stop 42 to locate it endwise. For the purpose of steadying the crankshaft while being operated upon in the manner above described, we mount on the ways 37 a steady rest frame 73. This is secured in adjusted position on the ways by means of a shoe 75 and bolts 75a operating like the shoe 36. Two of these steady rests may be used as shown, one at each side of the pair of cutters. Each steady rest is provided with a semi-circular recess 76 and with a pivoted cap 77. This cap is

also provided with a semi-circular recess registering with and completing the lower recess 76. It is held down in clamping position by a pivoted bolt and nut 78. We do not rely upon the interior surface of the recess 76 for securing the steadying action but we provide the steady rest 73 with two clamps 79 and the cap 77 with one. These clamps are adjusted radially by bolts 80 and held in adjusted position by bolts 81. They have inner curved bearing surfaces 82 and are adapted to be adjusted to a position for these bearing surfaces to accurately support the exterior of an eccentric circular disc 83. This disc is made in two parts bolted together and provided with an eccentric perforation 84 for receiving one of the pins, as for example the pin 2 of the crankshaft. They are also provided with two swivel studs 85 having bolts 86 adapted to project toward each other in a straight line and engage at diametrically opposite points a part of the crankshaft. Now as the crankshaft turns about a center between the centers of the pin 2 and the shaft S, as indicated in Fig. 22, the disc 83 will rotate on the center on which the shaft turns and the shaft will be steadied by this disc mounted as it is in a solid steady rest frame.

The description of the operation of the machine has been given in connection with the several parts and it is sufficient to say that this machine is shown as set up to mill off the contours of the four cheeks connecting the two pins 3 and 4 as shown in Fig. 14. These four cheeks are milled off in one revolution of the shaft, the shaft is removed and placed in another machine which will mill off the cheeks corresponding with the pins 2 and 5. It is then put into a third machine and the cheeks on the pins 1 and 6 are cut. In each case the crankshaft is made to turn about a different center, as indicated in Fig. 10. This is the most convenient way of operating this device because the time consumed in rotating the shaft through a complete revolution is considerable, in some cases as much as fifteen minutes. We find it easier to transfer the shafts in this way and use three machines because one man has plenty of time to operate the three machines and transfer the work from one to the other.

However, if it is desired to do all the work on one machine so that the shaft will not have to be taken out and put in another, all three of the locating devices shown in Figs. 8, 9 and 10 will have to be used. The four screws 45 and 46 are left on the machine whether in use or not but the locator 50 is used only for one of the three positions as it engages the pin 1 the cheeks of which have to be milled off, it has to be removed after positioning and before the milling operation commences. For a large job it is not as economical to work in this way as it is with three machines but it can be done satisfactorily if the party has only one machine and is working on a comparatively small job.

In the form shown in Figs. 27 to 30, which is the preferred form, the motor 11, as in the other case, drives the hubs 35 through shafting and gearing numbered 30 but in the connections I have provided a worm 87 on one of the shafts 30 driving a corresponding worm wheel 88 which is loose on the next shaft of this series. A clutch 89 is provided slidingly keyed to the last-named shaft 30 and adapted to positively connect the worm wheel with that shaft. This clutch is ordinarily closed in practice and the action and operation are the same as described in connection with the other figures.

It has been stated that the operation of this machine is necessarily slow. Therefore if it is necessary to turn the work through any considerable angle idly, it will consume considerable time. This clutch arrangement is provided to permit of the turning of the worm by hand as rapidly as desired at any time. In order to do that the clutch 89 is thrown out of operation by means of the clutch rod and head 90. Thus the power is disconnected from the hub rotating mechanism and that mechanism can be operated by a handle 91 slidable on one of the shafts 30 and adapted to be positively connected with it by a pin and slot connection 92. Now the two hubs can be rotated and the two milling tools moved through their cycle, either with the tools turning on their own axes through the connection of the motor 12, or not, as may be desired. The connections 61, 62 and 63 are operated by this hand operation as will be obvious to reciprocate the tools.

Although the machine set forth above is entirely practical, it involves a slight difficulty owing to the fact that while the shaft is turning through an arc at one end as shown in Fig. 7, the cutting is much more rapid, owing to the radius of action, than it is when cutting on one of the sides. In other words, the cutters do not take a uniform cut around the circumference of the cheeks and are doing considerably more work at one time than at another during a complete revolution. For that reason the parts have to be operated at such a speed as to permit of the most rapid cutting that has to take place. This is not a serious objection but still we have shown in Figs. 31 and 32 a method of overcoming the difficulty. In these figures, the parts of the machine are substantially the same as above described except with reference to the features that will now be referred to in detail. The shaft 61 drives the shaft 63 in the

same manner as set forth above. On the shaft 63 is placed a bevel gear 95 for driving a shaft 96. This drives a shaft 97 on which we place two elliptical gears 98. These elliptical gears mesh with companion elliptical gears 99 on opposite ends of the two spindles 34 of the hubs 35. Instead of rotating the two spindles 34 at constant speed, these spindles are rotated at a varying speed controlled by the shape of the elliptical gears. These gears are designed to change the speed of rotation of the spindles 34, and consequently of course the crankshaft, exactly in accordance with the shape of the elliptical cheeks so that the peripheries of these cheeks will rotate at a constant speed at the point at which the cutters are located.

In Figs. 34–41 we have shown a more steady form of holding and driving crotch. We prefer in this case to use one at both ends. The crotch 100 is provided with a flat plate 101 fitting against the end of the spindle 34 and bolted thereto centrally. The crotch itself is a trough-shaped body centered on the axis of the spindle and extending therefrom, thus providing a hollow space for receiving the end of the crankshaft. This trough is a little deeper than semi-circular in shape, as indicated in Fig. 37. Across its top from one vertical edge to the other extends a clamp 102 pivoted at 103 to one side of the trough of the crotch. This is provided with a well known pivot bolt 104 on the other side for fastening the cover down. The crotch is provided with a web across it under the clamp. The clamp and web have semi-circular recesses in which are center plates 105 having screws 106 for holding them. They are removable and replaceable to receive the ends of crankshafts of different sizes and positively locating them in proper position with respect to the center of the spindle.

The crotch extends beyond this clamp and is provided at its end with another clamp 107 similarly located and arranged but having a semi-elliptical shape inside to permit it to receive one of the cheeks C of the crankshaft. It also has a pivot pin 103 and pivoted locking bolt 104. The end of the crotch is provided with a transverse end cut out to provide an opening 108. Behind this is a block 109 on the crotch for receiving a transverse adjusting shaft 110 having a knurled head by which it can be manipulated. This shaft is supported in a perforation through one side of the crotch and has a pinion 111 on it meshing with a rack 112 on a plunger 113 carried by the block 109. This plunger is arranged parallel to the axis of the crankshaft and is moved in and out by the shaft 110. It is adapted to be moved out into the position shown in Fig. 35 for the purpose of projecting its conical end into one of the holes H with which the crankshaft cheeks are provided, these holes being concentric with the pins of the crankshaft. By projecting this conical end into one of these holes it serves to help drive the crankshaft. The plunger 113 can be held in its adjusted position by a holding screw 114. The plunger 113 and screw 114 are held in a block 109 which projects through the opening 108.

Located on the extreme flat front end of the crotch 100 and clamp 107 are two segments 117 and 118 forming a circular plate. These two segments together constitute a complete circle and the two of them are bolted to the end of the crotch and clamp through holes 119. They have semi-circular openings 120 which together form a circle for receiving the pin of the crankshaft, this opening being located sufficiently off center to receive the pin for which it is designed. The plate 117 also has an opening 121 registering with the opening 108 and through this the block 109 projects. The block is secured to segment 117 by screws 116.

The plate 117—118 is designed as a centering plate and for the purpose of centering it a center rest 125 is employed resting on the ways 37. This center rest is provided with centering pieces 126 adapted to be adjusted by bolts 128 and held by bolts 127. These are all arranged radially and one of them is located on an arm 129 pivoted on a stud 130. A removable pin 131 holds it in position. These centering pieces 126 have arcuate inner surfaces registering with the plate 117—118 and tending to hold it to rotate concentrically. It will be obvious that the center plate 117—118 rotates around this center as the pin of the crankshaft must do.

Although we have illustrated and described only three forms of the invention we are aware of the fact that other modifications can be made therein and that the invention can be used for the turning, milling or grinding of other elliptical irregular or eccentric shapes, and on devices other than crankshafts, without departing from the scope of the invention as expressed in the claims. Therefore we do not wish to be limited in these respects but what we do claim is:—

1. In a contour milling machine, the combination with a rotary reciprocable milling cutter spindle operable in a single horizontal plane, of means for rotating the work about an axis perpendicular to the axis of the spindle and located within the periphery to be milled, and means positively connected with said rotating means for automatically reciprocating the spindle at variable speeds but in synchronism with the rotation of the work.

2. In a contour milling machine, the combination with a reciprocable rotary milling cutter spindle operable in a single horizontal

plane, of means for rotating the work about an axis perpendicular to the axis of the spindle, and means positively connected therewith for reciprocating the spindle in synchronism with the rotation of the work and at such varying speeds during a complete rotation of the work that the work will rotate through a complete revolution while the spindle moves back and forth through a complete reciprocation and the spindle will be at all times at the required distance from the axis of rotation of the work.

3. In a machine for milling crankshafts, the combination with a rotary milling cutter spindle operable in a single horizontal plane, of means for supporting the crankshaft and rotating it about an axis at a distance from the axis of the shaft, and driven means for reciprocating said spindle at such a rate as to keep a pair of cheeks thereon in contact with the cutting face of a cutter on the spindle throughout a complete revolution of the crankshaft.

4. In a machine for milling crankshaft cheeks, the combination with a rotary and axially reciprocable cutter spindle, and means for reciprocating the spindle, of means for supporting a crankshaft with its axis at right angles to the axis of the spindle and rotating it about an axis at a distance from its own axis and from the center of a crank pin connecting the cheeks to be milled, to keep said cheeks in contact with the cutting face of the cutter throughout a revolution of the crankshaft.

5. In a machine for milling the cheeks of a crankshaft, the combination with a rotary milling cutter spindle having a cutter on the end thereof and provided with a flat cutting face, means to reciprocate said cutter in a horizontal plane, of means for supporting a crankshaft in position for a pair of cheeks thereon to come in contact with said flat cutting face and rotating it about an axis located between the center of the crank pin connecting said pair of cheeks and the axis of the crankshaft, and positive connections between the reciprocating means and the rotary means arranged to cause them to operate in synchronism to cause the shaft to rotate through a complete revolution while the spindle completes a reciprocation back and forth.

6. In a crankshaft cheek contour milling machine, the combination with a rotary and axially reciprocable milling cutter spindle, and means for rotating said spindle, of a pair of heads adjustable toward and from each other, each being provided with means for engaging the first crank pin of the crankshaft at diametrically opposite points thereon and locating said pin in a definite position around the axis of the crankshaft and centering the crankshaft to rotate with said head about an axis located between the center of another crank pin on the shaft and the axis of the shaft, a driving means, and means positively connected with the driving means for rotating said heads and for reciprocating said spindle.

7. In a machine of the character described, the combination with a cutter spindle, means for rotating it, and means for axially reciprocating it, of a pair of heads arranged in axial alignment, means for rotating said heads positively in synchronism with the reciprocation of the cutter spindle, and means on said heads for engaging the end crank pins of the crankshaft to be operated upon and so locating said crank pins that the shaft will be rotated by the heads on an axis located at a point between the center of another crank pin on the shaft and the axis of the shaft.

8. In a machine of the character described, the combination with a pair of heads and means for rotating them, of a holding crotch mounted on each head and having a rest for the end of the crankshaft located eccentrically, a clamp pivoted to said holding crotch and adapted to clamp the end of the shaft to the crotch in said eccentric position, and means on the crotch and clamp for locating one of the crank pins of the shaft in proper position for causing the shaft to be rotated about an axis between the axis of the shaft and the center of another one of the crank pins on the shaft.

9. In a machine of the character described, the combination with a pair of heads and means for rotating them, of a holding crotch mounted on each head, a clamp movably mounted on the holding crotch, said clamp and crotch having an eccentrically located recess for receiving a journal of the crankshaft and rotating it about a center at a distance from the center of said journal, said clamp and crotch having means thereon for locating one crank pin of the shaft in different positions around the center thereof.

10. In a machine of the character described, the combination with a pair of heads and means for rotating them, of a holding crotch, mounted on each head, a clamp movably mounted on the holding crotch, means for securing the clamp to the crotch, said clamp and crotch having an eccentrically located recess for receiving the end of the crankshaft and rotating it about a center at a distance from the center of said end, said clamp and crotch having means thereon for locating the first crank pin of the shaft in different positions around the center thereof to permit of changing the position of the crankshaft in the machine to cut the contour of cheeks located at an angle to each other.

11. In a machine of the character described, the combination of a pair of rotary heads in axial alignment, a holding crotch carried by each one, a crotch clamp carried

by each holding crotch and adapted to be secured thereto, the two crotches and clamps having recesses in axial alignment for receiving the journals of a crank shaft, and a plurality of means located on one crotch and clamp and spaced around the center for engaging one of the crank pins of the crank shaft in different positions around the center so as to permit of the cutting of the contour of a pair of cheeks on the shaft.

12. In a machine of the character described, the combination of a pair of rotary heads in axial alignment, a holding crotch carried by each one, a crotch clamp carried by each holding crotch and adapted to be secured thereto, the two crotches and clamps having recesses in axial alignment for receiving the journals of a crankshaft, and a plurality of pairs of screws adjustable toward each other and located in alignment on the crotch and clamp, the axial line of said screws of each pair being tangent to a circle drawn from the center of said recess, for engaging one of the crank pins of the crank shaft in different positions around the center so as to permit of the cutting of the contour of any pair of cheeks on the shaft.

13. In a machine of the character described, the combination of a pair of rotary heads in axial alignment, a holding crotch carried by each one, a crotch clamp carried by each holding crotch and adapted to be secured thereto, the two crotches and clamps having recesses in axial alignment for receiving the journals of a crankshaft and a plurality of means located on the crotch and clamp and spaced at equal angles around the center for engaging one of the crank pins of the crankshaft in different positions around the center, said engaging means comprising a locator detachably mounted on the holding crotch and having means for engaging the opposite sides of a crank pin between a pair of cheeks that are to be machined.

14. In a crankshaft milling machine, the combination with a milling cutter spindle, of a bed for supporting it, said bed having a pair of longitudinal ways, a hub mounted to slide on said ways, means for clamping the hub to the ways, said hub having a cylindrical passage therethrough, a head rotatably mounted in said passage, a worm gear fixed on the head and located within the hub, means for positively rotating said gear to rotate the head, and means on the end of the head for locating one of the crank pins of the crankshaft to be operated upon in a certain position around the circumference of the head.

15. In a milling machine, the combination with a milling cutter spindle, of a bed for supporting it, said bed having a pair of longitudinal ways, a hub mounted to slide on said ways, means for clamping the hub to the ways, said hub having a cylindrical passage therethrough, a head rotatably mounted in said passage, a gear on the head, means for rotating said gear to rotate the head, and means on the end of the head for locating an eccentric part of the work to be operated upon in a certain position around the circumference of the head, said head being provided with a fixed stop on the end thereof for engaging the end of the work for the purpose described.

16. In a machine of the character described, the combination of a pair of rotary heads in axial alignment, a holding crotch carried by each one, a crotch clamp carried by each holding crotch and adapted to be secured thereto, the two crotches and clamps having recesses in axial alignment for receiving the journals of a crankshaft, means located on the crotch and clamp for engaging one of the crank pins of the crankshaft, a steady rest having a rotatable element provided with an eccentric circular opening therethrough for receiving a crank pin, and means for engaging and holding a concentric portion of the axle of said crankshaft, whereby the rotation of the crankshaft about a center between the axis of the shaft and the axis of said pin will cause the rotatable element to rotate in the center rest.

17. In a crankshaft cheek contour milling machine, the combination with a rotary and axially reciprocable milling cutter spindle, and means for rotating said spindle, of a pair of heads adjustable toward and from each other, each being provided with means for engaging a crank pin of the crankshaft, and locating said pin, a driving means, means positively connected with the driving means for rotating said head and for reciprocating said spindle, and a steady rest for engaging the crankshaft comprising a circular disc adapted to rotate, said disc having a perforation therethrough eccentrically located for receiving one of the journals of the shaft, and means for engaging and adjusting a bearing on said shaft, whereby as the shaft rotates the disc will be rotated about a center between a crank pin and the shaft.

18. In a crankshaft cheek contour milling machine, the combination with a rotary and axially reciprocable milling cutter spindle, and means for rotating said spindle, of a pair of heads adjustable toward and from each other, each being provided with means for engaging a crank pin of the crankshaft at diametrically opposite points and locating said pin in a definite position around the axis of the crankshaft and centering the crankshaft to rotate with said head about an axis between the center of another pin and the axis of the shaft, a driving means, means positively connected with the driv-

ing means for rotating said head and for reciprocating said spindle, and a steady rest for engaging the crankshaft comprising a main part and a clamping part movably connected therewith and having a circular recess, said steady rest having bearing members radially adjustable thereon, a circular disc located between the ends of said bearing members and adapted to rotate in contact therewith, said disc being formed of two semi-circular plates bolted together and having a perforation therethrough eccentrically located for receiving one of the journals of the shaft, and a pair of screws carried by the disc at a distance from said opening for engaging and adjusting a bearing on said shaft, whereby as the shaft rotates the disc will be rotated about a center between a crank pin and the shaft.

19. In a crankshaft cheek contour milling machine, the combination with a rotary and axially reciprocable milling cutter spindle, and means for rotating said spindle, of means for engaging a crank pin of the crankshaft and centering the crankshaft to rotate it, a driving means, means connected with the driving means for rotating said head and for reciprocating said spindle, and a steady rest for engaging the crankshaft comprising a main part and a clamping part movably connected therewith and having a circular recess, said steady rest having bearing members radially adjustable thereon, a circular disc located between the ends of said bearing members and adapted to rotate in contact therewith, said disc being formed of two semi-circular plates bolted together and having a perforation therethrough eccentrically located for receiving one of the journals of the shaft, and a pair of screws carried by the disc at a distance from said opening for engaging and adjusting a bearing on said shaft, whereby as the shaft rotates the disc will be rotated about a center between a crank pin and the shaft.

20. In a machine of the character described, the combination with means for holding the two journals of a crankshaft and rotating them about an axis eccentric with respect to said journals, a driving means for rotating the shaft, a milling cutter spindle, means for rotating the spindle, a cam connected with said driving means to be rotated positively thereby, a gear segment connected with the cam to be oscillated thereby as the cam rotates and a rack meshing with said gear segment and having means for reciprocating the cutter spindle.

21. In a machine of the character described, the combination with a bed, of a pair of longitudinal ways on the bed, a pair of rotatable heads mounted on said ways and having means for supporting the journals of a crankshaft and rotating them about an eccentric axis, a driving means for operating said heads, a slide plate mounted on a surface on the bed and having transverse ways, a transverse slide adjustable on said ways, the transverse slide having ways, a pair of cross slides carried by the last named ways, a cutter spindle supported by each of said cross slides, and means positively connected with the driving means for reciprocating said cross slides and consequently the cutter spindles throughout a complete reciprocation when the heads rotate through a complete rotation.

22. In a machine of the character described, the combination with a bed and means on the bed for supporting and rotating a crankshaft on an eccentric axis, a slide adjustable on cross ways on the bed toward and from the crankshaft, a pair of cross slides supported on said slide and movable in the same direction, a shaft carried by the first named slide, means positively connected with a source of power for reciprocating the pair of slides from said shaft, means for adjusting the pair of slides with respect to the reciprocating means, and means on each of said slides of the pair for supporting a milling cutter spindle with its axis perpendicular to the axis of the crankshaft.

23. In a machine for milling crankshafts, the combination with a rotary milling cutter spindle, of means for supporting the crankshaft and rotating it about an axis at a distance from the axis of the shaft, means for reciprocating said spindle at such a rate as to keep a pair of cheeks thereon in contact with the cutting face of a cutter on the spindle throughout a complete revolution of the crankshaft, and connections constituting part of the crankshaft rotating means for varying the speed of rotation to cause the peripheries of the cheeks to run at a substantially constant speed during a complete rotation.

24. In a machine for milling crankshafts, the combination with a rotary milling cutter spindle, of means for supporting the crankshaft and rotating it about an axis at a distance from the axis of the shaft, means for reciprocating said spindle at such a rate as to keep a pair of cheeks thereon in contact with the cutting face of a cutter on the spindle throughout a complete revolution of the crankshaft, and connections constituting part of the crankshaft rotating means for varying the speed of rotation to cause the peripheries of the cheeks to run at a substantially constant speed during a complete rotation, said work rotating means having means for causing the contour surface to rotate at substantially a constant rate of speed past the cutter.

25. In a contour milling machine, the combination with a rotary reciprocable milling cutter spindle, of means for rotating the work about an axis perpendicular to the axis

of the spindle and located within the periphery to be milled, and means positively connected with said rotating means for reciprocating the spindle at variable speeds but in synchronism with the rotation of the work, the work rotating means comprising means for disconnecting the rotating means from the power, and means for then rotating the work by hand.

26. In a contour milling machine, the combination with a pair of spindles located opposite each other, of a holding and driving crotch located on the end of each spindle, each of said crotches having a clamp for centering and holding the end bearing of the crankshaft and being provided with a second clamp at a distance therefrom but rigidly connected therewith for centering and holding one of the pins of the crankshaft.

27. In a contour milling machine, the combination with a spindle, of a holding and driving crotch located on the end of the spindle, said crotch having a clamp for centering and holding one of the pins of the crankshaft, shaped and adapted to receive one of the cheeks of the crankshaft therein and being provided with a longitudinally movable plunger for engaging in the perforation through the crank pin to assist in holding and driving it.

28. In a contour milling machine, the combination with a spindle, of a holding and driving crotch located on the end of the spindle, said crotch having a clamp for centering and holding the end bearing of the crankshaft and being provided with a second clamp at a distance therefrom but rigidly connected therewith for centering and holding one of the pins of the crankshaft therein and being provided with a longitudinally movable plunger for engaging in the perforation through the crank pin to assist in holding and driving it.

29. In a contour milling machine, the combination with a spindle, of a holding and driving crotch located on the end thereof, said crotch having a clamp for centering and holding one of the pins of the crankshaft, provided with a circular plate on the face thereof formed in two pieces but held in position thereon, said plate having a circular opening between the two pieces for receiving the crank pin of the crankshaft and being provided with an opening therethrough at another point, and means for assisting in driving the crankshaft extending through the last named opening.

30. In a contour milling machine, the combination with a spindle, of a holding and driving crotch located on the end thereof, said crotch having a clamp for centering and holding the end bearing of the crankshaft and being provided with a second clamp at a distance therefrom but rigidly connected therewith for centering and holding one of the pins of the crankshaft, the latter clamp being provided with a circular plate on the face thereof formed in two pieces but held in position thereon, said plate having a circular opening between the two pieces for receiving the crank pin of the crankshaft and being provided with an opening therethrough at another point, and means for assisting in driving the crankshaft extending through the last named opening.

31. In a contour milling machine, the combination with a spindle, of a holding and driving crotch located on the end thereof, said crotch having a clamp for centering and holding one of the pins of the crankshaft, provided with a circular plate on the face thereof formed in two pieces but held in position thereon, said plate having a circular opening between the two pieces for receiving the crank pin of the crankshaft and being provided with an opening therethrough at another point, means for assisting in driving the crankshaft extending through the last named opening, and a steady rest engaging the circumference of said circular plate.

In testimony whereof we have hereunto affixed our signatures.

ALBERT J. GIFFORD.
BENJAMIN S. T. BISHOP.