May 11, 1937. E. L. ACKLEY 2,079,785

HOB GRINDING MACHINE

Filed July 13, 1934 10 Sheets-Sheet 1

Fig. 1.

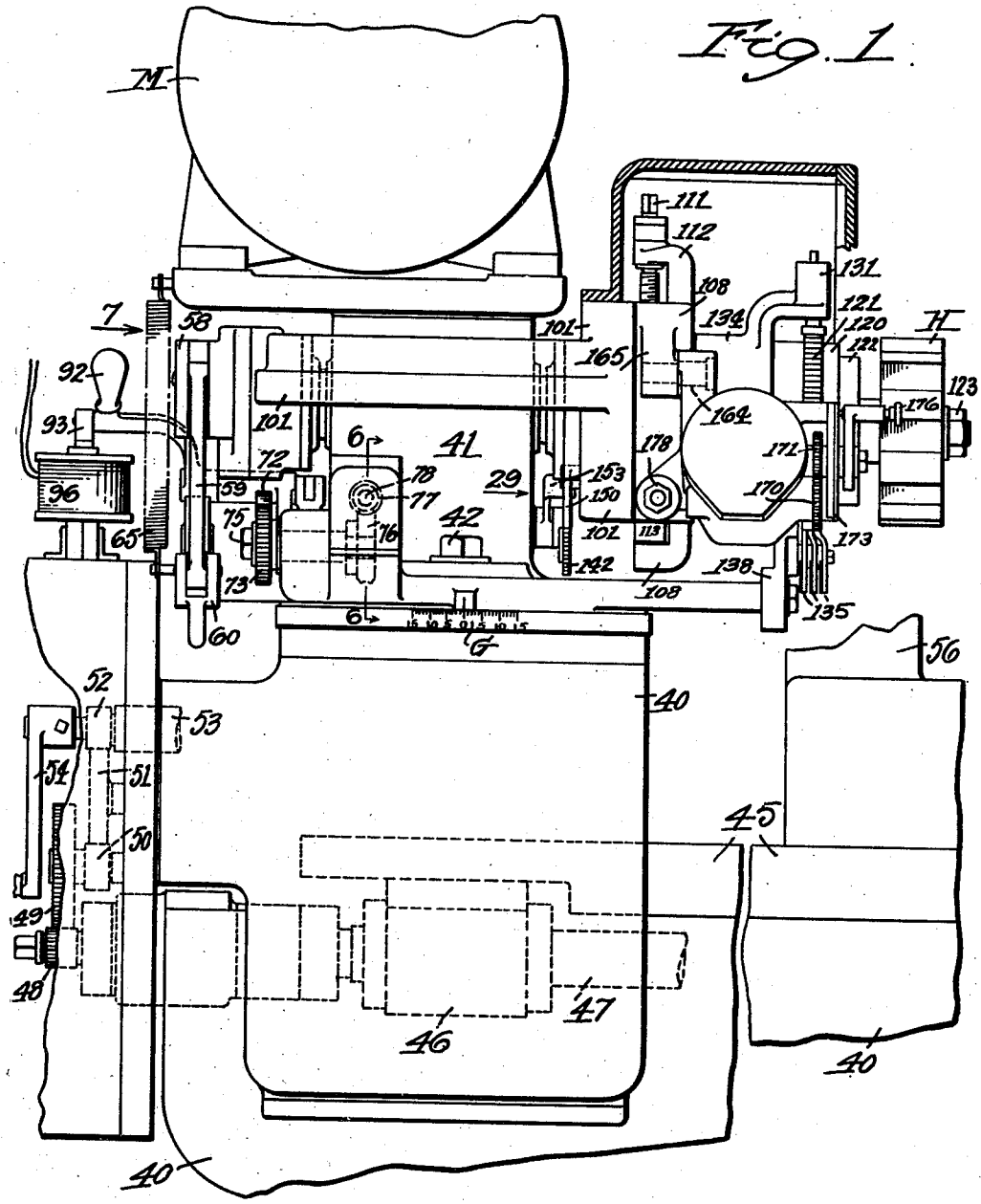
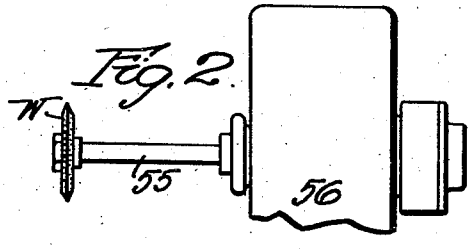


Fig. 2.



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HOB GRINDING MACHINE

Filed July 13, 1934 10 Sheets-Sheet 2

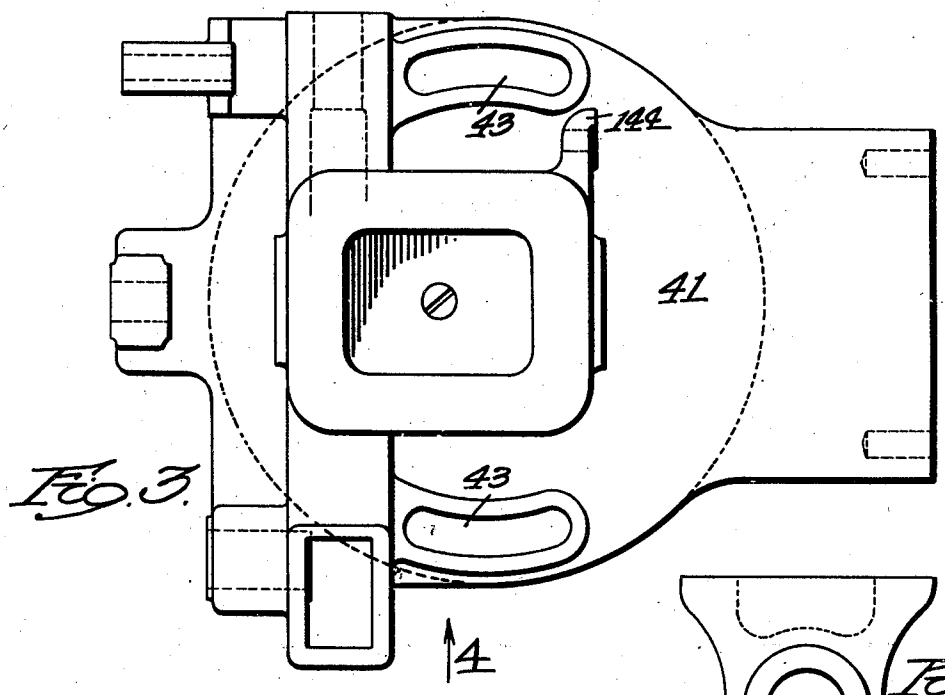


Fig. 3.

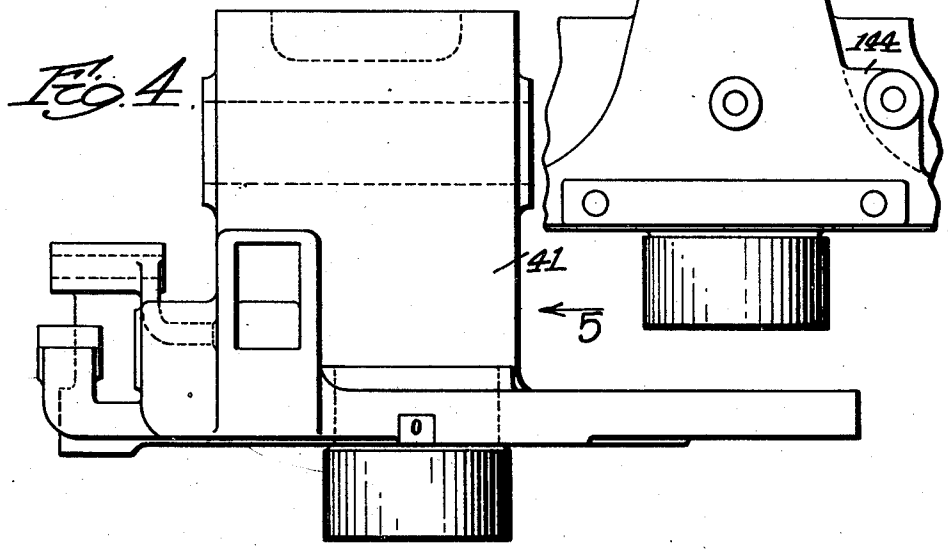


Fig. 4.

Fig. 5.

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May 11, 1937. E. L. ACKLEY 2,079,785

HOB GRINDING MACHINE

Filed July 13, 1934 10 Sheets-Sheet 3

Fig. 6.

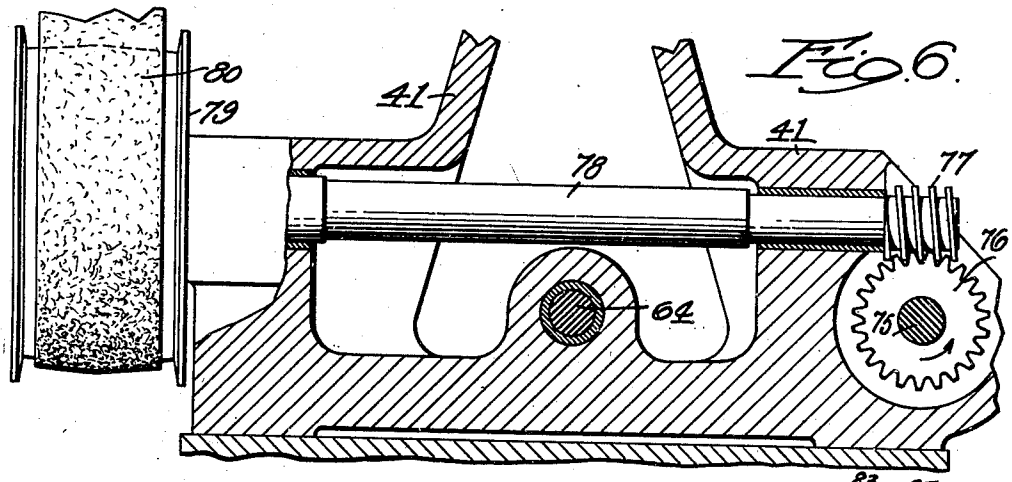


Fig. 9.

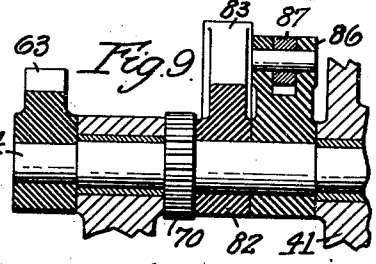
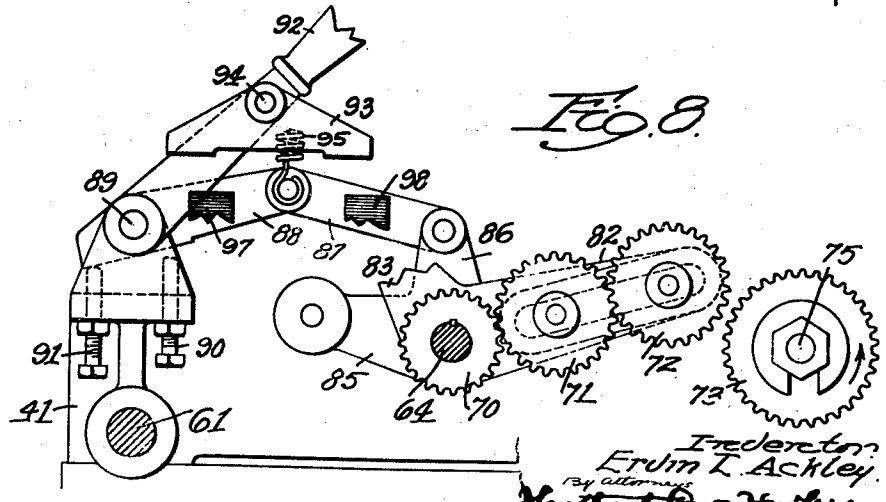


Fig. 7.

Fig. 8.



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May 11, 1937. E. L. ACKLEY 2,079,785

HOB GRINDING MACHINE

Filed July 13, 1934 10 Sheets-Sheet 4

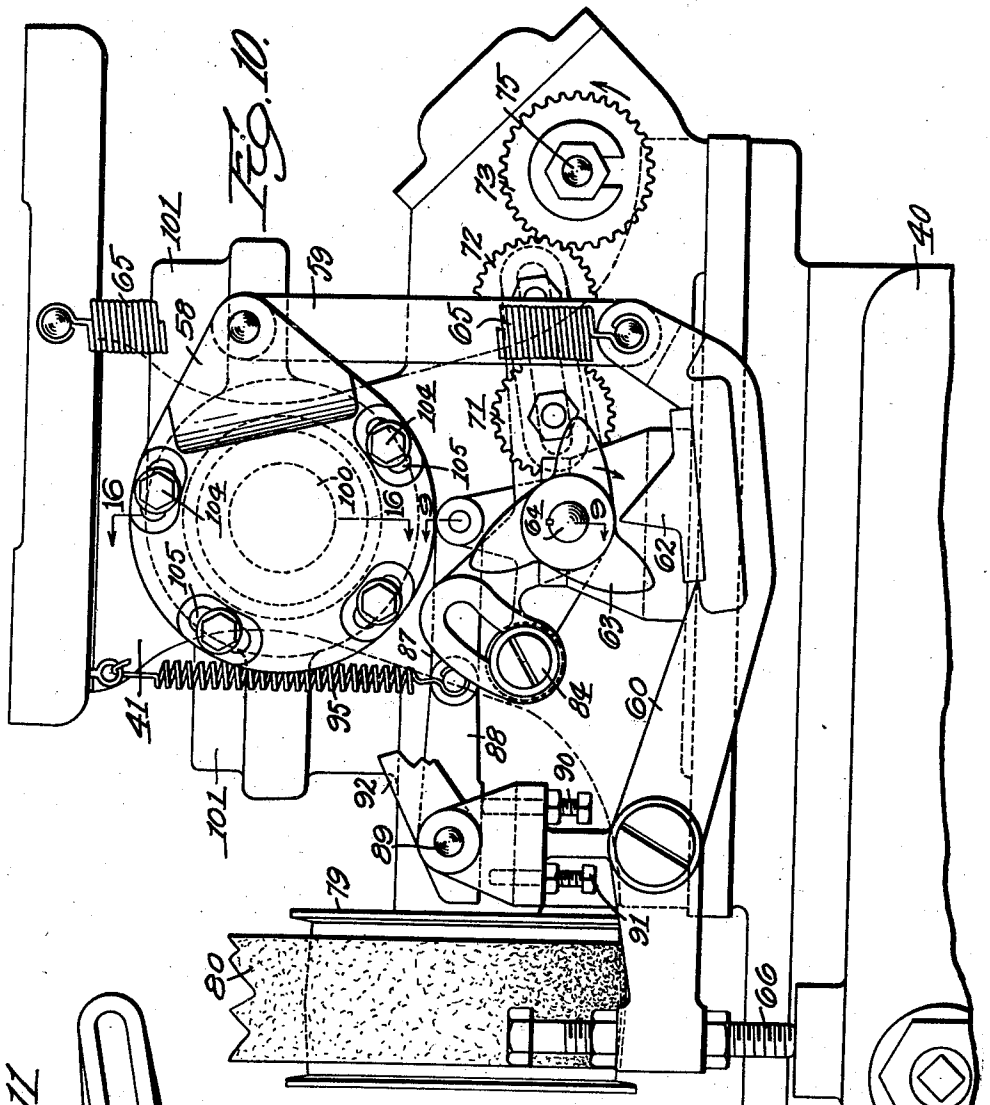


Fig. 10.

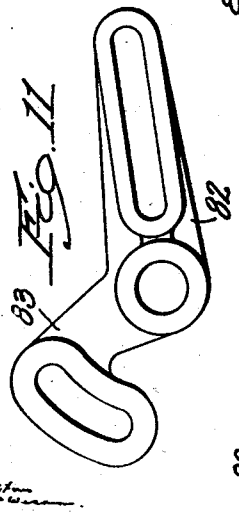


Fig. 11.

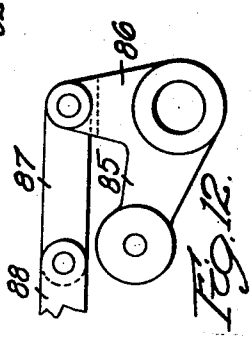


Fig. 12.



Fig. 13.

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May 11, 1937. E. L. ACKLEY 2,079,785

HOB GRINDING MACHINE

Filed July 13, 1934 10 Sheets-Sheet 5

Fig. 13.

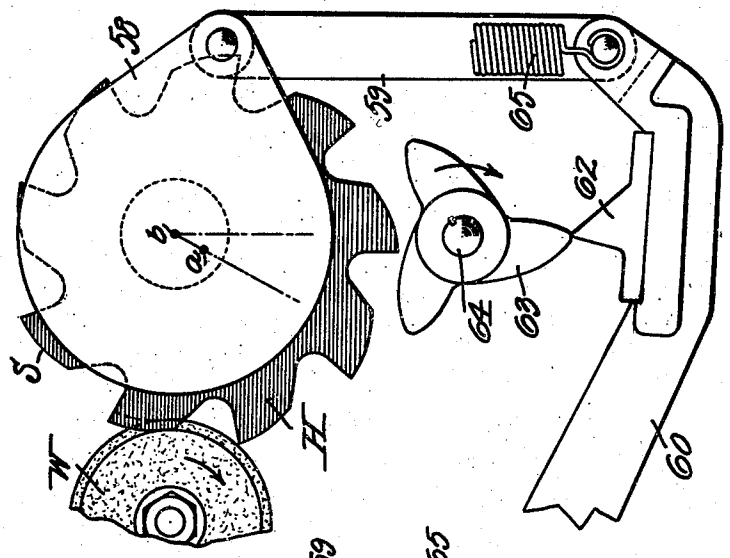
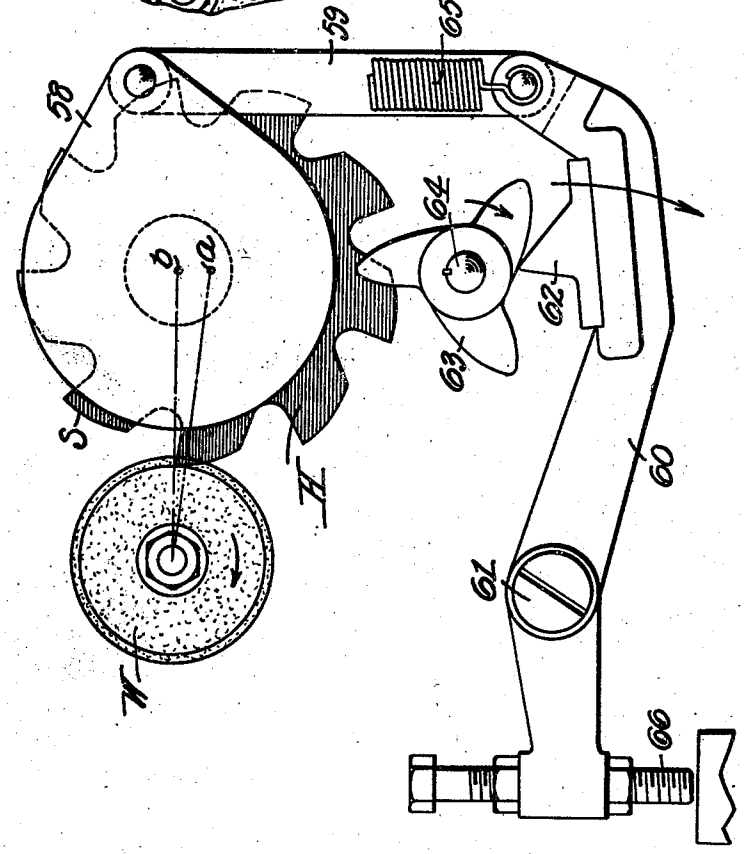


Fig. 14.



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May 11, 1937. E. L. ACKLEY 2,079,785

HOB GRINDING MACHINE

Filed July 13, 1934 10 Sheets-Sheet 6

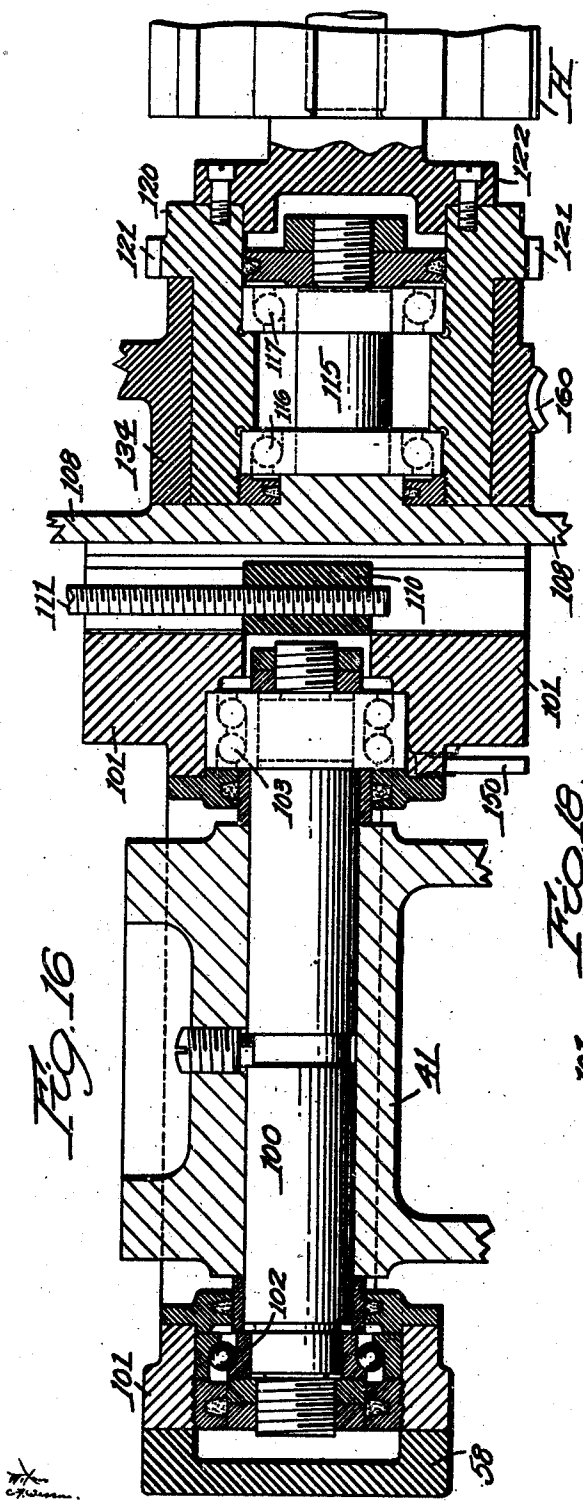


Fig. 16

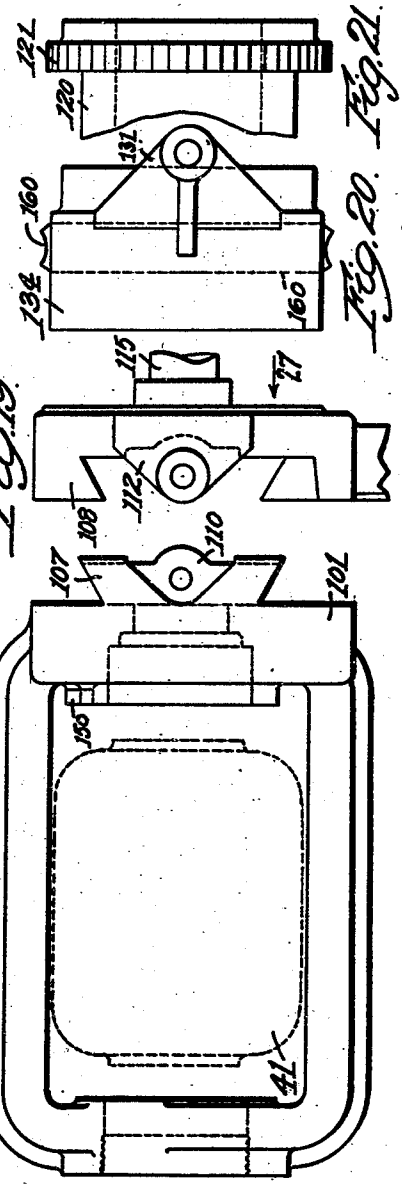


Fig. 21. Fig. 20. Fig. 19. Fig. 18.

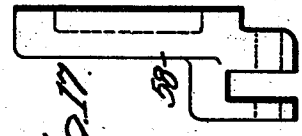


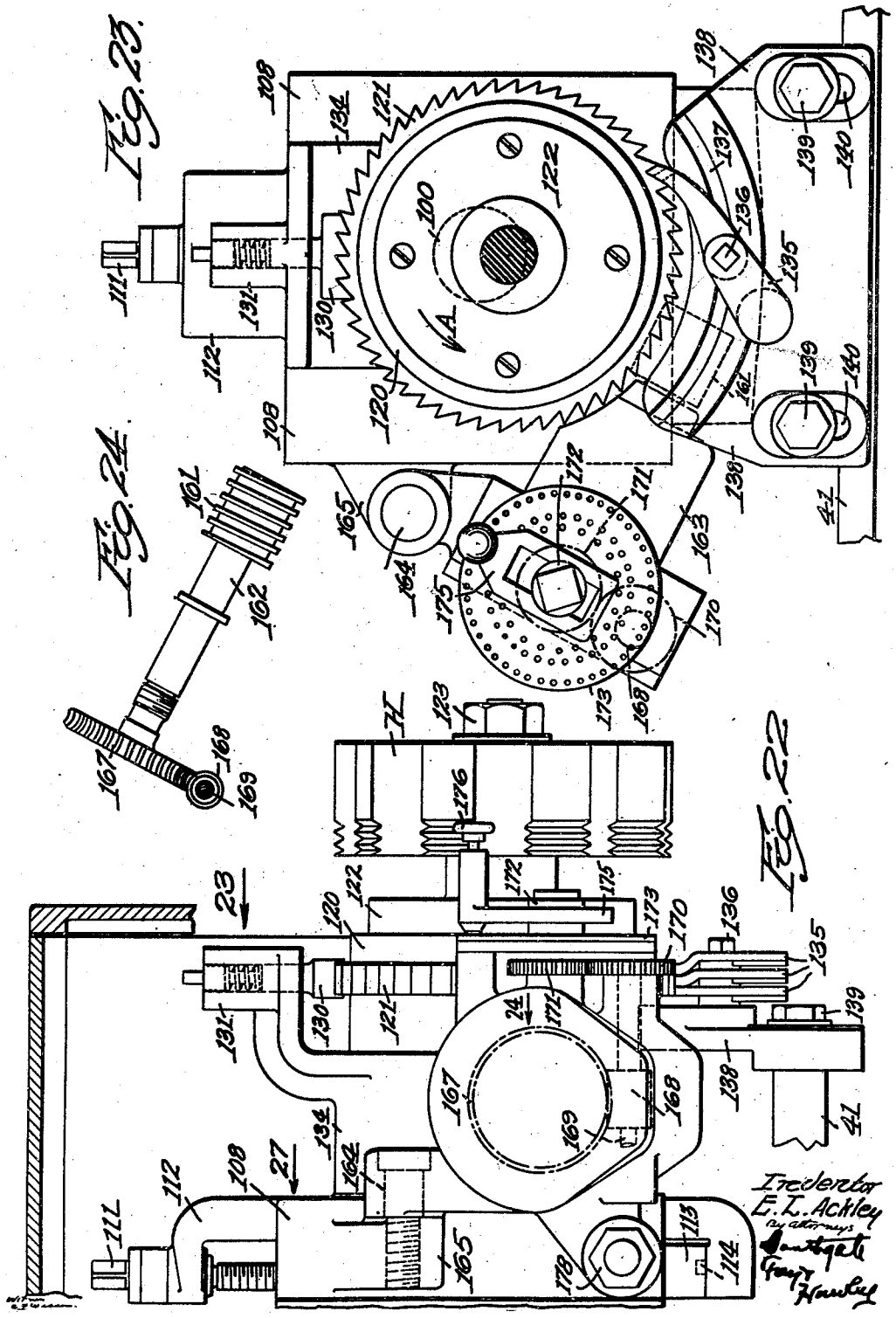
Fig. 17

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May 11, 1937. E. L. ACKLEY 2,079,785

HOB GRINDING MACHINE

Filed July 13, 1934 10 Sheets-Sheet 7



May 11, 1937. E. L. ACKLEY 2,079,785

HOB GRINDING MACHINE

Filed July 13, 1934 10 Sheets-Sheet 8

Fig. 27.

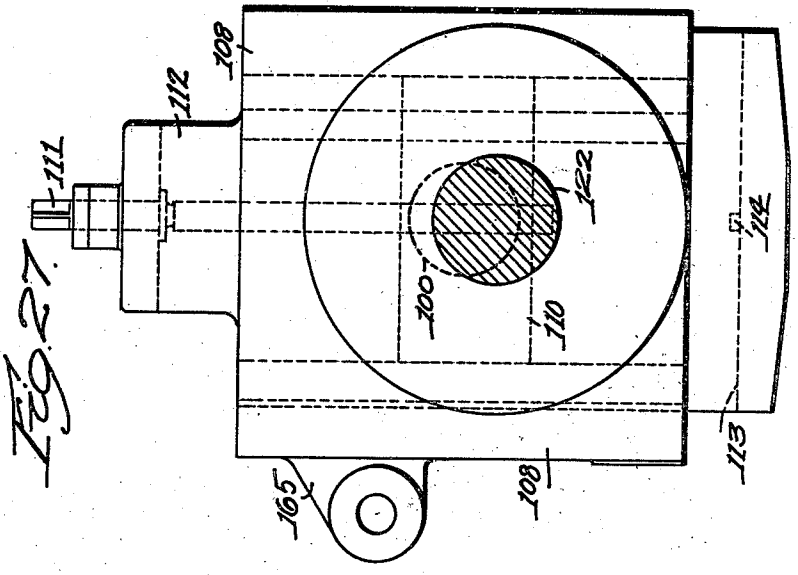


Fig. 25.

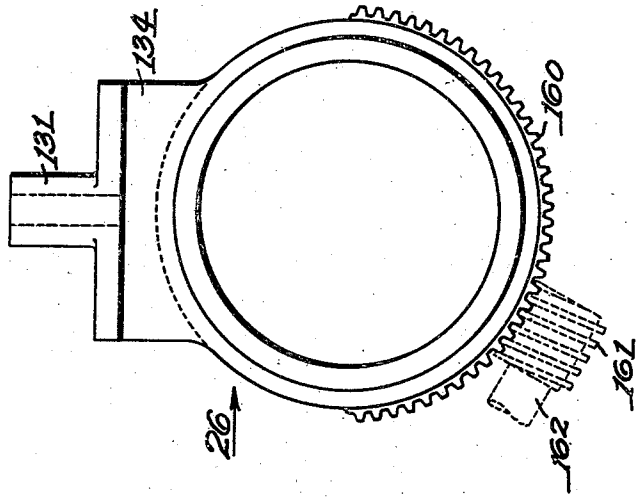
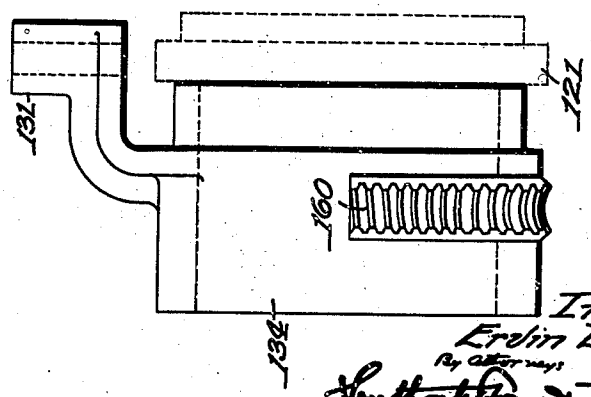


Fig. 26.



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May 11, 1937. E. L. ACKLEY 2,079,785

HOB GRINDING MACHINE

Filed July 13, 1934 10 Sheets-Sheet 9

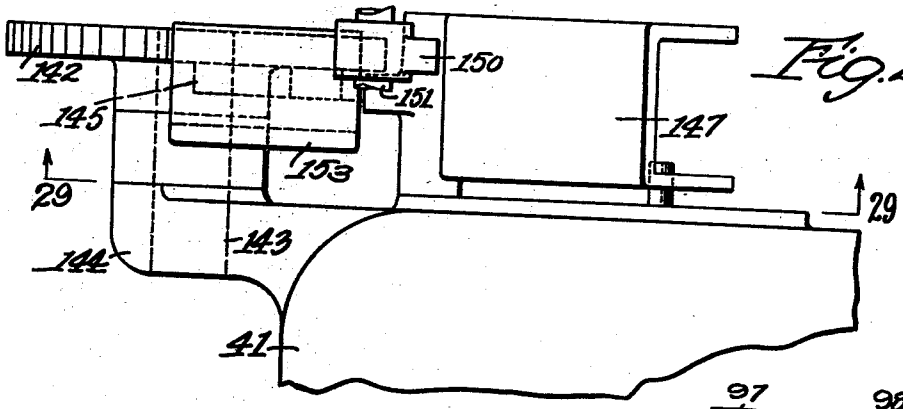


Fig. 28.

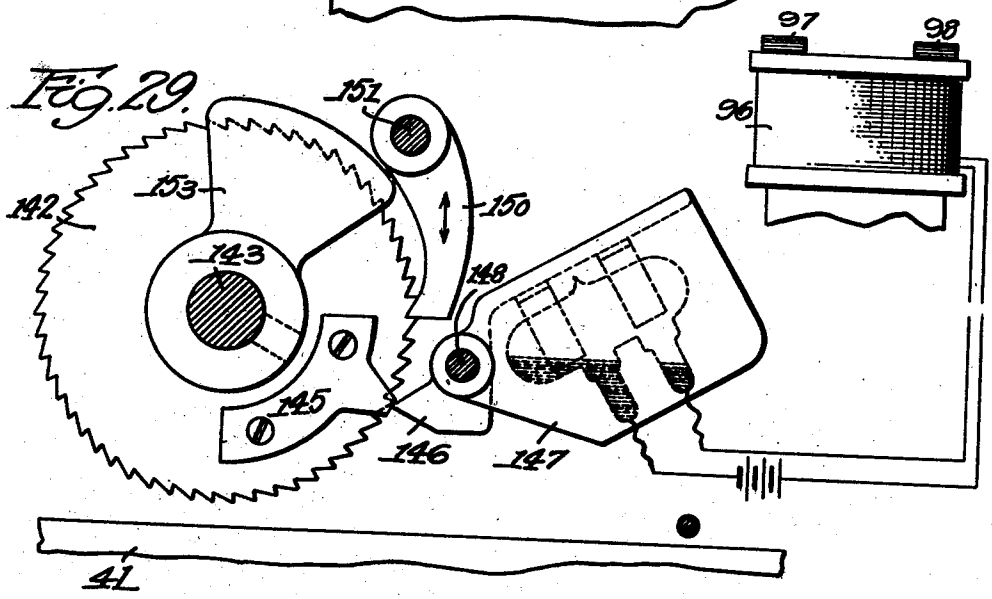


Fig. 29.

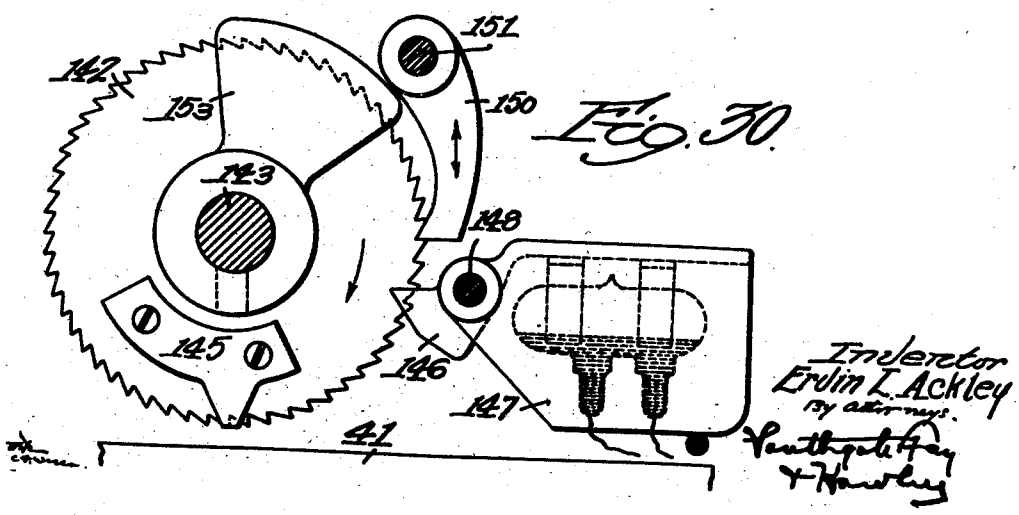


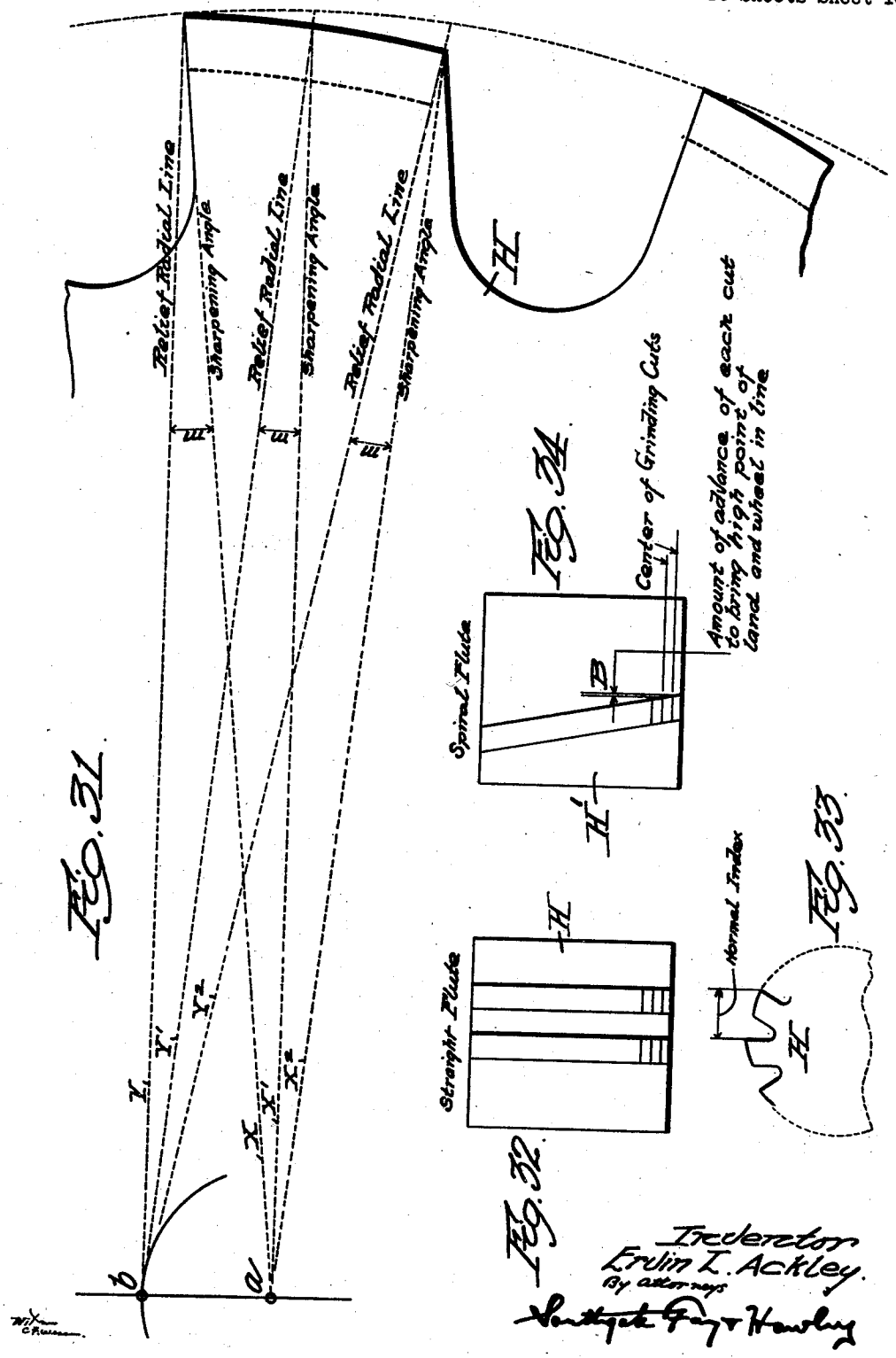
Fig. 30.

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HOB GRINDING MACHINE

Filed July 13, 1934 10 Sheets-Sheet 10



Patented May 11, 1937 2,079,785

UNITED STATES PATENT OFFICE

2,079,785

HOB GRINDING MACHINE

Ervin L. Ackley, Worcester, Mass., assignor to John Bath & Company, Worcester, Mass., a corporation of Massachusetts

Application July 13, 1934, Serial No. 735,019

12 Claims. (Cl. 51—37)

This invention relates to a machine for grinding hobs in such manner that an accurate tooth section will be preserved during the entire useful life of the hob.

To the accomplishment of this object, I have provided means by which the teeth of a hob may be ground about an offset or eccentric axis so selected that the hob when repeatedly re-sharpened at a given sharpening angle will maintain a substantially unchanged tooth section at the cutting point.

My invention further relates to arrangements and combinations of parts which will be hereinafter described and more particularly pointed out in the appended claims.

A preferred form of the invention is shown in the drawings, in which

Fig. 1 is a partial front elevation of a hob grinding machine embodying my invention;

Fig. 2 is a detail plan view of the grinding wheel support;

Fig. 3 is a plan view of the headstock for the work spindle;

Fig. 4 is a side elevation thereof, looking in the direction of the arrow 4 in Fig. 3;

Fig. 5 is a partial end view thereof, looking in the direction of the arrow 5 in Fig. 4;

Fig. 6 is an enlarged transverse sectional elevation, taken along the line 6—6 in Fig. 1;

Fig. 7 is an end view of certain parts, looking in the direction of the arrow 7 in Fig. 1;

Fig. 8 is a view similar to Fig. 7 but showing the parts in a different relation;

Fig. 9 is a detail sectional view, taken along the line 9—9 in Figs. 7 and 10;

Fig. 10 is a partial left-hand end elevation of the machine;

Figs. 11, 12 and 13 are detail side views of certain parts to be described;

Fig. 14 is a diagrammatic view illustrating the method of operation of my improved hob grinding machine;

Fig. 15 is a view similar to Fig. 14 but showing the parts in a different relation;

Fig. 16 is a sectional front elevation of the headstock and parts associated therewith;

Figs. 17 to 21 are separate plan views of parts appearing in section in Fig. 16;

Fig. 22 is an enlarged front elevation of certain indexing mechanism;

Fig. 23 is an end view thereof, looking in the direction of the arrow 23 in Fig. 22;

Fig. 24 is a detail side elevation of certain parts, looking in the direction of the arrow 24 in Fig. 22;

Fig. 25 is an end view of an adjusting ring or sleeve;

Fig. 26 is a side elevation thereof;

Fig. 27 is a front elevation of a relieving slide, looking in the direction of the arrow 27 in Fig. 19;

Fig. 28 is a plan view of certain knock-off mechanism;

Fig. 29 is a sectional elevation, taken along the line 29—29 in Fig. 28;

Fig. 30 is a view similar to Fig. 29 but showing the parts in a different position;

Fig. 31 is a diagrammatic view showing the maintenance of a substantially uniform cutting angle by the use of this invention;

Fig. 32 is a plan view of a hob having straight flutes;

Fig. 33 is an end view thereof, and

Fig. 34 is a plan view of a hob having spiral flutes.

General structure

Referring to Fig. 1 my improved grinding machine comprises a frame 40 on which a headstock 41 (Fig. 3) is secured by bolts 42 extending through segmental slots 43. Graduations G (Fig. 1) may be provided on the frame 40 to cooperate with an index line at the lower edge of the headstock 41. By the use of the graduations and index, the headstock may be set at any desired angle for grinding tapered work.

A wheel carriage 45 (Fig. 1) is slidable in guideways longitudinally of the base 40 and may be provided with a nut 46 through which extends a lead screw 47 mounted in suitable fixed bearings and held from axial movement therein.

The lead screw 47 is connected to a pinion 48, gear 49, pinion 50, gear 51 and pinion 52 to a shaft 53 having a handle 54 secured thereon. By turning the handle a predetermined amount after each revolution of the hob is completed, the grinding wheel carriage may be adjusted axially of the hob a distance equivalent to a tooth space.

The grinding wheel W (Fig. 2) is mounted on a wheel spindle 55 rotatable in a wheel support 56 mounted on the wheel carriage 45 (Fig. 1). The grinding wheel W may be driven by a motor in the support 56 or in any other suitable or convenient manner.

Operation

The general theory of operation of my improved machine will be best understood by reference to Figs. 14 and 15. A hob H is mounted to rotate about an axis a, and the axis a is sup-

ported for oscillation about an eccentric axis *b*, both movements taking place simultaneously during the grinding of each tooth groove in each hob land.

In Fig. 14 the parts are shown substantially at the beginning of a grinding operation on a groove in one of the lands, and the axis *a* is at its farthest operative distance from the axis of the wheel W. An eccentric plate 58 (Fig. 14) is connected by a link 59 to a cam lever 60 mounted on a fixed pivot 61 and having a cam follower 62 engaging a three-point cam 63 mounted on a cam shaft 64. A spring 65 holds the cam follower 62 against the cam 63, and an adjustable stop screw 66 limits upward or return movement of the eccentric plate 58.

As the cam 63 advances from the position shown in Fig. 14 to that shown in Fig. 15, the link 59 is pulled downward and the eccentric plate 58 is turned to the position shown in Fig. 15. This shifts the axis *a* about the eccentric axis *b* and causes the hob H to advance past the grinding wheel W to the position shown in Fig. 15, while at the same time the axis *a* of the hob is shifted toward the grinding wheel W to the position indicated in Fig. 15.

This combined action causes the grinding wheel to grind a tooth groove along the backwardly relieved surface S of a hob land, this land surface and the tooth groove being both concentric with the axis *b* of the plate 58 rather than with the axis *a* of the hob.

After the parts reach the position shown in Fig. 15, further rotation of the cam 63 allows the spring 65 to return the parts to the position shown in Fig. 14, except that return angular movement of the hob is prevented by mechanism to be described so that the hob is relatively advanced during said return movement into position for grinding the next succeeding land.

The exceptional results attained by this eccentric grinding operation will be more fully explained after the mechanism for effecting this result has been described in detail.

Cam driving mechanism

The cam shaft 64 (Fig. 10) is provided with a gear 70 (Fig. 8) which is connected through change gears 71 and 72 to a gear 73 mounted on a shaft 75 (Fig. 1) rotatable in a bearing in the headstock 41 and having a worm wheel 76 (Fig. 6) engaged by a worm 77 on a worm shaft 78 also rotatable in bearings in the headstock 41 and having a pulley 79 at its rear end connected by a belt 80 to a motor M (Fig. 1) mounted on the headstock 41. The gear 73 on the shaft 75 is thus continuously rotated during the operation of the machine.

The change gears 71 and 72 are mounted on a slotted arm 82 (Figs. 8 and 11) mounted to swing about the axis of the cam shaft 64. The arm 82 has a second and slotted arm 83 associated therewith which is adapted to be adjustably secured by a bolt 84 (Fig. 10) to the arm 85 (Fig. 12) of a toggle lever 86 (Fig. 8), also mounted to swing about the axis of the cam shaft 64.

The arm 86 is connected by toggle links 87 and 88 to a fixed pivot 89. Stop screws 90 and 91 define limits of movement of the toggle link 88 in both directions. A handle 92 (Fig. 8) is connected to swing with the toggle link 88, and a magnet armature 93 is pivoted at 94 on the handle 92. A spring 95 tends constantly to break the toggle.

A magnet 96 (Figs. 1 and 29) having pole faces 97 and 98 (Fig. 8) is positioned to be engaged by the armature 93 when the parts are moved to the position shown in Fig. 7, in which position the change gear 72 engages the driving gear 73. The cam 63 is thus continuously rotated.

The parts will be retained in this position so long as the magnet 96 is energized, but they will move to the inoperative position shown in Fig. 8 as soon as the magnet circuit is broken.

The control circuit for the magnet 96 will be hereinafter described.

Hob oscillating mechanism

I will now describe the mechanism for supporting the hob and causing it to oscillate about an offset or eccentric axis.

A shaft 100 (Fig. 16) is fixed in the headstock 41 and a yoke or open frame member 101 (Fig. 18) is mounted to oscillate about the axis of the shaft 100, preferably on anti-friction bearings 102 and 103. The eccentric plate 58 previously described is adjustably secured to the end of the yoke 101 by bolts 104 (Fig. 10) extending through slots 105 in the plate 58. It is obvious that as the cam 63 (Fig. 10) rotates, the plate 58 and yoke 101 will be oscillated about the axis of the shaft 100 by the action of the cam transmitted through the cam lever 60 and link 59.

The right-hand end of the yoke or frame 101 (Fig. 18) is provided with dove-tailed guideways 107 to receive a cross slide 108 (Fig. 19). A nut 110 (Figs. 16 and 18) is secured in a recess in the end of the yoke 101 and cooperates with an adjusting screw 111 (Fig. 1) mounted in a bracket 112 (Fig. 22) extending from one end of the cross slide 108. The adjusting screw 111 is held from axial movement in the bracket 112, and rotation of the screw 111 consequently causes a corresponding movement of the cross slide 108 along the guideways 107.

A removable gauge block 113 (Fig. 22) may be used for setting the cross slide. Preferably a plurality of such blocks of varying thickness will be provided. A pin 114 prevents displacement of the block while the machine is running.

A stud 115 (Figs. 16 and 19) projects outward from one face of the cross slide 108 and is provided with anti-friction bearings 116 and 117 for an index ring 120 (Figs. 16 and 21). The index ring is provided with ratchet teeth 121 (Fig. 23) and at its outer end supports an arbor 122 (Fig. 16) concentric with the ring.

The hob H (Figs 1 and 16) is mounted on the arbor 122 and is held from angular movement thereon by a clamping nut 123. The offset or eccentricity of the axis of the arbor 122 relative to the axis of the fixed shaft 100 may be adjusted by turning the adjusting screw 111, by which adjustment any desired offset relative to the axis of the shaft 100 may be obtained.

Feeding mechanism

The mechanism for feeding the hob forward during the grinding operation and from one land to the next is best shown in Figs. 23 to 27. A spring-pressed toothed plunger 130 (Fig. 23) is slidably mounted in a bracket 131 (Fig. 22) carried by an adjusting ring 134, which in turn is rotatably mounted on the index ring 120 (Fig. 16).

A plurality of weighted holding pawls 135 (Figs. 22 and 23) are mounted on a pivot stud 136 which may be adjusted to any desired position in a segmental slot 137 in a stand 138 secured to a portion of the headstock 41 by bolts 139 extending through slots 140 in the plate.

Connections to be described maintain the adjusting ring 134 in a normally fixed angular relation to the cross slide 108, except as said angular relation is changed at times by manual adjustment of the ring. For the present, it will be assumed that the adjusting ring 134 oscillates with the cross slide 108 as the eccentric plate 58 is oscillated by the cam 63, and that the ring and slide maintain a relatively fixed angular relation.

As the cross slide 108 swings in the direction of the arrow A in Fig. 23, the index ring 120 and hob H swing with the cross slide 108 and adjusting ring 134. On the return movement of the cross slide and adjusting ring, the holding pawls 135 prevent return movement of the index ring and hob, so that the plunger 130 is moved backward relative to the ratchet teeth 121 a distance corresponding to the angular spacing of the lands on the hob H.

At each forward swinging movement of the yoke 101, cross slide 108 and adjusting ring 134, the hob H is advanced past the grinding wheel W from the position shown in Fig. 14 to the position shown in Fig. 15, and the return movement brings the next succeeding land to the position shown in Fig. 14. Obviously the extent of oscillation will be adjusted to correspond with the angular spacing of the lands on the hob.

Stopping device

I have provided special devices for controlling the circuit of the magnet 96 and these devices are best shown in Figs. 28 to 30. A ratchet plate 142 is mounted on a stud 143 fixed in a projection 144 (Figs. 3 and 5) at the back of the headstock 41. A cam plate 145 (Fig. 29) is secured to one side of the ratchet wheel 142 and engages a cam follower 146 movable with a switch member 147 and mounted to swing on a fixed pivot 148.

The switch member 147 may comprise a usual mercury switch or circuit closer, connected in the control circuit of the magnet 96 (Fig. 29). A pawl 150 hangs loosely from a stud 151 on the yoke 101 (Fig. 16) and is caused by gravity to operatively engage the teeth of the ratchet wheel 142 as the pawl is swung downward with the yoke. The upward return movement of the pawl is idle.

A shield 153 is adjustably secured to the stud 143 on which the ratchet wheel 142 is mounted and may be set in any desired fixed angular position, thus controlling the number of teeth taken by the pawl 150 at each feeding movement.

The parts are shown in Fig. 29 in inoperative or idle position, with the circuit of the magnet 96 broken, and with the toggle levers 87 and 88 in the position shown in Fig. 8, in which position, as previously explained, the drive for the cam 63 is interrupted.

When it is desired to start the machine, the handle 92 (Fig. 7) is pressed downward to bring the armature 93 against the pole pieces 97 and 98. The handle 92 is held in this position until the yoke 101 has been once oscillated, thus advancing the ratchet wheel 142 (Fig. 29) to cause the cam follower 146 to drop off of the projection on the cam plate 145 and to move to the circuit-closing position shown in Fig. 30.

The machine will then continue in operation until the ratchet wheel 142 has made one complete revolution, bringing the cam plate 145 again to the position indicated in Fig. 29, in which position the switch 147 is opened and the magnet circuit is broken, thus stopping the rotation of the cam 63.

The shield 153 will be so adjusted that one revolution of the ratchet wheel 142 will correspond to one revolution of the index ring 120 and hob H. At the completion of each revolution, the rotary feed stops and the grinding wheel carriage is manually advanced axially of the hob to the next tooth groove by means of the handle 54 (Fig. 1) and connecting gearing.

If the hob has straight flutes, as indicated in Fig. 32, the machine is then ready to be restarted and to proceed with the grinding of the next circumferential series of thread grooves.

Angular adjusting mechanism

If a hob with spiral flutes is to be ground, as shown at H' in Fig. 34, the hob H' must be advanced angularly a slight predetermined amount after each circumferential series of thread grooves is ground and before the grinding of the next series is begun. The reason for this slight angular advance is clearly apparent in Fig. 34.

For the purpose of accomplishing this slight angular advance, I provide the special adjusting mechanism best shown in Figs. 22 to 27. The adjusting ring 134 (Figs. 25 and 26) is provided with worm gear teeth 160 in its lower portion, which are engaged by a worm 161 on a worm shaft 162. The worm shaft 162 is mounted in a head 163 (Fig. 23) secured by a pivot bolt 164 to a lug 165 (Fig. 27) at the side of the cross slide 108.

The worm shaft 162 has a worm gear 167 (Fig. 24) at its upper end, which worm gear is engaged by a worm 168 on a worm shaft 169 (Fig. 22) mounted in bearings in the head 163 and having a gear 170 at its outer end.

The gear 170 meshes with a gear 171, preferably of equal size and mounted to rotate about a fixed axis on the stand 163. The gear 171 has a hub portion 172 (Fig. 22) extending through an axial opening in an index disc 173 fixed to the stand 163. A slotted plate 175 is radially adjustable at the end of the hub 172 and is provided with a spring plunger 176 which may be caused to enter any desired perforation in the index disc 173.

Circles of perforations of different angular spacing are provided on the disc 173, and the plate 175 may be adjusted to bring the plunger 176 into radial alignment with any selected circle of perforations.

When grinding a hob with spiral flutes, such as is shown in Fig. 34, the necessary angular advance after grinding each circumferential series of thread grooves will be determined on the index disc 173. After each series is completed, the plunger 176 will be advanced the requisite number of holes to give the hob H an angular advance movement corresponding to the distance B (Fig. 34).

An adjusting nut 178 (Fig. 22) is provided for adjusting the worm 161 to closely meshing relation with the worm gear teeth 160 (Fig. 25) on the lower part of the adjusting ring 134.

General operation

Having described the details of construction of the different parts of my improved machine, I will now briefly indicate the general operation.

Assuming that the grinding wheel W has been adjusted to the desired hob diameter and is in the position shown in Fig. 14, the machine is started by depressing the handle 92 as previously described, and the cam 63 will then move the cam lever 60 from the position shown in Fig. 14 to that shown in Fig. 15. This swings the eccentric plate 58 and produces both an angular advance feed

of the hob H about its own axis and also a simultaneous movement of said axis from the position shown at *a* in Fig. 14 to that shown at *a* in Fig. 15.

The grinding wheel W is thus caused to grind a thread groove in the face of the land, which face is concentric with the axis *b* (Figs. 14 and 15) corresponding to the center of the fixed shaft 100 (Fig. 16).

After reaching the point shown in Fig. 15, the eccentric plate 58 is oscillated in the opposite or return direction, swinging the hob away from the grinding wheel and at the same time advancing the next land to grinding position.

These operations are repeated until thread grooves are ground in a radial plane in all of the lands of the hob, whereupon the magnet circuit is broken by the switch mechanism shown in Figs. 28 to 30 and the machine is brought to rest.

By thus grinding a hob with the teeth moving about an eccentric axis, I am able to produce a hob which may be repeatedly ground at a constant sharpening angle without perceptibly changing the tooth section. This characteristic is made plain in the enlarged diagrammatic view (Fig. 31) in which the lines X, X′ and X^2 indicate cutting faces produced by sharpening in successive planes each passing through the axis *a* of the hob.

The lines Y, Y′ and Y^2 indicate corresponding lines drawn through the point *b* about which the tooth grooves of the land were ground as indicated in Figs. 14 and 15. The angle *m* between the pairs of lines X—Y, X′—Y′, and X^2—Y^2 will be seen to be substantially constant throughout the entire cutting width of the land.

I thus produce a hob which may be repeatedly reground without perceptible change in tooth section and which may accordingly be thus reground until the entire working surface of the hob has been fully utilized. The hobs may have either straight or spiral lands and the machine may be adapted to the production of tapered hobs by angular adjustment of the headstock.

If repeated grinding cuts in the same thread groove are desired, the holding pawls 135 may be disabled, thus preventing forward feed at the end of the cut.

The machine may also be used with a wide-face wheel for surface grinding of the lands.

Having thus described my invention and the advantages thereof, I do not wish to be limited to the details herein disclosed, otherwise than as set forth in the claims, but what I claim is:—

1. A hob grinding machine comprising a grinding wheel, a supporting member for a hob, a ratchet wheel on said supporting member, means to relatively adjust said wheel and hob axially, said supporting member being mounted to swing about a fixed axis eccentric to the axis of said hob but parallel thereto, means to oscillate said supporting member about said fixed axis, and relatively fixed pawl means engaged by said ratchet wheel on the return swing of said supporting member and ratchet wheel and thereby effective to angularly advance said hob relative to its supporting member.

2. A hob grinding machine comprising a grinding wheel, a supporting member for a hob, means to relatively adjust said wheel and hob axially, said supporting member being mounted to swing about a fixed axis eccentric to the axis of said hob but parallel thereto, means to oscillate said supporting member and hob about said fixed axis and relative to said wheel, said wheel operating on said hob during the oscillating advance movement in one direction only, means to maintain a fixed angular relation between said hob and supporting member during each oscillating advance movement in said direction, and means to shift said hob angularly relative to said supporting member during each return swing of said supporting member and hob and while said grinding wheel is out of engagement with said hob.

3. A hob grinding machine comprising a grinding wheel, a supporting member for a hob, means to relatively adjust said wheel and hob axially, means to oscillate said hob and supporting member about an axis eccentric to the axis of said hob but parallel thereto and within the periphery of the supporting member, means to hold said hob in fixed angular relation to said supporting member only during the advance swing thereof and during the grinding coaction of said wheel and hob, and a feeding device rendered operative by the return swing of said supporting member to angularly shift the hob relative to said member, said shifting movement taking place entirely during said return swing.

4. In a hob grinding machine, means to simultaneously grind and relieve a thread groove in a hob, means to advance said hob angularly relative to said grinding wheel, automatic means to stop the grinding operation at the completion of each single revolution of the hob and at the simultaneous completion of each circumferential series of thread grooves in said hob, and means to adjust said automatic stopping mechanism to correspond to the number of lands in said hob.

5. In a hob grinding machine, means to simultaneously grind and relieve a thread groove in a hob, means to advance said hob angularly relative to said grinding wheel, a continuously rotating driving shaft, a magnet to hold said hob-advancing means in operative relation to said driving shaft, and a stopping device effective to break said magnet circuit when a circumferential series of thread grooves is completed.

6. A hob grinding machine comprising a grinding wheel, a supporting member for a hob, means to relatively adjust said wheel and hob axially, said supporting member being mounted to swing about a fixed axis, a cross slide on said supporting member, means to rotatably support a hob on said cross slide, means to radially adjust said cross slide on said supporting member, means to oscillate said supporting member, and means to feed said hob a predetermined angular amount during each return movement of said supporting member.

7. The combination in a hob grinding machine as set forth in claim 6, in which additional manual means is provided for angularly advancing said hob relative to said cross slide and support.

8. The combination in a hob grinding machine as set forth in claim 6, in which an additional indexing device is mounted on said cross slide and is manually operable to advance said hob relative to said cross slide and supporting member.

9. The combination in a hob grinding machine as set forth in claim 6, in which additional manual means is provided for angularly advancing said hob relative to said cross slide and support, said latter means including an index plate and a radially adjustable arm having a plunger cooperating with said plate.

10. In a hob grinding machine, a frame, a headstock angularly adjustable on said frame, a grinding wheel, means to adjust said grinding wheel axially, a shaft fixed in said headstock, a yoke mounted to swing on said shaft, means to

oscillate said yoke with a predetermined swing, a cross slide mounted for radial adjustment on said yoke, a stud on said cross slide, a hob support rotatably mounted on said stud, means to cause said hob support to swing with said cross slide during a grinding operation, and means to give said hob support a feeding movement relative to said cross slide during each return swing of said hob support.

11. The combination in a hob grinding machine as set forth in claim 10, in which additional means is provided for angularly adjusting the means which swings said hob support, the adjustment being relative to said cross slide and of a predetermined slight amount which will compensate for the angular advance of a spiral land.

12. A hob grinding machine comprising a grinding wheel, a supporting member for a hob, means to relatively adjust said wheel and hob axially, mean to oscillate said hob and supporting member about an axis eccentric to the axis of said hob but parallel thereto, and means to maintain a fixed angular relation between said hob and supporting member during the grinding operation on each tooth of the hob, said oscillating means comprising a continuously rotating cam, a cam lever swinging about a fixed pivot and connected to said supporting member, a cam follower on said lever, and adjusting means to limit the return movement of said cam lever.

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