Feb. 24, 1953

O. E. STAPLES ET AL

2,629,290

HOBBING MACHINE

Filed Oct. 27, 1948

5 Sheets-Sheet 1

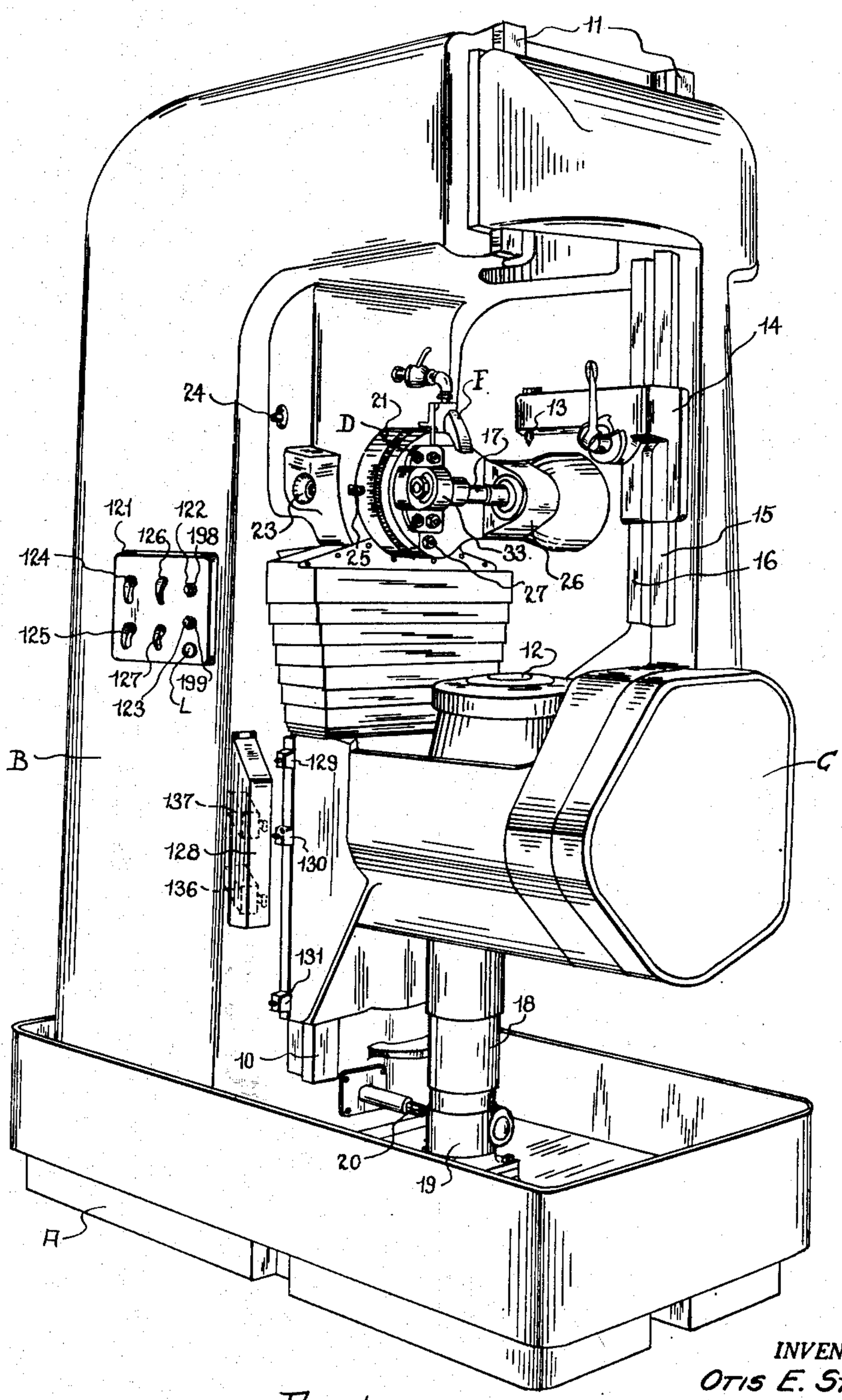

Fig. 1

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5 Sheets-Sheet 2

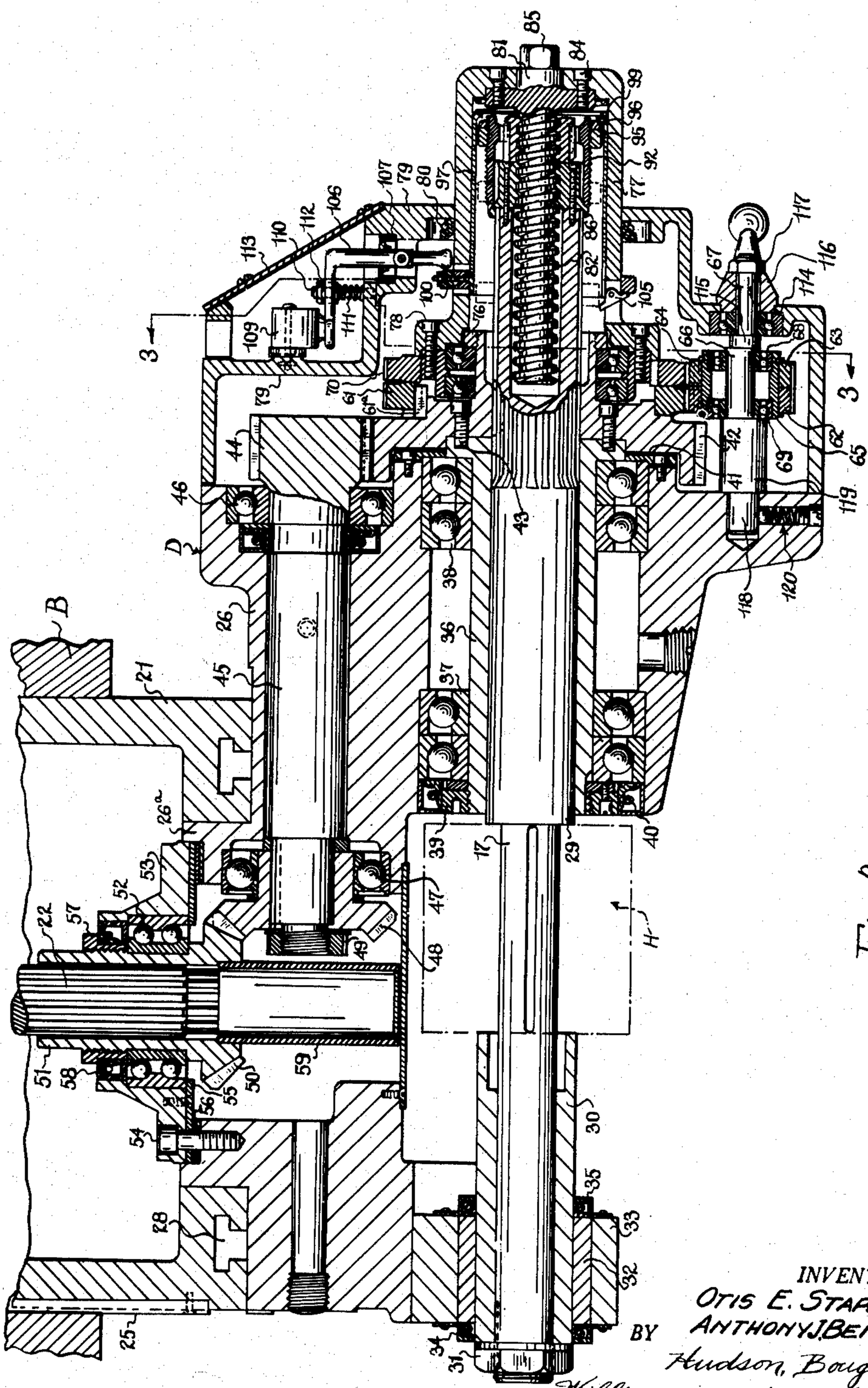

Fig. 2

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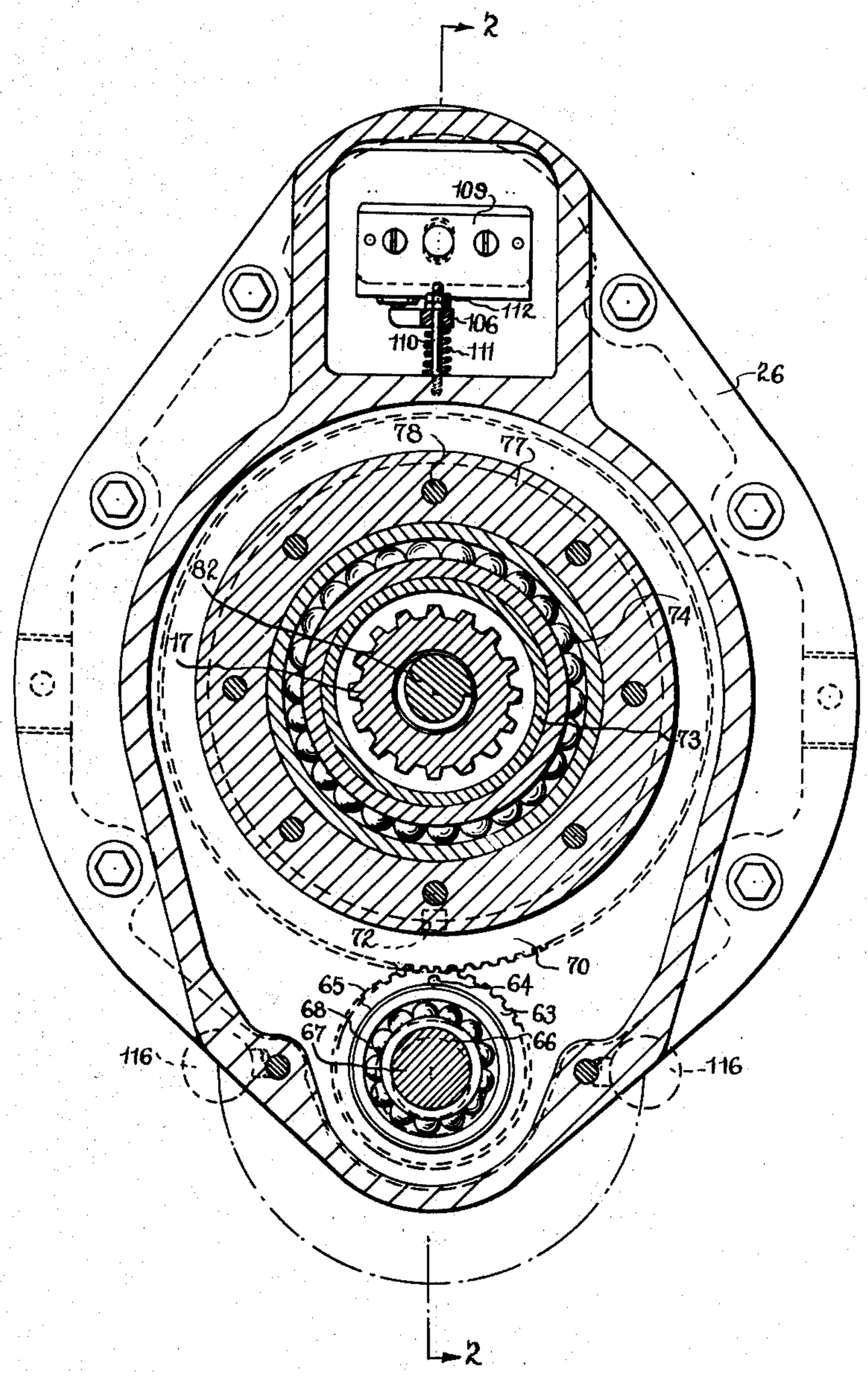

Fig. 3

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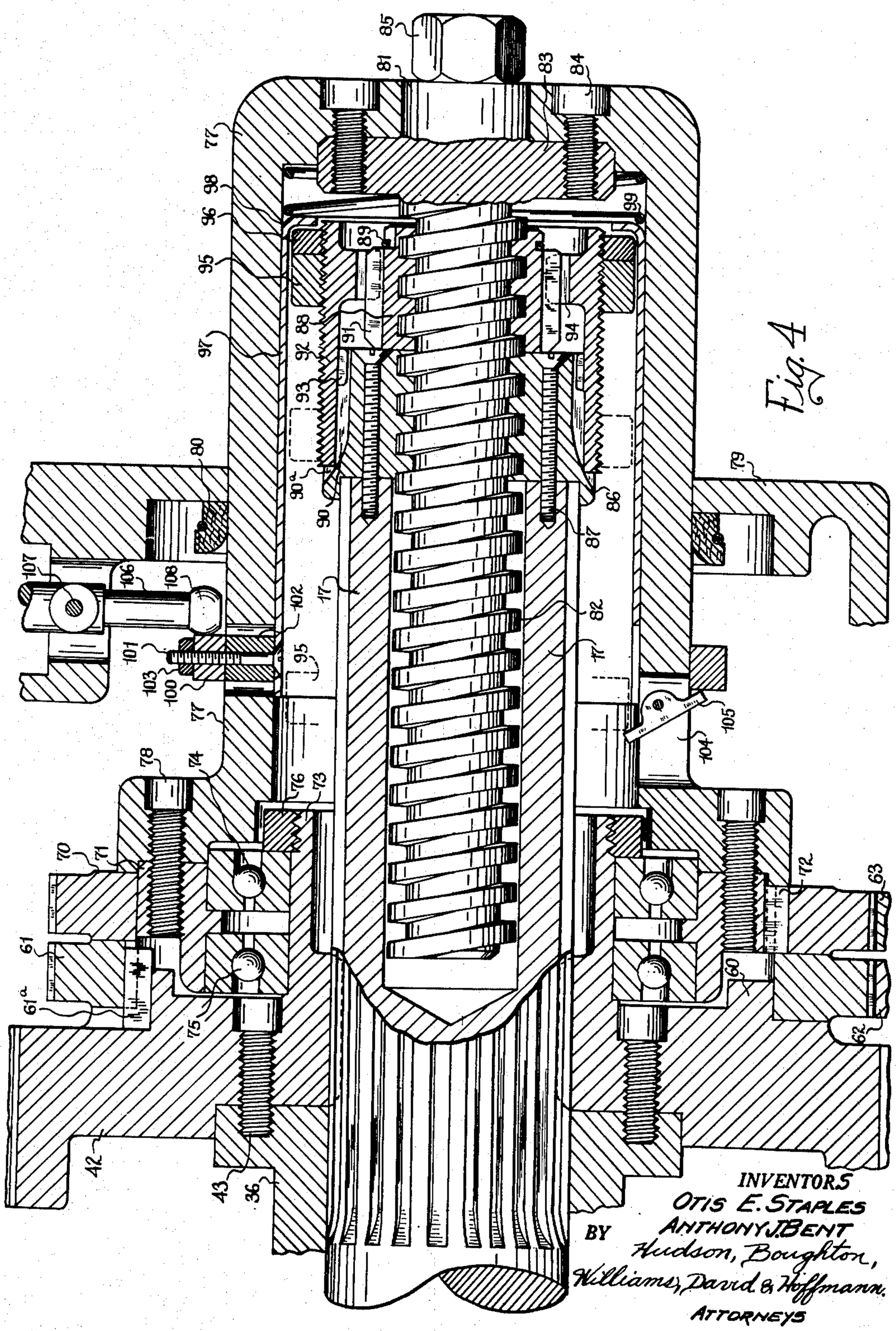

Fig. 4

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Feb. 24, 1953 O. E. STAPLES ET AL 2,629,290

HOBBING MACHINE

Filed Oct. 27, 1948 5 Sheets-Sheet 5

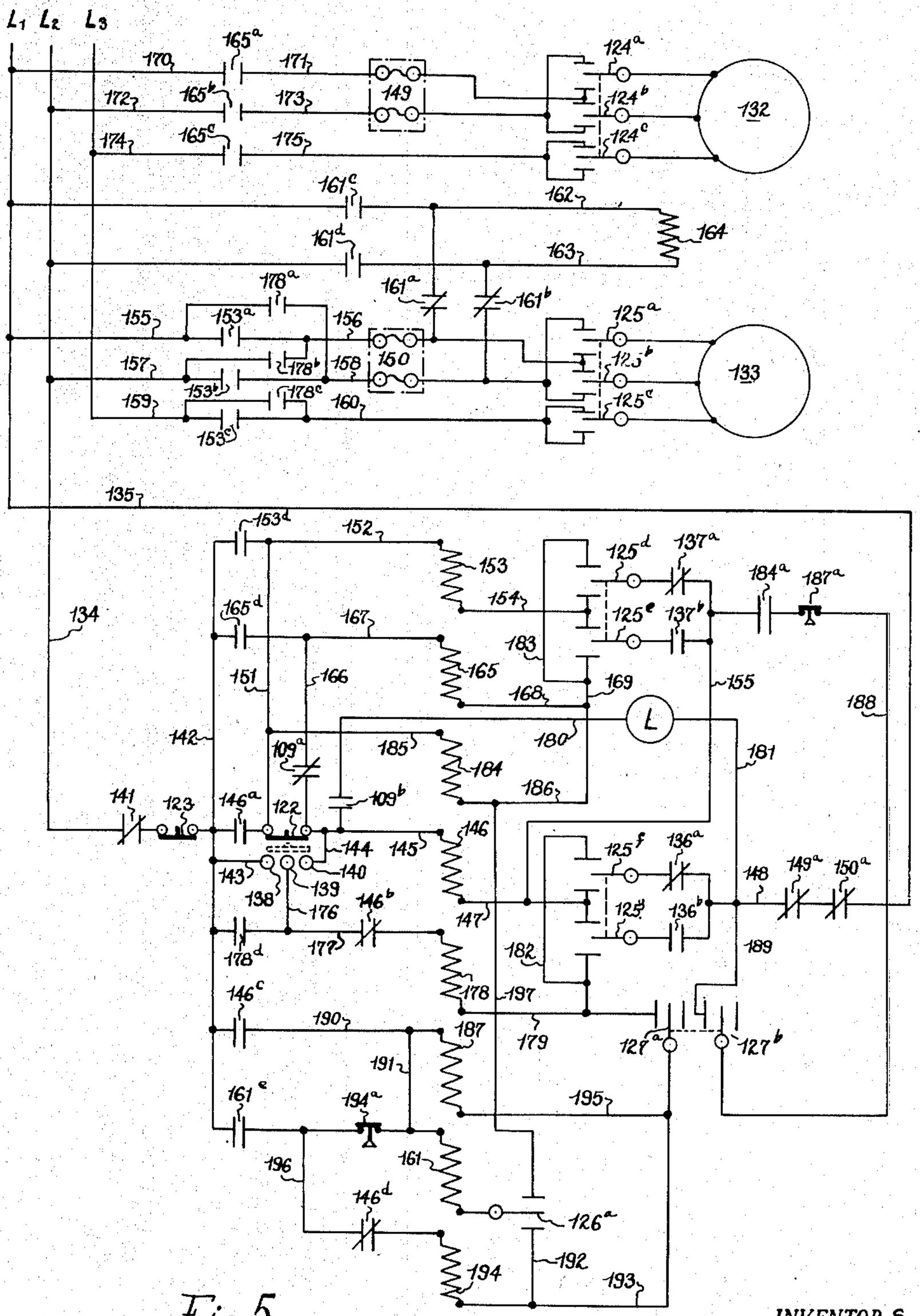

Fig. 5

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Patented Feb. 24, 1953

2,629,290

UNITED STATES PATENT OFFICE

2,629,290

HOBBING MACHINE

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Application October 27, 1948, Serial No. 56,726

15 Claims. (Cl. 90—4)

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The present invention relates to hobbing machines and, more particularly, to hobbing machines of the axial feed type as distinguished from tangential feed type hobbing machines.

In the operation of hobbing machines of the axial feed type, it has heretofore been customary to periodically advance the hob, that is move the hob tangentially of the work spindle after a number of blanks have been cut so as to bring a new section of the hob into cutting position. This practice does not make full use of the hob since, in order to insure that an entirely new section thereof is in cutting position, it is necessary to leave an unused portion between the section that has just been used and the next section to be utilized. These portions intermediate successive settings have performed no, or very little, cutting so that the wear, etc., incident to the cutting operation being performed is not uniformly distributed over the usable or effective length of the hob. More recently the hob has been continuously advanced or moved tangentially of the work during the cutting operation in such a manner that the hob is advanced an amount equal to its usable or effective length once during some relatively long period of time, such as a work day, a half day, or the like. At the end of each period the hob is replaced, if necessary, and the direction of advance reversed or the mechanism returned to its original position and the cycle repeated.

The principal object of the present invention is the provision of a novel and improved hobbing machine and hob head, of the character referred to, comprising means for effecting a continuous advance of the hob tangentially of the work during the cutting operation, which means includes novel mechanism for stopping the machine at the completion of the particular cut or cycle of operations being performed at the time the hob reaches a predetermined point in its advance tangentially of the work.

Another object of the invention is the provision of a novel and improved hobbing machine and hob head as set forth in the preceding object and wherein the mechanism for stopping the machine, in response to a predetermined tangential advance of the hob, is readily adjustable to permit selection of the extent of that advance, whereby the machine and mechanism are readily adapted for use of hobs of different length and/or to work periods of different durations.

A further object of the invention is the provision of a novel and improved hobbing machine and hob head as set forth in the two preceding

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objects wherein the mechanism responsive to tangential or axial advance of the hob is conveniently located adjacent the end of the hob head housing so that it is readily accessible for servicing and adjustment.

An additional object of the invention is the provision of a novel and improved hobbing machine and hob head as set forth in any of the preceding objects and wherein the mechanism for stopping the machine at the completion of the predetermined advance of the hob includes a signal for automatically indicating that the predetermined point in the tangential advance of the hob has been reached.

The invention also has as an object the provision of a novel and improved hobbing machine and hob head as set forth in the preceding objects wherein the mechanism responsive to tangential or axial advance of the hob is relatively economical to manufacture, easy to install and is so located in the machine that it does not require increase in the size of the hob head adjacent the hob carried thereby.

The invention further resides in certain constructions and combinations and arrangements of parts and further objects and advantages will be apparent from the following description of the preferred embodiment, described with reference to the accompanying drawings, forming a part of this specification, in which similar reference characters designate corresponding parts, and in which:

Fig. 1 is a perspective view of a hobbing machine embodying the present invention;

Fig. 2 is a sectional view, with portions in elevation, through the center line of the hob head and approximately on the line 2—2 of Fig. 3;

Fig. 3 is a sectional view substantially on the line 3—3 of Fig. 2, with certain parts in elevation;

Fig. 4 is an enlarged fragmentary view of a portion of the right-hand side of Fig. 2 more clearly illustrating, in section, the mechanism for axially shifting the hob and for operating the stopping mechanism after a predetermined advance of the hob; and

Fig. 5 is a simplified, schematic wiring diagram for the electrical circuit of the machine.

Although the invention is susceptible of various modifications and alternative constructions, it is herein shown and described as embodied in a hobbing machine similar to that shown in United States Patent No. 2,307,428, issued January 5, 1943, except that the shape of the machine is slightly different, some of the electrical control

devices have been relocated, and the hob head is carried by a member slidably supported in a cylindrical aperture in the vertical column or frame rather than being supported on horizontal ways.

Generally speaking, the machine is of vertical construction and comprises a base A, a vertical column or gooseneck B supported upon the base A, a work head C vertically movable upon vertically spaced pairs of ways 10, 11 on the column B, and a tool or hob head D carried by a cylindrical member slidably supported in a horizontal cylindrical aperture in the column B and adjustable therein toward and from the work head. The work, which may be a gear blank, a shaft to be splined, or the like, is adapted to be rotatably supported in the work head C by having one end supported in a chuck or some other suitable means, not shown, attached to the upper end of the work spindle 12. The other end of the work is engaged and supported by a tail center 13 carried by a tail slide 14, the latter being supported for vertical movement toward and from the work spindle upon ways 15, 16 formed on the work head.

The hob spindle or arbor 17 is rotatably supported in the hob head D in a manner hereinafter more specifically described and during operation of the machine is rotated in timed relation to the rotation of the work spindle 12 by a cut motor located in the lower part of the column B and operatively connected to the respective spindles in a manner similar to that disclosed in the aforesaid patent and hence is not here shown nor described in detail. The hob head D is preferably provided with a conventional means F for supplying a cutting fluid to the hob and work.

The work head C is adapted to be reciprocated along the vertically spaced pairs of ways 10, 11, to cause a work blank carried by the work head to be moved axially past a hob fixed to the hob arbor 17 and to return the work head to its initial position, by a cooperating lead screw and nut connected to the work head C and the base A, respectively. The lead screw is located within the chip guard 18 and is driven at a relatively slow speed in timed relation to the rotation of the hob and work spindles from the work spindle drive. The nut is rotatably supported in a housing 19, bolted to the base A, and is adapted to be rotated at a relatively high speed through the medium of a worm and worm wheel drive by a high speed, reversible traverse motor located within the column B and connected thereto by the shaft 20. These mechanisms are likewise similar to those shown in the aforementioned patent to which reference is had for the details thereof.

The cylindrical member 21 which carries the hob head D is slidably supported in a cylindrical aperture in the column B and is concentric with respect to the main drive shaft 22 of the machine. The member 21 is adapted to be moved longitudinally within the cylindrical aperture by means of a screw 23 to effect adjustment of the hob toward and from the work spindle, the member 21 being clamped in any adjusted position by a clamp mechanism actuated by a clamp screw 24 and being prevented from rotating in the cylindrical aperture by a key 25. The hob head D comprises a hob head housing 26 having a cylindrical portion 26*a* projecting into a cylindrical aperture in the front end of the member 21 and through the medium

of which the housing 26 and, in turn, the hob head D are rotatably connected to the front end of the member 21 concentric with the axis of the shaft 22. The hob head D is adapted to be secured in any desired angular position by bolts 27, the heads of which engage within a circular T-groove 28 in the front face of the member 21.

The hob H, which is indicated by broken lines in Fig. 2, is keyed to the arbor 17 intermediate a shoulder 29, formed on the arbor by a change in its diameter, and a sleeve 30 which is retained on the arbor by a nut 31 provided on the threaded outer end of the arbor. Hobs of different lengths may be utilized by employing a spacing washer or sleeve between the hob and the shoulder 29 and/or by utilizing a sleeve 30 of different length from that shown.

The sleeve 30 is slidably and rotatably supported in a bushing 32 provided in an outboard support 33 which is attached to the hob housing 26, the bushing being held from axial movement by combined retainers and oil seals 34 and 35. The arbor 17, to the right of the hob as viewed in Fig. 2, is slidably supported in a sleeve 36. This sleeve is rotatably supported in the hob head housing 26 by pairs of antifriction bearings 37 and 38. The bearings 37 are retained in place between a shoulder in the housing 26 and a nut and washer assembly 39 secured to the outer end of the sleeve 36, an oil seal 40 being interposed between the nut and washer assembly and the adjacent surface of the housing 26. The bearings 38 are retained in place between a shoulder in the housing 26 and a plate 41 secured to the housing by machine screws or the like.

The right-hand portion of the hob arbor or spindle 17, as viewed in Fig. 2, is splined, and slidably keyed thereto is a hob arbor gear 42 which is connected to an external flange on the right-hand end of the sleeve 36 by machine screws 43. The gear 42 is continuously in mesh with a hob drive pinion 44 formed on the right-hand end of a shaft 45 which is rotatably supported in the housing 26 by antifriction bearings 46 and 47. The left-hand end of the shaft 45 has a bevel gear 48 keyed thereto, the gear being held in place by a nut 49 on the threaded end of the shaft 45. The gear 48 is continuously in mesh with a bevel drive gear 50 which has an elongated splined hub 51 in which is received the splined end portion of the drive shaft 22. The hub 51 of the gear 50 is rotatably supported by a pair of antifriction bearings 52 mounted in a bearing cap or member 53 which is connected by screws 54 to the rear end of the cylindrical portion 26*a* of the housing 26, a bearing retaining plate 55 and shims 56 being interposed between the bearing cap and the hob head housing. The rear portion of the inner race of the bearings 52 is engaged by a nut 57 threaded upon the hub 51 of the gear 50 and a suitable oil retainer or seal 58 is provided between the nut 57 and the rear portion of the bearing cap 53. The bearings 52 and their retainers cooperate with the gear 50 to prevent axial displacement of the latter, the hob head housing 26 and the cylindrical member 21, however, being movable axially of the drive shaft 22 to permit adjustment of the hob head toward and from the work spindle. The gear 50 is provided with a cylindrical shaft seal 59 to protect the end of the drive shaft 22,

when it projects forwardly of the gear 50, and to prevent the entrance of foreign matter into the splines of the gear and shaft.

As mentioned heretofore, the hob arbor or spindle 17, in addition to its rotation, is given a slow axial movement or feed. For this purpose the hub of the gear 42 is elongated and has a stepped portion 60 on which a gear 61 is supported, the gears 42 and 61 being connected for rotation by a key 61*a*. The gear 61 meshes with a gear 62 which is connected to rotate with a gear 63 by means of a pin or rod 64 extending through the two last-mentioned gears. The gears 62 and 63 are supported upon a bushing 65 which, in turn, is rotatably supported upon a cylindrical portion 66 of a shaft 67 by antifriction bearings 68 and 69. The portion 66 is eccentrically disposed with respect to the axis of the shaft 67 so that the gears 62 and 63 may be placed in mesh with or disengaged from the gears 61 and 70 respectively as hereinafter described.

The gear 70, which is adapted to mesh with the gear 63, is mounted upon a bearing retaining ring 71, the ring being connected for rotation with the gear 70 by a key 72. The bearing retaining ring 71, and hence the gear 70, are journalled for rotation upon a reduced diameter portion 73 of the hub of the gear 42 by antifriction bearings 74 and 75, the bearings being held in place by a nut 76 screwed upon the threaded end of the said reduced diameter portion 73. The bearing ring 71 has a hollow cylindrical cap member 77 connected thereto by machine screws 78 which extend through a flange of the cap member and are screwed into tapped holes in the ring 71. The outer end of this cap member 77 projects through an opening in an end cover 79 for the hob head housing 26, an oil seal 80 preferably surrounding the cap member adjacent the opening through the cover 79.

The outer end of the cap member 77 is apertured to receive a cylindrical portion 81 of a hob arbor shifting screw 82 which extends within the cap member and is freely received in an axial bore provided in the adjacent end of the hob arbor or spindle 17. A flange 83 is provided intermediate the threads of the screw 82 and the cylindrical portion 81 thereof, this flange being disposed within a recess in the inner face of the end of the cap member 77 and secured thereto by screws such as 84 so that the hob shift screw 82 is rotatable with the cap member 77 and the gear 70. Exteriorly of the cap member the hob shifting screw 82 is provided with a polygonally-shaped portion 85 which is adapted to be engaged by a wrench or other tool for actuation of the mechanism when returning the hob arbor or spindle to its initial position as hereinafter described.

Threadably engaged with the hob shifting screw 82 is a nut member 86 which is secured by screws 87 to the adjacent end of the hob arbor 17. Also threaded upon the hob shifting screw 82, and disposed intermediate the nut 86 and flange 83, is a second nut member 88, the hub of which is extended and preferably provided with a locking spring 89. The outer peripheries of the nut members 86 and 88 are provided with splines or gear teeth 90 and 91, respectively. Surrounding the peripheries of the nut members 86 and 88 is an adjusting lock gear 92, the interior of which is provided with two spaced series of gear teeth or splines 93 and 94 cooperating, respectively, with the gear teeth or splines 90, 91 on the nut members 86, 88 so that the two nut members are held from relative displacement during operation of the mechanism.

The nut 88 and the lock gear 92 cooperate with the nut 86 to provide a means for preventing backlash between the threads of the screw 82 and of the nut 86. To effect adjustment of these parts, the lock gear 92 is moved axially until the gear teeth or splines 90, 93 on the nut 86 and the lock gear 92 are disengaged, the gear teeth or splines 91, 94 on the nut 88 and the lock gear, however, remaining in engagement. The lock gear 92 is then rotated, while the screw 82 is held stationary, until there is no backlash between the screw and the nuts whereupon the lock gear is axially moved to the position as shown in Figs. 2 and 4 so that the gear teeth or splines 90, 93 are reengaged. Since the gear teeth or splines 91, 94 remain in engagement, and since the nut 86 is connected to the hob arbor, the adjusted position of the nut 88 relative to the nut 86 is retained. To facilitate this adjustment, the nut 86 may be provided with grooves 90*a*, which are extensions of the grooves or spaces between the teeth or splines on the nut 86, and the lock gear 92 may be provided with one or more longitudinal marks or grooves so that the extent of relative rotation between the lock gear 92 and the nut 86 during adjustment may be readily determined.

The outer periphery of the lock gear 92 is threaded, and screwed thereon is a pair of control rings or nut members 95 and 96, the bores of which are threaded to cooperate with the threads on the lock gear 92 so that the ring or nut members may be disposed at any positions along the length of the member 92. Preferably, however, the nut or ring member 96 remains adjacent the rear or left-hand end of the lock gear 92 while the ring or nut member 95 is adjusted to various positions axially of the lock gear to provide for control of the machine in response to different predetermined axial distances of movement of the hob arbor as hereinafter described.

Slidably disposed upon the inner cylindrical surface of the cap member 77 is a relatively thin cylindrical sleeve 97 the end portion of which, adjacent the closed end of the cap member 77 is turned inwardly to provide a flange 98. This flange forms an abutment for one end of a compression spring 99, the other end of which bears against the inner face of the end of cap member 77, the spring 99 being normally uncompressed as indicated in Figs. 2 and 4. The cap member 77 adjacent the inner or unflanged end of the sleeve 97 is provided with a plurality of radial openings. A feed control ring 100 is slidably disposed exteriorly of the cap member 77 and is connected with the sleeve member 97 by flat-headed screws 101 which extend outwardly from the sleeve member 97 passing through bushings 102 between the sleeve 97 and ring 100, the outer ends of the screws being provided with nuts 103. The diameters of the bushings 102 are such that they have a sliding fit within the elongated slots in which they are disposed so that the sleeve member is constrained to rotate with the cap member and in addition can move axially relative thereto a limited extent.

The cap member 77 is also provided with a plurality of slots 104, of which one only is shown in Figs. 2 and 4, in which levers 105 are pivotally mounted with one end of the levers extending into contact with the control ring 100. The

other ends of the levers 105 extend inwardly of the bore of cap member 77 and into the path of movement of the ring or nut member 95, which in its advanced position, i. e., the extreme left-hand position indicated in broken lines in Figs. 2 and 4, is adapted to engage the levers and rock the latter.

The cover member 79 is provided with a radial opening through which passes a portion of a bent lever 106, the lever being provided with a pivot pin 107 which is supported in this opening of the housing 79. The inner or lower end of the lever 106, as viewed in Figs. 2 and 4, is provided with a somewhat spherical enlarged portion or knob 108 which is adapted to engage the control ring 100. The portion of the lever on the other side of the pivot 107, and exteriorly of the housing 79, is bent at substantially right angles and has a portion thereof engaging the actuating pin or member of a microswitch 109 which is adjustably supported upon the housing 79. Intermediate the point of engagement of switch 109 with the lever 106 and the substantially vertical portion of the latter, the lever is provided with an elongated slot through which passes a pin 110. The lower end of this pin is secured to the adjacent outer surface of the housing 79 and between the said housing and the lever is disposed a compression spring 111, the outer end of the pin 110 being threaded and provided with nuts 112. The construction just described is such that the spring 111 continuously urges the lever 106 to the position as shown in Figs. 2 and 4, but the lever may rock about its pivot 107 when the ring 100 moves to the right as viewed in these figures, thereby operating the switch 109. The switch 109 and the portion of the lever 106 exteriorly of the housing 79 are preferably enclosed by suitable cover plates such as 113.

It will now be apparent that rotation of the drive shaft 22 is transmitted through the bevel gears 50 and 48, thus rotating the shaft 45 and pinion 44 and the latter drives the gear 42 thereby rotating the hob arbor 17 and the hob H attached thereto. In addition, this rotation of the gear 42 drives the gear 61 which, in turn, causes the gears 62 and 63 to rotate since the former is connected to the latter. Consequently, the gear 70, the cap member 77, and the feed screw 82 are rotated. The speed of rotation of the feed screw 82 is equal to that of the hob arbor plus or minus a very small increment so that feed screw rotates relative to the hob arbor or spindle 17 at a very slow rate thereby causing the latter to be moved axially through the sleeve 36 due to the action of the nuts 86 and 88. As the hob spindle thus moves axially it carries therewith the control rings or nuts 95 and 96. When the hob arbor has moved axially a sufficient distance to dispose the control ring or nut 95 in its extreme left-hand, broken line position, as shown in Figs. 2 and 4, it engages the levers 105, rocking the latter counterclockwise, as viewed in these figures, thus forcing the ring 100 and hence the sleeve 97 to the right against the force of the compression spring 99. This movement of the control ring 100 rocks the lever 106 counterclockwise about its pivot 107, thereby actuating the switch 109, which, as hereinafter described in detail, is connected in the control circuit for the machine so as to stop the operation of the latter at the completion of a hobbing operation and light a signal lamp L indicating that the hob has advanced to its predetermined position and must be replaced or reground. The extent of the shift of the hob and its spindle prior to actuation of the switch 109 may be adjusted by adjusting the position of the control nut 95 upon the adjusting lock gear 92, the limits of this adjustment for the illustrated machine being indicated by the full and broken line positions of this ring or nut member adjacent the extremities of the threads on the member 92.

As mentioned heretofore, the advance of the hob arbor and the hob carried thereby is extremely slow and yet this is effected by a minimum of gears, the gearing shown for this purpose being that known as "differential gearing," the construction and operation of which is more fully described and claimed in the copending application of Thomas Barish, Serial No. 86,482, filed April 9, 1949. For the present purposes, it is sufficient to note that this gearing is such that the ratio of the number of teeth on at least one of the pairs of meshing gears 61, 62 and 63, 70 is not a whole number. That is to say, the quotient of the number of teeth on the gear 61 by the number of teeth on the gear 62, for example, is equal to a whole number plus or minus a small integer. The sign, whether plus or minus, depends upon the hand of the thread on the screw 82 and upon whether the mechanism is adapted to shift the hob arbor to the right or to the left. By way of example but without limitation thereto, the number of teeth on gears 61, 62, 63 and 70 may be, respectively, 244, 81, 83 and 250. With such a ratio of gears the screw 82 is given one revolution relative to the hob arbor spindle for approximately every 10,000 revolutions of the latter and, if there be 10 threads to the inch on this screw, it will be readily apparent that the advance of the hob arbor is in the order of 10 millionths of an inch per revolution of the arbor. Consequently, by suitable adjustment of the control ring or nut 95 upon the lock gear 92, the length of time required for the hob arbor to move axially to the position for actuation of the switch 109 can be made equal to the length of a work shift or any desired relatively long interval of time so that the machine may be serviced in its normal idle time and its productive time is not interrupted. Moreover, since the hob is being continuously advanced, the wear on its surface is equally distributed thereover so that the hobs will perform satisfactory service for longer periods of time than when they are adjusted intermittently as previously mentioned. The rate of hob advance and its direction for a given screw 82 may be readily selected by substituting for the gears 61, 62, 63 and 70 others having different numbers of teeth. Moreover, the direction of axial movement of the hob arbor may be readily reversed for a given set of these gears by simply reversing their positions.

As stated above, the gears 62 and 63 are journalled upon an intermediate portion of the shaft 67 which is eccentric with respect to the axis of that shaft. To the right of the eccentric portion 66, as viewed in Fig. 2, the shaft 67 has a concentric portion of reduced diameter which is journalled in the cover member 79 by antifriction bearings 114, a collar 115 being disposed between the bearings 114 and the eccentric portion of the shaft. Exteriorly of the cover member 79, the shaft 67 has a handle member 116 keyed thereto, the outer end of the shaft 67 being threaded and provided with a nut 117 to retain the handle in place. The inner, or left-hand, portion 118 of the shaft 67 is concentric and is journalled in

a bore provided in the housing **26** and between the portions **66** and **118** the shaft **67** has a concentric portion **119** of larger diameter forming shoulders abutting the housing **26** and the bearings **69**.

The portion **118** of the shaft **67** is provided with two recesses spaced 180° apart with which a spring pressed ball detent **120** selectively cooperates to retain the shaft in either of two positions corresponding with the engaged and disengaged positions of gears **62** and **63** with respect to the gears **61** and **70**. That is, with the handle **116** disposed as illustrated in Fig. 2, the eccentric portion **66** of shaft **67** is at its uppermost position so that the gears **62** and **63** are engaged with the gears **61** and **70**. Hence, rotation of the hob arbor or spindle **17** also causes the latter to be slowly moved or shifted axially. When the hob arbor has moved axially the predetermined distance, as determined by the setting of the control nut **95**, the switch **109** is actuated, as above described, terminating operation of the machine and lighting the signal lamp L. The operator then rocks the handle **116** through 180° to the second position thereof thus disposing the eccentric portion at its lowermost position and disengaging the gears **62** and **63** from the gears **61** and **70** thereby interrupting the driving connections between the hob arbor **17** and the hob shifting screw **82**. A wrench or other tool may then be applied to the polygonally shaped portion **85** of screw **82** and the latter, together with the hob arbor returned to its initial position. When the hob arbor has reached its extreme left-hand position, as viewed in Figs. 2 and 4, the ring or nut **96** engages the flange **98** of the sleeve **97**. This slightly compresses the spring **99**, moving the feed control ring **100** sufficiently to actuate the switch **109**, thereby relighting the indicating lamp L. The hob arbor is then moved in the opposite direction, that is, to the left as viewed in Figs. 2 and 4, until the lamp L is extinguished. This represents the position in which the ring or nut **96** has moved from engagement with the flange **98** so that the spring **99** is no longer compressed and hence the control ring **100** is so disposed that the lever **106** returns to its initial position under influence of the spring **111**.

In the event the advance of the hob arbor to its extreme forward or left-hand position, as shown in Figs. 2 and 4, has occurred at a time such that the machine is conditioned to begin a cutting or hobbing operation which has been prevented by the actuation of switch **109**, the circuit to the cut motor should be opened before returning the hob arbor to its initial position in order to insure that the machine will not automatically resume operations before the hob has been replaced and properly positioned. Even though the operation of the machine is stopped by switch **109** at the end of a hobbing operation and before the machine is conditioned for a new operation, it is good practice to open the circuit to the cut motor while returning the hob arbor to its initial position.

When the hob arbor has been returned to its initial position, the handle **116** is again rocked through 180° thus reengaging the gears **62** and **63** with the gears **61** and **70**. The circuit to the cut motor is then restored and operation of the machine may then be resumed. The spring detent **120** holds the shaft **67**, and hence the gears **62** and **63**, in either of the two above-described positions after being moved thereto by the operator rocking the handle **116** through an arc of 180°, the two positions of the handle being indicated by broken lines in Fig. 3.

The operation of the machine is electrically controlled. For this purpose the vertical column B of the machine is provided with a control panel **121** having a start switch **122**, a stop switch **123**, a switch **124** for controlling the direction of rotation of the hob and work, a "job selector" switch **125** for controlling the direction of the operating cycle, a "feed on–off" switch **126**, and a switch **127** for automatically terminating the feed prior to stopping the rotation of the work and hob. The start and stop switches are preferably of the push button type, while the switches **124**, **125**, **126** and **127** are multiple contact switches having two operating positions for the movable contacts thereof. Adjacent the lower ways **10** of the machine is a housing **128** which is provided with a work head travel controlled switch **136** operated by the adjustable stop **129** and a second work head travel control switch **137** operated by the adjustable stops **130** and **131** carried by the lower portion of the work head. The other side of the work head is preferably provided with two spaced stops or abutments, not shown, adapted to actuate an overtravel limit switch mounted on the column B.

Briefly stated the operation of the machine is as follows: A work blank is positioned in the work head, being held by a chuck on the work spindle **12** and by the tail center **13**, and the machine is then started by pushing the start button **122**. This energizes the rapid traverse motor, which is connected with the shaft **20**, thus causing relatively rapid vertical movement of the work head C to bring the work adjacent the hob H. Just prior to the time the work engages the hob, the stop member **129** actuates a switch in the housing **128**, stopping the rapid traverse motor and starting the cut motor. The latter rotates the shaft **22** and hence rotates both the work and the hob and causes the work head to move vertically at a relatively slow rate. After the work has been moved at the slow rate past the hob so that the latter has cut or hobbed the work, the stop **131** engages another switch within the housing **128**, terminating operation of the cut motor and hence the rotation of the work and the hob and the relatively slow movement of the work head. The work is then removed, and, upon again depressing the start button, rapid traverse motor is again energized moving the work head C rapidly back to its initial position, movement in this direction being terminated by the stop **130** engaging the last-mentioned switch within the housing **128**. As mentioned above, the hob arbor is slowly shifted in an axial direction when the hob is in rotation and, after the arbor has shifted to the maximum extent as determined by the setting of the control ring or nut **95**, the switch **109** is actuated, thus lighting the lamp L, which is preferably mounted upon the control panel **121**. If the machine be effecting a hobbing operation when the switch **109** is operated, the machine does not stop at this time, but only after the operation has been completed, whereupon the hob may be replaced and the operations repeated as above described.

The electrical control system for the machine is so arranged that the cycles of operation of the machine may be started with the work head C in either of its normally extreme vertical positions. That is to say, with the switch **125** set in one position, circuits are set up to effect the cycle of operations such that the work head C

moves in an upward direction during the hobbing operation, and with the switch 125 set in the other position thereof, the work head C is moved downwardly during the hobbing operation. The selector switch 124 controls the direction of rotation of the motor driving the hob arbor and the work so that rotation in either direction may be effected as desired. Therefore it will be apparent that either "climb" hobbing or "conventional" hobbing can be effected in either direction of movement of the work head by suitable setting of the switches 124 and 125, and by inserting or removing an idler gear in the work spindle drive change gears or in the feed change gears of the mechanism, as is described in the previously-mentioned Patent 2,307,428.

The switch 127 enables the feed of the work to be automatically terminated a predetermined time before the stopping of the hob arbor in order to provide for "clean up" of the work, while the switch 126 enables the feeding movement of the machine to be terminated at any time without interrupting the rotation of the hob and work. This latter feature is advantageous in setting up the machine or for checking its operation. Moreover, the machine is provided with the usual suitable safety switches, such as the previously-mentioned overtravel limit switch for the work head to prevent the latter from being moved beyond a predetermined point in the event the switch operated by the stops 130, 131 should fail to operate.

Fig. 5 of the drawings represents a simplified, schematic wiring diagram showing the manner in which the above-mentioned switches are connected to effect the previously-mentioned operations. As shown therein, the cut motor 132, which effects rotation of the hob arbor and work spindle and feeding movement of the latter, as well as the rapid traverse motor 133 are alternating current motors of the 3-phase reversible type. Hence, the power supply lines L1, L2 and L3 are connected to a source of alternating current of the 3-phase type, the motors 132 and 133 being connectible therewith by operation of the switches 124, 125 and certain contacts of various relays, the coils of which are represented in the lower part of Fig. 5 which forms the control portion of the circuit, this portion of the circuit being energized through wires 134 and 135 connected respectively with the power supply lines L2 and L1. It will be understood that, if desired, the wires 134 and 135 may be supplied with electrical power through a transformer connected between these wires and the power lines L1 and L2 instead of connecting the wires directly to the power supply lines. Likewise, a conventional cutout switch may be employed in the power supply circuit connected with the power supply lines L1, L2 and L3 if desired. The connections of the various switches together with the relays employed for controlling the operation of the machine will be readily apparent from a consideration of Fig. 5 in conjunction with the following detailed description of the various modes of operation of the machine.

OPERATION

"Conventional" cutting, feed "up"

With the switch 125 set for effecting hobbing while the work head is moving upwardly, the movable contacts 125*a*, 125*b*, 125*c*, 125*d*, 125*e*, 125*f*, and 125*g* are all moved into engagement with the stationary contacts indicated directly therebelow in Fig. 5. The switch 124 is then set for rotation of the cut motor 132 by moving the switch 124 to dispose its contacts 124*a*, 124*b* and 124*c* in engagement with the stationary contacts indicated directly therebelow. The switch 126 is set so that its movable contact 126*a* engages the stationary contact indicated directly therebelow, while the switch 127 is set so that its contacts 127*a* and 127*b* are in engagement with the stationary contacts indicated to the right of these movable contacts. The machine is thus conditioned to perform its cycle of operations by effecting a rapid traverse of the work head upwardly to a position which disposes the work adjacent the hob, the work head thereafter moving upwardly at the relatively slow feeding rate with the hob rotating clockwise, as viewed in Fig. 1. At the beginning of the cycle of operations the work head C is at its lowermost or "down" position so that switch 136 operated by the stops 130 and 131 has its contacts 136*a* closed and its contacts 136*b* open. Likewise, the contacts 137*a* and 137*b* of the switch 137, which is actuated by the stop 129, are respectively closed and opened.

After the operator has positioned a work blank in the work head C, the machine is started by depressing the start push button 122, thus causing the latter to bridge across the stationary contacts 138, 139 and 140. This closes a circuit from the wire 134 through the normally closed contacts 141, of the previously-mentioned overtravel limit switch, through the normally closed stop switch 123 to a wire 142, thence through a wire 143, the now depressed start switch 122 and wire 144 to a wire 145 connected with one terminal of the coil of a relay 146. The circuit is completed from the other terminal of coil of relay 146 through a wire 147, the contact 125*f* of switch 125, contacts 136*a*, to a wire 148 and thence through the normally closed contacts 149*a* and 150*a* to the wire 135. Consequently, the relay 146 is energized thereby closing its normally open contacts 146*a* and 146*c* and opening its normally closed contacts 146*b*.

Closing of the contacts 146*a* completes a circuit from the wire 142 through a wire 151 to a wire 152 which is connected with one terminal of the coil for a relay 153. The other terminal of the coil of this relay is connected by a wire 154 with the lower stationary contact cooperating with the movable contact 125*d* which, it will be remembered, has been initially positioned in its lowermost position. Hence, this circuit extends through contacts 137*a* to a wire 155, which is connected with the wire 147, so that the circuit for the relay 153 is likewise completed through the contacts 125*f*, 136*a*, wire 148, contacts 149*a* and 150*a* to the wire 135, with the result that the relay 153 is energized. This closes the contacts 153*a*, 153*b*, 153*c*, and 153*d* of relay 153. Contacts 153*d* provide a holding circuit for relay 153 about the contacts 146*a* and the start switch 122. Hence, when the start switch 122 is released and returns to its initial position, the resulting deenergization of relay 146 does not deenergize relay 153. Moreover, as soon as the start switch has returned to its initial position relay 146 is again energized through the now closed contacts 153*d* so that the contacts 146*a*, 146*c* are again closed and the contacts 146*b* opened.

The contacts 153*a*, 153*b*, and 153*c* are respectively disposed intermediate wires 155 and 156, 157 and 158, 159 and 160 which connect the rapid traverse motor 133 with the power supply lines L1, L2 and L3 through the contacts 125*a*, 125*b* and 125*c* of switch 125. The latter contacts being

disposed in their lowermost positions as previously mentioned, the rapid traverse motor 133 is energized for rotation in a direction which effects rapid movement of the work head in an upward direction. Current is also supplied from the wires 156, 158 through the normally closed contacts 161*a* and 161*b* of a relay 161 to the wires 162 and 163 connected with the terminals of the solenoid 164 of a solenoid-operated brake. This brake is associated with the shaft 20, connected to the power output shaft of the rapid traverse motor, and is of the conventional type, the brake being normally engaged with the shaft by a spring, but is disengaged by energization of solenoid 164. Consequently, the shaft 20 is freed for rotation at the same time that the motor 133 is energized.

As the result of the relay operations just described, the work head is now moved rapidly upward until the stop 129 engages the switch 137 in the housing 128, thus moving the contacts 137*a* to open position and the contacts 137*b* to closed position. Opening the contacts 137*a* deenergizes the relay 153, thus opening the contacts 153*a*, 153*b*, 153*c* and 153*d* with consequent deenergization of the rapid traverse motor 133 and of the solenoid 164 for the brake. Therefore, the movement of the work head at the relatively rapid rate is terminated. The closing of the contacts 137*b* now energizes a relay 165 through a circuit extending from the wire 142, through the closed contacts 146*a*, start switch 122, closed contacts 109*a* and wires 166 and 167 to one terminal of the coil of the relay 165, the other terminal of the relay being connected by wires 168 and 169 to the lower stationary contact with which the movable contact 125*e* was initially engaged, the circuit being completed through the now closed contacts 137*b* and wire 155, etc. to the wire 135.

The energization of the relay 165 closes its normally open contacts 165*a*, 165*b*, 165*c* and 165*d*. The contacts 165*d* provide a holding circuit about the contacts 146*a*, but this function is not necessary at this time. The contacts 165*a* and 165*b* and 165*c* are connected intermediate wires 170 and 171, 172 and 173, 174 and 175 respectively, connecting the power supply lines L1, L2, and L3 through the contacts 124*a*, 124*b* and 124*c* to the cut motor 132. Consequently, the cut motor is now energized and rotates the hob in a clockwise direction as viewed in Fig. 1. This motor also effects a feeding movement of the work head in a vertically upward direction and rotates the work spindle or support 12. Consequently, the work is now carried into engagement with the hob and progressed therepast at a feeding rate so that the work is hobbed. After the hobbing has been completed, as determined by the setting of the stop 131, the latter engages the switch 136 in the housing 128, opening the contacts 136*a* and closing the contacts 136*b* thereof. Opening of the contacts 136*a* deenergizes the relay 165, thereby opening its contacts 165*a*, 165*b*, 165*c* and 165*d* so that the cut motor 132 is deenergized with the result that the rotation of the hob and work are discontinued as well as the vertical feeding movement of the work head. Opening the contacts 136*a* has also opened the circuit through the relay 146 so that the latter is deenergized and the holding circuit through its contacts 146*a* is released, the latter contacts and contacts 146*c* being opened and the contacts 146*b* being closed by the deenergization of relay 146.

The finished work is now removed from the work head C and the start button 122 again depressed into engagement with the contacts 138, 139 and 140. This closes a circuit from the wire 142 through the wire 143 and the depressed start button 122 to a wire 176 connected between the contact 139 and a wire 177, the circuit extending from the wire 177 through the normally closed contacts 146*b* of relay 146 to the coil of a relay 178 and from the latter through a wire 179 to and through the contact 125*g*, the now closed contacts 136*b*, wire 148, and contacts 149*a*, 150*a* to the wire 135. Consequently, the relay 178 is now energized and closes its normally open contacts 178*a*, 178*b*, 178*c* and 178*d*. Closing of the contacts 178*d* provides a holding circuit for the relay 178 around the start switch 122 so that the relay remains energized when the start switch is released and returns to its initial position. Closing of the contacts 178*a* has interconnected the wires 155 and 158, while closing of the contacts 178*b* has interconnected the wires 157 with 156, the contacts 178*c* again connecting the wire 159 with 160. Therefore the rapid traverse motor 133 now has two of its leads reversed with the result that it is energized for rotation in the reverse direction, that is, in a direction which effects movement of the work head in a downward direction. Simultaneously with the energization of the motor 133, the solenoid 164 is energized through the normally closed contacts 161*a* and 161*b* with the result that the brake on shaft 20 is released so that the work head is now moved rapidly downward.

During the downward movement of the work head, the stop 129 thereon engages the switch 137 to again close the contacts 137*a* and open the contacts 137*b*. This has no effect on the circuit other than to prepare it for a new operation. When the work head reaches its lowermost position, the stop 130 engages the switch 136 again closing its contacts 136*a* and opening its contacts 136*b*. Opening of the contacts 136*b* de-energizes the relay 178, thereby opening contacts 178*a*, 178*b*, 178*c* and 178*d* so that the solenoid 164 of the brake and the rapid traverse motor 133 are deenergized with the result that movement of the work head is terminated.

The operation may be repeated with a new workpiece by simply positioning the latter in the work head and operating the start button, and the above-described cycle of operation is repeated. It will be remembered, however, that for each revolution of the hob the latter is shifted axially a small extent which may, for example, be in the order of 10 millionths of an inch per revolution of the arbor. Consequently, eventually the arbor will have shifted sufficiently to cause the ring or nut 95 to engage the levers 105, thus shifting the control ring 100 and the sleeve 97 to the right as viewed in Figs. 2 and 4, against the force of the spring 99. This rocks the lever 106 and operates the switch 109 to open its normally closed contacts 109*a* and close its normally open contacts 109*b*. If the work head be moving upwardly at the feeding rate, and hence hobbing be in progress, the relay 165, controlling the cut motor 132 as mentioned above, will be closed and will be held energized by its holding contacts 165*d*. Consequently, opening of the contacts 109*a* will not prevent the continuance of the hobbing operation. Nevertheless, the closing of the contacts 109*b* closes a circuit from the wire 145 through wires 180 and 181 which connect the lamp L with the contacts 109*b* and the wire 148, with the result that the lamp L is illuminated, indicating that the hob should be replaced.

When the hobbing operation is completed, the work head may be traversed to its lowermost position, as above described, by operation of the start button 122. If, however, the operator should now position a new workpiece in place and start the machine again by actuating the button 122, the work head simply rapidly traverses to bring the work adjacent the hob, as above described. When the work has reached this position and hence the contacts 137*a* have been opened and the contacts 137*b* closed, the relay 165 is not now energized since the circuit through the contacts 109*a* is now open. Consequently, the cut motor 132 is not energized so that hobbing cannot be effected with the worn hob and the latter must be replaced as previously described. While returning the hob arbor to its initial position and replacing the hob, the switch 124 should be placed in its intermediate position so that the contacts 124*a*, 124*b* and 124*c* are disposed as indicated in Fig. 5. This prevents the cut motor 132 from being energized while work of replacing the hob is being effected.

As mentioned above, the hob arbor is returned to its initial position by rocking the handle 116 through 180° to disengage the gears 62 and 63 from the gears 61 and 70 and then rotating the screw 82 through means of a wrench or other tool applied to the polygonal head 85. As the hob arbor begins its return movement, the nut 95 moves from engagement with the lever 105 so that the spring 99 returns the sleeve 97 and control ring 100 to their initial positions so that the lever 106 rocks clockwise, as viewed in Figs. 2 and 4. This closes the contacts 109*a* and opens the contacts 109*b* of the switch 109. Closing of the contacts 109*a* does not, however, result in energization of the cut motor 132 since the switch 124 has been moved to circuit opening position. Opening of the contacts 109*b* extinguishes the lamp L. When the hob arbor has been returned to its extreme retracted position, the nut 96 engages the flange 98 again actuating the switch 109 opening the contacts 109*a* and closing the contacts 109*b*. The closing of the contacts 109*b* again lights the lamp L indicating that the hob arbor has been fully retracted. The operator then rotates the screw 82 in the reverse direction until the lamp L is extinguished thus indicating that the spring 99 is no longer compressed and the contacts 109*a* are closed while the contacts 109*b* are open. After the hob has been replaced and the gears reengaged by operation of the handle 116, the switch 124 is again actuated to position its contacts 124*a*, 124*b* and 124*c* into engagement with the lowermost cooperating contacts, whereupon the motor 132 will be energized, since the contacts 109*a* are now closed so that the relay 165 is energized therethrough. It will be apparent, therefore, that a hobbing operation once started is carried to completion and is not interrupted while work is being hobbed. Nevertheless, the machine is so controlled that a new hobbing operation cannot be commenced until the worn hob has been replaced.

In the event it is desired to stop the machine at any time, this may be readily effected by depressing the stop button 123 thereby opening the control circuit and deenergizing any of the relays that may then be energized. Likewise, if the switch 136 should fail to operate at the proper time, the excessive travel of the work head operates the switch 141, opening the control circuit and stopping the machine. Moreover, if either the cut motor 132 or the rapid traverse motor 133 should draw excessive current for any reason, the corresponding current overload relay 149 or 150, which respectively control the contacts 149*a* and 150*a*, operate to deenergize the control circuit.

"Conventional" cutting, feed "down"

The machine may be operated so that the cutting operation will be in the conventional manner, but the direction of feed will be downwardly, by merely reversing the switches 124 and 125 from their positions for effecting hobbing while the work head is fed upwardly. This will place the contacts 124*a*, 124*b* and 124*c* of the former switch in engagement with the uppermost stationary cooperating contacts of that switch, and the contacts 125*a*, 125*b*, 125*c*, 125*d*, 125*e*, 125*f* and 125*g* of the latter switch in engagement with their uppermost stationary contacts. It will be apparent, therefore, that when the motor 132 is energized during the operation of the machine, the hob and work will rotate in the reverse direction to that previously described and the feed will be in the downward direction. Hence the type of cutting will be the same as previously referred to or, in other words, will be "conventional."

With the switches 124 and 125 in the positions just mentioned, actuation of the start switch 122 into engagement with the contacts 138, 139 and 140 now closes a circuit from the wire 142 through the wire 143, the start switch 122, wires 176, 177 and the normally closed contacts 146*b* to the relay 178 and from the latter through the wires 179 and 182 to the contact 125*f*, which is now in engagement with the adjacent upper stationary contact of the switch, as viewed in Fig. 5, thence through the now closed contacts 136*a*, wire 148, contacts 149*a*, 150*a* to the wire 135. Relay 178 is therefore energized closing its normally open contacts 178*a*, 178*b*, 178*c* and 178*d*. Closing the contacts 178*d* provides a holding circuit for the relay 178 about the start switch 122 so that the relay 178 remains energized when the start switch is released and returns to its initial position. Closing of the contacts 178*a*, 178*b* and 178*c* respectively connect the wires 155 and 158, 157 and 156, 159 and 160. But since the contacts 125*a*, 125*b* and 125*c* are now in engagement with their uppermost stationary contacts, the rapid traverse motor 133 is energized for rotation in a forward direction. At the same time, current is supplied through the normally closed contacts 161*a*, 161*b* energizing the solenoid 164 of the brake with the result that the rapid traverse motor now moves the work head rapidly upward. During the upward movement of the work head the stop 129 engages and operates the switch 137, thus moving the contacts 137*a* to open position and the contacts 137*b* to closed position. This prepares the circuit for subsequent operation but does not initiate operation of the cut motor at this time since the relay 146 has not been energized and hence the contacts 146*a* are open so that no circuit can be completed to the relay 165.

When the work head reaches its uppermost position, the stop 131 engages and actuates the switch 136, thus moving the contacts 136*a* to open position and the contacts 136*b* to closed position. Opening the contacts 136*a* interrupts the circuit through the relay 178 deenergizing the latter and thereby opening the contacts 178*a*, 178*b*, 178*c*, 178*d* with the result that the rapid traverse motor is stopped and the brake applied

so that the movement of the work head terminates.

A workpiece may now be positioned in the work head and upon again depressing the start button 122, a circuit is completed from the wire 142 through the wire 143, the start switch 122 in its depressed position, wire 144 and 145 to and through relay 146, the wire 147, and the contact 125*g* which is now in engagement with its upper stationary contact, to and through the now closed contact 136*b*, wire 148, contacts 149*a* and 150 to the wire 135. Relay 146 is therefore energized closing its contacts 146*a* and 146*c* and opening its contacts 146*b*. The closing of contacts 146*a* completes a circuit therethrough and through wires 151, 152 to and through the relay 153 to the contact 125*e*, which it will be remembered is in engagement with its upper stationary contact, thence through the now closed contacts 137*b*, which were closed during the upward movement of the work head. The circuit is completed through the wire 155, contact 125*g*, and the now closed contact 136*b*, which was closed when the work head reached its upper position, the circuit continuing through the wire 148, contacts 149*a* and 150*a* to the wire 135. Relay 153 is therefore energized, closing its normally open contacts 153*a*, 153*b* 153*c* and 153*d*. Contacts 153*d* provide a holding circuit for the relay 153, so that when the start switch is released and returns to its initial position, the resulting deenergization of relay 146 does not deenergize relay 153. Upon return of the start switch to its initial position the relay 146 is again energized through the contacts 153*d*. Relay 146 therefore again closes its contacts 146*a*.

The closing of the contacts 153*a*, 153*b*, 153*c* energizes the motor 133 for rotation in the reverse direction, it being remembered that the contacts 125*a*, 125*b* and 125*c* were initially positioned in engagement with their upper stationary contacts. Also, current is supplied through closed contacts 161*a*, 161*b* to the solenoid 164 of the brake and hence the motor 133 moves the work head rapidly downwardly until the work is adjacent the hob as determined by the position of the stop 129. When this position is reached, the stop 129 engages the switch 137 moving the contacts 137*a* to closed position and the contacts 137*b* to open position. Opening of the contacts 137*b* deenergizes relay 153 so that the rapid traverse motor 133 is stopped and the brake applied. Closing of the contacts 137*a* now completes a circuit from wire 142 through the now closed contacts 146*a*, start switch 122, contacts 109*a*, wires 166 and 167 to the relay 165 and from the latter through the wires 168, 169 and 183 to the contact 125*d*. This circuit continues through the contact 125*d* and the now closed contacts 137*a*, wire 155, contact 125*g* and the contacts 136*b* which, it will be remembered, were closed when the work head reached its uppermost position, to the wire 148 and thence through the contacts 149*a*, 150*a* to the wire 135.

The relay 165 is therefore energized closing its normally open contacts 165*a*, 165*b*, 165*c* and 165*d*. Contacts 165*d* provide a holding circuit for the relay, while contacts 165*a*, 165*b*, and 165*c* energize the motor 132, it being remembered that the initial positioning of the switch 124 disposes the contacts 124*a*, 124*b* and 124*c* such that the motor 132 now rotates in a direction which causes the work head to move downwardly at the feeding rate and also provides proper directional rotation of the hob and work. Therefore, the

work is hobbed as the head is fed downwardly until the stop 130 engages and actuates the switch 136 moving the contacts 136*b* to open position and the contacts 136*a* to closed position. Opening the contacts 136*b* deenergizes the relay 146 and relay 165, thus deenergizing the motor 132 so that the feeding movement and the rotation of the hob and work spindles is terminated and the circuit is prepared for a new operation.

After the work has been removed, the previously-described cycle of operation may be repeated again and again until the hob has advanced the predetermined distance for which the ring or nut 95 has been set. When, however, the hob arbor and hob have advanced to their extreme positions, thereby actuating the switch 109, closing its contacts 109*b* and opening its contacts 109*a*, further hobbing operations are prevented, but a hobbing operation in progress may be completed. Thus, the work head may be rapid traversed to its uppermost position as above described by depressing the start button, work may be loaded into the machine and the work rapid traversed down to a point adjacent the hob by again depressing the start button. However, when the work comes adjacent the hob so that the switch 137 is actuated by the stop 129, the cut motor 132 is not energized since the circuit to the relay 165, which controls the motor, is now open at the contacts 109*a*. Likewise, at this time, the contacts 109*b* will be closed so that the lamp L is lighted, indicating that the hob must be replaced. The machine may be restored to operating condition as above described by returning the hob arbor to its initial position which will result in closing of the contacts 109*a* and extinguishing the lamp L by opening the contacts 109*b*.

"Climb" cutting, feed "up"

As described in the previously mentioned Patent 2,307,428, a machine of the type here illustrated and described may have an idler gear inserted in the feed change gears so that the direction of feed is reversed without reversing the direction of rotation of the hob and work. In other words, with the switch 124 set with its contacts 124*a*, 124*b* and 124*c* at their uppermost positions as viewed in Fig. 5, the hob will now rotate in a counterclockwise or reverse direction as viewed in Fig. 1, while the feed will be "up" instead of "down." With the feed "up" and the hob rotating as just mentioned the hob will attempt to climb the work during the cutting or hobbing operation or, in other words, the operation will be "climb" cutting or hobbing. Hence, with the switch 125 set so that its movable contacts are in their lowermost positions as viewed in Fig. 5, the first described cycle of operations will be repeated, the only difference being the direction of rotation of the hob. Hence the description of the circuit and operations will not be repeated, it being noted that the switch 109 operates as before to prevent further hobbing operations after the hob has reached its extreme of axial movement and the cycle has been completed.

"Climb" cutting, feed "down"

The machine can likewise be operated to effect "climb" cutting or hobbing but with the feed being produced by downward movement of the work head C by utilizing an idler gear in the feed change gears and by reversing the positions of the switches 124 and 125. The cycle of opera-

tion is the same as that described with respect to "conventional" cutting, feed "down" and hence will not be repeated. In this mode of operation also the switch **109** operates to prevent further hobbing operations after the hob has reached its extreme of axial movement and the cycle of operation has been completed.

Automatic feed cutout—cleanup operation

As previously mentioned, the machine is provided with a switch **127** to enable the machine to be operated with a cleanup feature. That is to say, the machine is so operated that at the completion of the hobbing operation the feeding movement of the work head is terminated a predetermined time interval before the rotation of the work and hob cease so that the hob remaining in engagement with the work and without feed of the latter thereby effecting a cleanup of the end of the cut. This feature is especially useful when splining or the like is being cut since it insures that the ends of the splines will all lie in the same transverse plane. When this feature of the machine is to be employed, the switch **127** is positioned so that its movable contacts **127***a* and **127***b* engage the left-hand stationary contacts adjacent thereto as viewed in Fig. 5. Let it be assumed that the operation will otherwise be "conventional" cutting or hobbing with the feed "up."

The machine is started, as before described, by depressing the start button and operates as mentioned above to rapid traverse the work adjacent the hob. When this point is reached the switch **137** is actuated, as previously described, closing contacts **137***b* and opening the contacts **137***a*. Hence, the work is now moved at a feeding rate while the hob and work are rotated since the cut motor is energized through the energization of the relay **165**. At the same time that the relay **165** is energized, a relay **184** is energized by the closing of the contacts **137***b*, the circuit for this relay extending from the wire **142** through the contacts **146***a*, wire **151** and wire **185** to the relay **184**, thence from the latter through the wire **186** and wire **169**, contact **125***e* and the closed contacts **137***b* to the wire **155**, the circuit continuing through the latter wire and the contacts **125***f*, contacts **136***a* to the wire **148**, thence through the contacts **149***a*, **150***a* to the wire **135**. Energization of the relay **184** closes its normally open contacts **184***a* which are connected between the wire **155** and the normally closed contact **187***a* of a timing relay **187**. The contact **187***a* is connected by a wire **188** to the contact **127***b* which is now closed with the cooperating stationary contact connected by a wire **189** to the wire **148**.

Consequently, a holding circuit is provided for the relay **146** about the switch **136** through the wire **155**, contacts **184***a*, **187***a*, wire **188**, contact **127***b* and wire **189**. The cutting or hobbing operation continues during the upward movement of the work head at the feeding rate imparted by the motor **132** as previously described under "'Conventional' cutting, feed 'up'." When, however, the upper limit of this movement has been reached so that the stop **131** moves the contacts **136***a* to open position and the contacts **136***b* to closed position, relay **146** is not now deenergized since the above-described holding circuit therefor has been provided through the contacts **184***a*, **187***a* and **127***b*. Likewise, relay **165** remains energized through the contacts **184***a*, **187***a*, etc., so that the cut motor **132** remains in operation for a predetermined period of time after operation of the switch **136**, the length of this period being determined by the relay **187** which is a timing relay, preferably adjustable, and operates the contact **187***a* as hereinafter described.

While the cut motor **132** remains in operation, thus rotating the hob and work spindles, there is no feeding of the work head at this time since the operation of switch **136** has completed a circuit through the now closed contacts **146***c* of relay **146**, wires **190** and **191** to the relay **161** and through the latter and the contact **126***a*, which is in its lowermost position, wires **192** and **193**, contact **127***a* to and through the contact **125***g* and the now closed contacts **136***b*, the circuit being completed through wire **148**, contacts **149***a*, **150***a* to the wire **135**. The relay **161** is therefore energized thus opening its normally closed contacts **161***a* and **161***b* and closing its normally open contacts **161***c* and **161***d*. Current is therefore supplied to the solenoid **164** of the brake for shaft **20** energizing the latter. Therefore, the shaft **22** is free to rotate and hence the screw and nut assembly which effects vertical movement of the work head is ineffective to produce this movement since both the screw and the nut freely rotate. As a result the work is not fed even though the latter and the hob are rotated and hence the final portion of the cutting operation is subjected to a cleanup operation which, as mentioned before, enables work such as splining to be cut so that all the upper ends of the splines lie in the same transverse plane.

The operation of switch **136** at the upper limit of travel of the work head has, as mentioned before, closed the contacts **136***b*. This energizes the timing relay **187** through the now closed contacts **146***c*, the wire **190**, the coil of relay **187**, wire **195**, contacts **127***a*, **125***g* and **136***b* to wire **148**. Since the relay **187** is a timing relay, it does not operate its contact **187***a* immediately upon energization but only at the end of a predetermined time interval thereafter. The timing relay **187** is of conventional type and is adjusted to provide the desired amount of rotation of the hob and work after termination of the feed of the work head. This time interval may, for example, be in the order of the length of time required for one complete revolution of the work after termination of the feeding.

When the predetermined time interval for which relay **187** is set has elapsed, this relay moves its contact to circuit opening position thus deenergizing relay **146**. Deenergization of relay **146** opens its contacts **146***a* and **146***c* thereby deenergizing relays **165**, **184** and **187** so that the motor **132** is deenergized. The relay **161**, however, remains energized for a short time interval after the deenergization of the motor **132** so as to insure that the brake is not applied before the desired rotation of the work and hob have been completed, thus insuring against incomplete cleanup operation. For this purpose the relay **161** is provided with another set of contacts **161***e* which are normally open but which are closed upon energization of relay **161** to provide a holding circuit for the latter. This circuit extends from the wire **142** through the contacts **161***e*, the normally closed contact **194***a* of a second timing relay **194**, the relay **161**, contact **126***a*, wires **192**, **193**, contact **127***a*, contact **125***g*, contacts **136***b*, wire **148**, and contacts **149***a* and **150***a* to the wire **135**.

The energization of the timing relay **194** is under control of the normally open contacts

161*e* and a pair of normally closed contacts 146*d* of relay 146. Consequently, when the contacts 161*e* are closed and while the relay 146 is still energized, that is, prior to the deenergization of the motor 132, the timing relay 194 is not energized since the contacts 146*d* are held open. After the relay 187 has operated to move its contact 187*a* to circuit opening position thereby deenergizing relays 146, 185 and 165 so that the motor 132 is deenergized, the circuit to the relay 194 is then completed through the now closed contacts 146*d* of relay 146, the circuit extending from the wire 142 through the now closed contacts 161*e*, wire 196, normally closed contacts 146*d*, relay 194, wire 193, contacts 127*a*, 125*g*, and 136*b* to wire 148. Since the relay 194 is a timing relay, so that energization of this relay does not immediately result in operation of the contact 194*a* to open position, the latter remains closed for a predetermined time interval after the energization of the relay 194. At the end of this interval the contact 194*a* is moved to open position thus deenergizing relay 161 so that the solenoid 164 of the brake is deenergized, thus applying the brake. This time delay is interposed to insure that the brake is not prematurely applied while the desired rotation imparted by the cut motor to the work and the arbor is still continuing, as by coasting, after the motor is deenergized. The deenergization of the relay 161 reopens its contacts 161*e* so that the timing relay 194 is deenergized, restoring the circuit to the condition such that the work may now be removed from the work head, the machine being returned to its initial position by again operating the start button 122, as described above under "'Conventional' cutting, feed 'up'."

The above-described automatic feed cutout to provide cleanup may also be utilized when the machine is operating in accordance with the above-described cycle of operations known as "'Conventional' cutting, feed 'down'." In this instance, the switches 124 and 125 are positioned as above described for this type of operation, that is to say, with their movable contacts in engagement with the cooperating upper adjacent stationary contacts and the switch 127 is moved to engage its contacts 127*a* and 127*b* with the adjacent left-hand contacts as viewed in Fig. 5. The switch 126 is likewise positioned with its contact 126*a* in engagement with the contact connected to wire 192.

With the machine thus set up the initial actuation of the start button 122 causes the work head to rapidly move upwardly as above described under the heading of "'Conventional' cutting, feed 'down'." During this movement, the stop 129 on the work head engages and actuates the switch 137 to close its contacts 137*b* and open contacts 137*a*. At the end of the vertical movement stop 131 actuates switch 136 to close the contacts 136*b* and open the contacts 136*a*, thereby terminating the rapid movement in the upward direction. The workpiece is then applied to the work head and the start button 122 again actuated. The work head moves rapidly downward until the work is adjacent the hob at which time the switch 137 is again operated by the work head to terminate the rapid movement and begin the cutting or hobbing operation and feeding movement, these operations being effected and continuing as above described under the heading of "'Conventional' cutting, feed 'down'" until the work head has moved to a position corresponding to the end of the cutting

operation, thereby actuating the switch 136 to close the contacts 136*a* and open the contacts 136*b*. The motor 132 is not deenergized at this time, however, but continues to rotate without further feed of the work head, the relay 165 remaining energized through the contacts 125*d*, 137*a*, 184*a*, 187*a*, wire 188, contact 127*b*, and wire 189 which is connected with wire 148. Likewise, the operation of the switch 136 to closed position has energized the relay 161 through the circuit extending from the wire 142, the now closed contacts 146*c*, wire 190, wire 191, the coil of the relay 161, contact 126*a*, wires 192 and 193, contact 127*a*, wire 182, contacts 125*f* and 136*a* to the wire 148. Therefore, the contacts 161*c* and 161*d* are closed and contacts 161*a* and 161*b* are opened with the result that the solenoid 164 for the brake is energized so that the continued rotation of the motor 132 does not effect any further feed of the work head. This continued rotation effects cleanup of the work and is terminated by operation of the relays 187 and 194 as above described for the cleanup with "'Conventional' cutting, feed 'up'."

The cleanup feature above described may also be employed with "climb" hobbing with the feed being either "up" or "down" in the same manner as described for "conventional" cutting or hobbing with feed "up" or "down." In all cases the switch 109 actuated by the axial movement of the hob arbor prevents further hobbing operations when the hob arbor has moved to its extreme advanced position.

Feed out

The switch 126 is provided for the purpose of permitting operation of the machine without feeding movement of the work head. This mode of operation is useful in cutting or hobbing certain types of work and is especially useful in setting up the machine or in checking its operation. When it is desired to thus operate, the switch 126 is positioned so that its movable contact 126*a* engages its upper stationary contact, as viewed in Fig. 5. Let it be assumed that the machine is otherwise set for "conventional" hobbing or cutting with the feed "up" and that the work head is provided with a workpiece. Depressing the start button 122 now operates, as before, to energize the relay 146 and the relay 153, the latter effecting energization of the rapid traverse motor 133 in a direction such that the work head moves upwardly, it being remembered that the brake is released by energization of the solenoid 164 through the normally closed contacts 161*a* and 161*b*.

When the work head has traversed the predetermined distance required to bring the work adjacent the hob, the switch 137 operates, as before, to close the contacts 137*b* and open the contacts 137*a*, thus deenergizing relay 153 and consequently deenergizing the rapid traverse motor 133 and reapplying the brake. The closing of contacts 137*b* results in energization of the relay 165, as previously described, so that the cut motor 132 is placed in operation causing the hob and the work to rotate. At the same time, however, a circuit has been completed from wire 142 through the now closed contacts 146*c*, wires 190 and 191, the coil of relay 161, contact 126*a*, wires 197, 186 and 169 to the contact 125*e*, the circuit continuing through the now closed contacts 137*b*, wire 155, contacts 125*f*, and 136*a* to the wire 148. This energizes relay 161, thus closing its contacts 161*c*, 161*d*, 161*e* and opening its contacts

161*a*, 161*b*. Therefore, the solenoid 164 of the brake is energized so that both the feed screw and nut may freely rotate with the result that there is no feeding of the work head and hence the machine will continue in this condition until the switch 126 is positioned to bring its contact 126*a* into engagement with its lower stationary contact, which is connected with the wire 192, thereby deenergizing the relay 161 so that the brake is reapplied and feeding may be effected, the operation of the machine then continuing in the same manner as before described.

This no-feed feature may likewise be employed with "conventional" cutting or hobbing with feed in the downward direction by setting the switches 124 and 125 for such operation but with the switch 126 set so that its contact 126*a* closes the circuit to the wire 197. The machine will then operate as previously described for "'Conventional' cutting, feed 'down'" until the work head has brought the work adjacent the hob at which time the rapid traverse motor 133 is deenergized and the cut motor 132 is energized, as previously described. However, no feeding of the work occurs since the relay 161 is then energized through the circuit extending from the wire 142 through contacts 146*c* and relay 161 to and through the contact 126*a*, wires 197, 186, 169, 183, contacts 125*d*, 137*a*, wire 155, contact 125*g* and the now closed contacts 136*b* to the wire 148. Hence the hob and work are rotated without feed of the work head until the switch 126*a* is moved to engage the contact which is connected with the wire 192, whereupon relay 161 is deenergized and the operation continues to completion.

The no-feed feature may also be employed with "climb" cutting or hobbing. Furthermore, the feed may be interrupted during a cutting or hobbing operation of either the "conventional" or "climb" type by simply actuating the switch 126 to position its contact 126*a* in engagement with the upper stationary contact connected with the wire 197. When cutting or hobbing is in progress the relay 146 will be energized so that contacts 146*c* are closed and hence the actuation of switch 126 will result in energization of relay 161 thereby terminating the feed without interrupting the rotation of the hob and work. Feeding may be resumed by simply reversing the position of switch 126.

Stop-and-start switches

Both the start switch 122 and the stop switch 123 are of the push button type and include ferrules 198 and 199, respectively. The ferrule 198, associated with the start button 122 is adapted to secure the latter in an intermediate position, as indicated by dotted lines in Fig. 5, in which position the movable contact of the switch is out of engagement with all of its stationary contacts. This feature is employed to facilitate setting up of the machine and operates as follows: The start button 122 is initially depressed into engagement with its contacts 138, 139 and 140, and the ferrule 198 is adjusted so that when the button is released by the operator, it will be held in its intermediate position as indicated by the dotted lines in Fig. 5. The initial depression of the start button 122 closes the circuit from the wire 142 through the wire 143 and start button 122 to the wire 144, thus energizing relay 146 when the machine is set for "'Conventional' cutting, feed 'up'." This energization of relay 146 closes its normally open contacts 146*a* thus energizing relay 153 through the last-mentioned contacts, wire 151, wire 152, the coil of the relay 153, wire 154 and contacts 125*d*, 137*a*, wire 155, contact 125*f* and contacts 136*a*, the circuit extending to the wire 148 and through the contacts 149*a*, 150*a* to the wire 135. Hence, relay 153 is energized, closing its normally open contacts 153*d* and providing a holding circuit for the relay 153 so that when the start button 122 is released the resulting deenergization of relay 146 does not result in deenergization of relay 153. Moreover, the relay 146 is not again energized since it will be remembered that the start button 122 is now held in its intermediate position.

The energization of the relay 153 has closed its contacts 153*a*, 153*b*, and 153*c* thereby energizing the motor 133 effecting rapid traverse of the work head to bring the work adjacent the hob, whereupon the switch 137 is actuated to open its contacts 137*a* and close its contacts 137*b*. This deenergizes the relay 153 so that the motor 133 and movement of the work head stop. The circuit to the relay 165 is not completed at this time however, since the start button is held in its intermediate position. Consequently, the motor 132 is not energized so that the work head does not move and the hob and work are not rotated. This enables the hob to be adjusted relative to the work and to effect such other adjustment of the mechanism as is necessary. The machine may be started upon the remaining portion of its cycle by simply returning the ferrule 198 to its initial position thus releasing the latter which is then depressed again. This actuation of the start button 122 completes a circuit through the button in its depressed position and through the wire 144, contacts 109*a*, wire 166 and wire 167 to the relay 165 and from the latter through the contact 125*e*, contacts 137*b*, which are now closed, wire 155, contact 125*f*, contact 136*a* to the wire 148. The relay 165 is therefore energized closing its contacts 165*a*, 165*b*, 165*c* and 165*d*. The latter contacts provide a holding circuit for the relay 165 maintaining the latter energized when the start button is released, while the contacts 165*a*, 165*b* and 165*c* effect energization of the cut motor 132 so that the hob and work are rotated and the work head is moved vertically at the feeding rate, the operations continuing as previously described.

The machine may likewise be operated by employing the ferrule 198 to hold the start button 122 in an intermediate position when the machine is employed for "conventional" cutting, feed "down." In this situation the start button is initially depressed, the ferrule not yet being adjusted to hold the button partially depressed, with the result that the work head is rapidly traversed to its uppermost position in the usual manner. When the start button is again depressed to effect downward movement of the work head, the ferrule is then actuated to hold the start button in its intermediate position. The operation is then substantially as described above, the work head being now moved downwardly at the rapid rate until the work is adjacent the hob at which time the switch 137 will be actuated to deenergize the rapid traverse motor, but the intermediate position of the start button prevents the relay 165 from being energized so that the motor 132 is not energized and there is no rotation of the hob or the work nor any feeding movement of the work head.

The operation of the machine when employing

the ferrule and with the apparatus set for "climb" hobbing with feed either "up" or "down" is the same as for conventional cutting with corresponding feed.

The ferrule **199** provided for the stop button **123** is adapted to hold the latter in its depressed or open position. Hence, this stop button may be depressed and the ferrule actuated to hold it in that position whenever it is desired to work upon the machine or otherwise prevent operation of any of the parts thereof, since the stop button **123** controls energization of the entire control circuit.

SUMMARY

Variations may be made in the types of switches and relays employed and certain of the features described may be omitted. In all cases, however, that is, whether the cutting or hobbing be "conventional" or "climb" and with feed "up" or "down," also whether with or without clean-up, the axial shift of the hob arbor to its predetermined extreme advanced position effects actuation of the switch **109**, thus lighting the lamp L by closing the contacts **109***b*, and prevents a new cycle of hobbing from being started by opening the contacts **109***a*, it being noted, however, that a hobbing operation in progress when the switch **109** is actuated is allowed to be completed.

It should therefore now be apparent that the invention provides a novel and improved hobbing machine employing axial shift of the hob arbor at a relatively slow rate and so controlled that when the hob has been shifted a predetermined extent, operation of the machine is terminated at the end of a hobbing cycle and cannot be resumed until the hob arbor has been returned to its initial position. Moreover, the mechanism for thus controlling the machine in accordance with the hob shift is easily accessible and may be readily adjusted to vary the predetermined distance of shift that may occur before actuation of the switch **109**. Furthermore, the said mechanism is so located adjacent the end of the hob head that no increase is required in the size of the latter adjacent the hob carried by the head so that the head may be readily adjusted angularly without interference with the work head or the work supported therein.

While the preferred embodiment of the invention has been described in considerable detail, it is to be understood that this is by way of example only and that the invention is not limited to the particular details shown and described.

Having thus described the invention, we claim:

1. A hob head for an electrically controlled hobbing machine comprising a hob arbor driven by an electric motor, means journalling said hob arbor for rotary and axial movements, means adapted to be rotated and including gearing operatively connected to said arbor adjacent one end of the latter for producing rotation and axial movement of the arbor, the distance of the said axial movement for each hobbing operation performed by a hob on said arbor being a small fraction of the useful length of the hob, means connected with said hob arbor intermediate said gearing and the adjacent end of said arbor for movement with the latter, an electrical switch adapted to be connected in the control circuit for the hobbing machine to control the motor which operates said arbor, and means cooperating with said switch and the said means connected with the arbor to actuate the said switch when the arbor has moved axially a predetermined distance corresponding to the useful length of the hob on said arbor.

2. A hob head as defined in claim 1 and in which the means connected with said arbor includes means for securing the said means to the arbor at different axial positions therealong to thereby select the extent of axial movement of the arbor prior to the actuation of said switch.

3. A hob head as defined in claim 1 and in which the means cooperating with said switch and with the said means connected with the arbor includes means for operating said switch when the arbor has reached either extreme of its predetermined extent of axial movement.

4. A hob head as defined in claim 1 and in which the means cooperating with said switch and with the said means connected with the arbor comprises a pivoted lever and means normally urging said lever into engagement with said switch.

5. A hob head for an electrically controlled hobbing machine driven by an electric motor, the said head comprising a hob arbor, means journalling said hob arbor for rotary and axial movements, means adapted to be rotated and including gearing operatively connected to said arbor adjacent one end of the latter for producing rotation and axial movement of the arbor upon energization of the motor of the hobbing machine, the distance of the said axial movement for each hobbing operation performed by a hob on said arbor being a small fraction of the useful length of the hob, a first member connected with said hob arbor intermediate said gearing and the adjacent end of said arbor for movement with the latter, a second member supported adjacent said one end of said arbor for limited movement relative to said arbor, means adjacent either end of said second member adapted to be engaged by said first member and to thereby move the said second member, an electrical switch supported adjacent the said one end of the arbor and adapted to be connected in the control circuit for the hobbing machine to control the motor of the machine, and means cooperating with said second member and said switch for actuating the latter when the former is moved by the said first member whereby the said switch is actuated at either extreme of the extent of axial movement of said arbor corresponding to the useful length of the hob on the arbor.

6. A hob head as defined in claim 5 and wherein the connection of said first member to said arbor includes means for securing the said first member to the arbor at different axial positions therealong to thereby select the extent of axial movement of the arbor prior to actuation of said switch.

7. A hob head for an electrically controlled hobbing machine, the said head comprising a hob arbor, means journalling said hob arbor for rotary and axial movements, a housing enclosing one end of said arbor and providing a support for said journalling means, means adapted to be rotated and including gearing within said housing operatively connected to said arbor adjacent the enclosed end of the latter for producing rotation and axial movement of the arbor, a first member connected with said hob arbor within said housing intermediate said gearing and the enclosed end of said arbor for movement with the latter, a second member supported within said housing adjacent said enclosed end of said

arbor for limited axial movement with respect to said arbor, means adjacent either end of said second member adapted to be engaged by the said first member and to thereby axially move said second member, an electrical switch supported by said housing adjacent the said enclosed end of the arbor and adapted to be connected in the control circuit of the hobbing machine, means cooperating with the said second member and said switch for actuating the latter when the former is axially moved by the said first member whereby the said switch is actuated at either extreme of the extent of axial movement of said arbor and of the means connected therewith.

8. A hob head for an electrically controlled hobbing machine, the said head comprising a hob arbor, means journalling said hob arbor for rotary and axial movements, means adapted to be rotated and including gearing operatively connected to said arbor adjacent one end of the latter for producing rotation and axial movement of the arbor, a first member connected coaxially with said hob arbor intermediate said gearing and the adjacent end of said arbor for movement with the latter, a second member supported in radially spaced coaxial relationship with respect to said one end of said arbor for limited axial movement with respect to said arbor, means normally urging said second member in one direction of its axial movement, means adjacent either end of said second member adapted to be engaged by said first member and to thereby axially move the said second member in the direction opposite to that in which it is urged, an electrical switch supported adjacent the said one end of the arbor and adapted to be connected in the control circuit for the hobbing machine, and means cooperating with said second member and said switch for actuating the latter when the former is axially moved by the said first member, whereby the said switch is actuated at either extreme of the extent of axial movement of said arbor and of the means connected therewith.

9. A hob head as defined in claim 8 and wherein the connection of said first member to said arbor includes means for securing the said first member to the arbor at different axial positions therealong to thereby select the extent of axial movement of the arbor prior to actuation of said switch.

10. A hob head for a hobbing machine having electrical means including a motor and a control circuit for effecting operation of the machine, the said hob head comprising a housing, a hob arbor, means in said housing journalling said hob arbor for rotary and axial movements with respect to the housing, a shaft rotatably supported in said housing and adapted to be operatively connected for rotation by said motor, means including gearing within said housing adjacent one end of the latter and operatively connecting said shaft and arbor for producing rotation and axial movement of the latter when said shaft is rotated, means adjustably connected to said hob arbor intermediate said gearing and the adjacent end of said housing for movement with the arbor, an electrical switch supported on said housing adjacent the said one end of the arbor, the said switch being connected in the control circuit of the hobbing machine to control the energization of said motor, and means cooperating with said switch and the said means connected with the arbor to actuate the said switch when the arbor has moved axially a predetermined distance corresponding to the adjusted position of the said means connected to said arbor.

11. In a hobbing machine having a rotatable and axially movable hob arbor, the combination of means adjustably connected with said hob arbor adjcent one end of the latter to move therewith, an electrical switch mounted adjacent the said one end of the hob arbor, means cooperating with the said means on the hob arbor and with the said switch to actuate the latter when the hob arbor has moved axially a predetermined distance as determined by the adjusted position of said first-mentioned means, and an electrical circuit controlled by the actuation of said switch, the said circuit including relay means establishing circuit relationships in response to actuation of said switch for preventing the beginning of a new hobbing operation while permitting a hobbing operation in progress at the time of the switch actuation to continue to completion.

12. A hobbing machine as defined in claim 11 and further comprising an indicating means in said circuit and controlled by actuation of said switch for indicating a predetermined distance of axial movement of said hob arbor.

13. In an electrically controlled hobbing machine having a rotatable and axially movable hob arbor, the improvement which comprises, a member disposed coaxially of said hob arbor adjacent one end of the latter, means to connect said member to said arbor at different axial distances therealong adjacent said one end of the arbor, an electrical switch mounted adjacent the said one end of the hob arbor and connected in the control circuit for the machine, means cooperating with said switch and adapted to be engaged by the said member to operate the switch when the hob arbor has moved axially a preselected distance corresponding to the adjusted position of the member, and an electrical circuit controlled by the actuation of said switch, the said circuit including relay means establishing circuit relationships in response to actuation of said switch for preventing the beginning of a new hobbing operation while permitting a hobbing operation in progress at the time of the switch actuation to continue to completion.

14. A hobbing machine comprising a hob arbor, a work support, means including an electric motor for rotating said arbor and support and to produce relative movement between said arbor and support axially of the axis of said work support, means including gearing connected with said hob arbor adjacent one end of the latter to axially shift the arbor in response to rotation thereof, an electrical circuit for controlling the energization of said motor, manually operable switch means in said circuit for initiating a hobbing operation, means in said circuit for automatically deenergizing said motor when a hobbing operation has been completed, switch means in said circuit adapted when actuated to prevent energization of said motor, means including a member adjustably connected with said hob arbor intermediate said gearing and the adjacent end of said arbor for actuating the last-mentioned switch means when said hob arbor has moved axially a predetermined distance, and means in said circuit for maintaining said motor energized after a hobbing operation has been started and until that hobbing operation is completed regardless of the actuation of said last-mentioned switch means during the hobbing operation, the last-mentioned means being ineffective to permit energization of said motor when

said manually operable switch means is actuated to initate another hobbing operation after the said last-mentioned switch means has been actuated.

15. A hobbing machine as defined in claim 14 and further comprising an indicating means in said control circuit and controlled by actuation of said last-mentioned switch means for indicating a predetermined distance of axial movement of said hob arbor.

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