June 21, 1938. R. S. DRUMMOND 2,121,479

MACHINE FOR FINISHING GEARS

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FIG. 2.

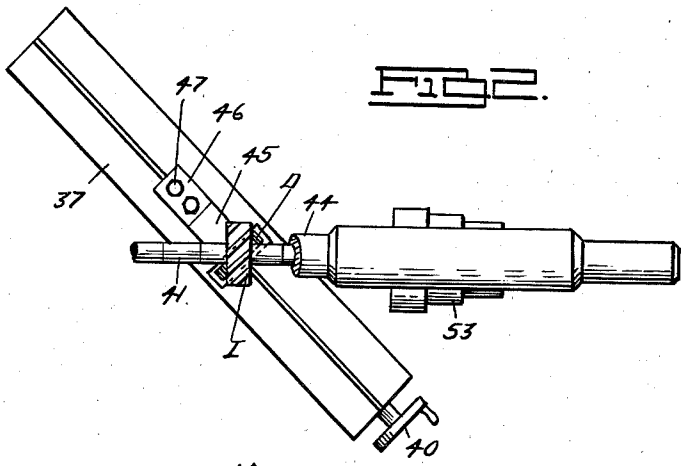
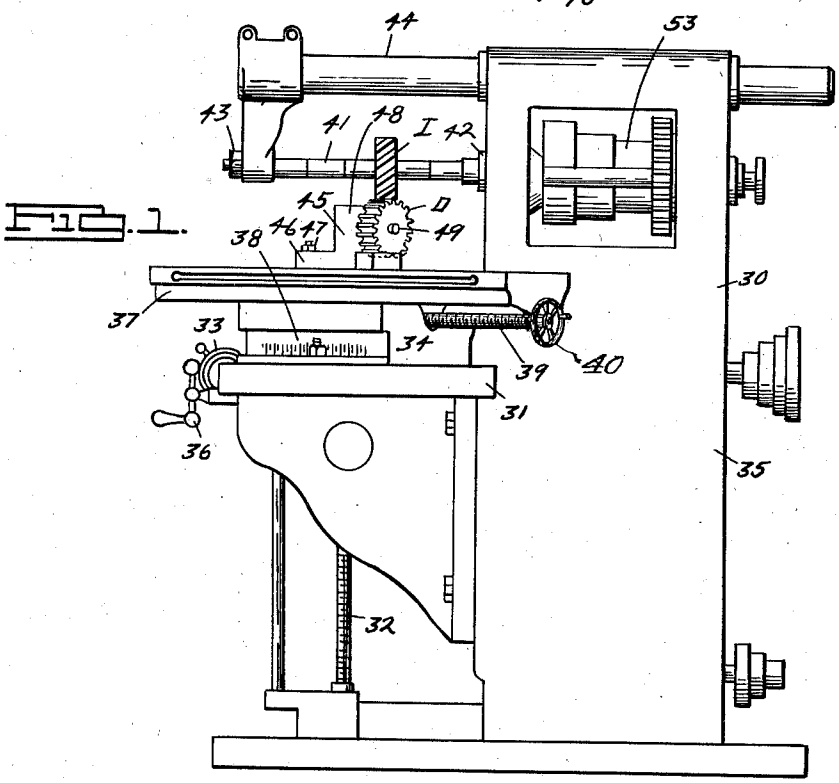


FIG. 1.



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FIG. 9.

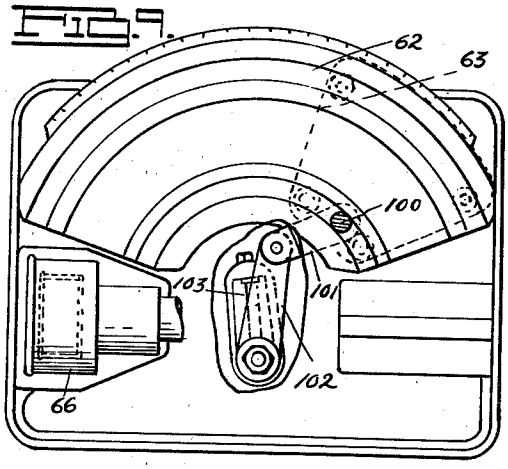
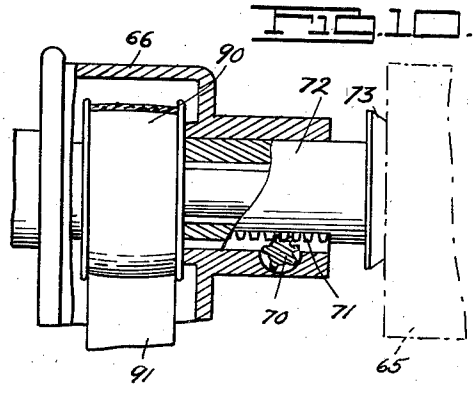


FIG. 10.



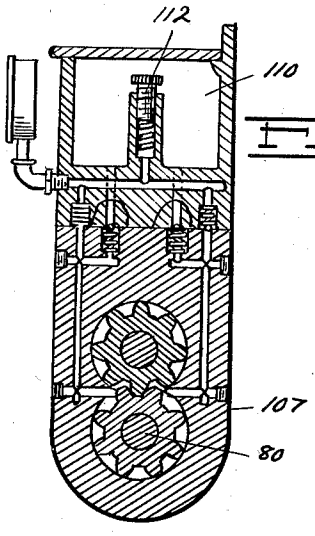


FIG. 11.

FIG. 3.

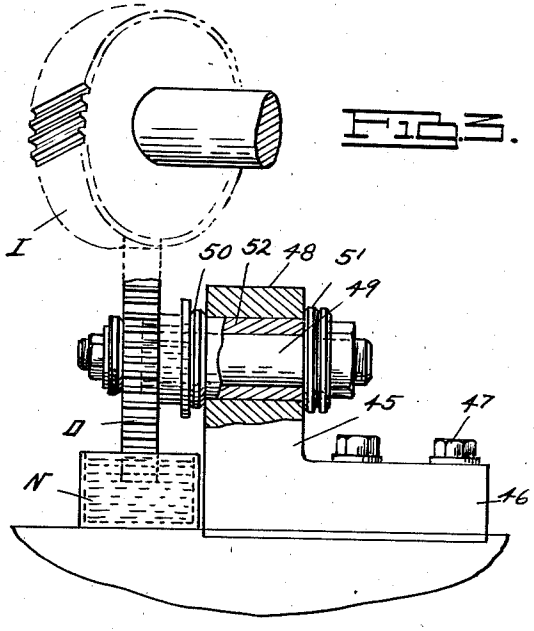
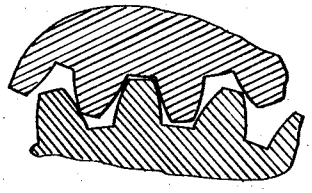


FIG. 5.



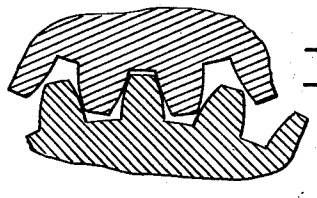


FIG. 4.

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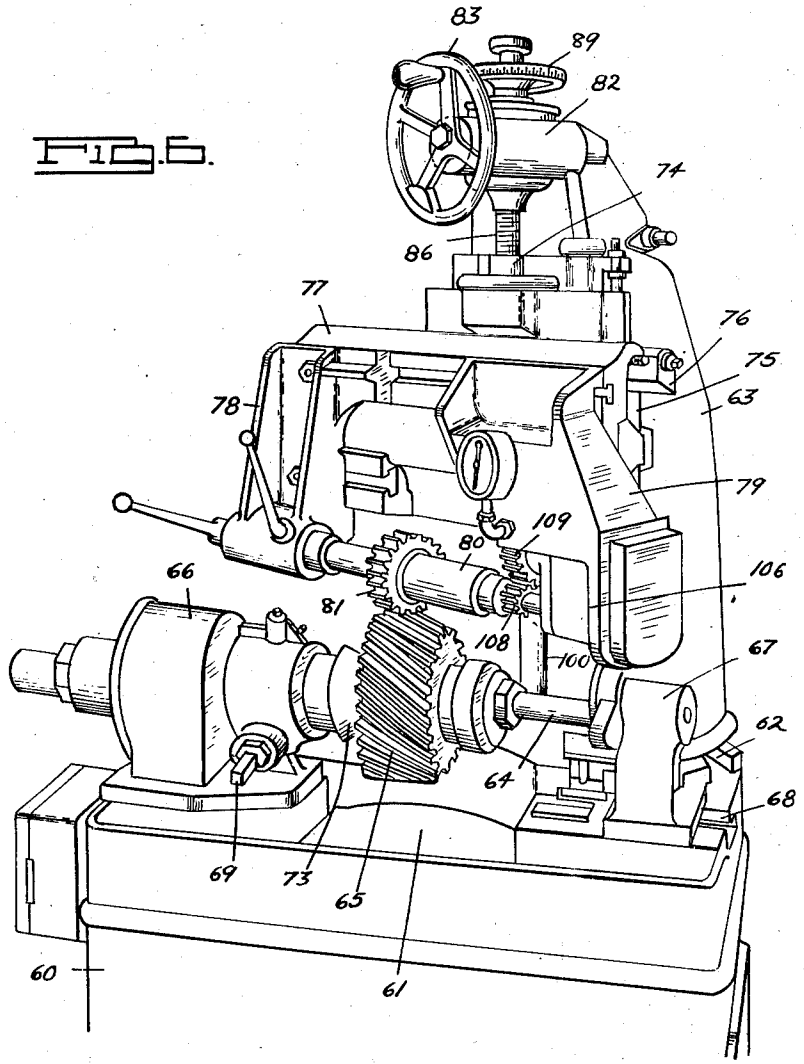
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Fig. 6.



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Fig. 7.

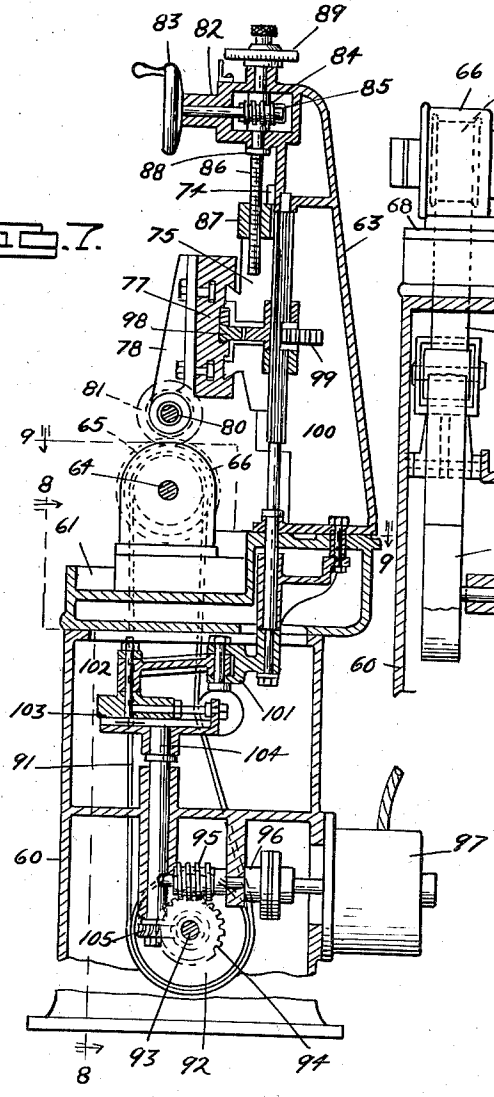
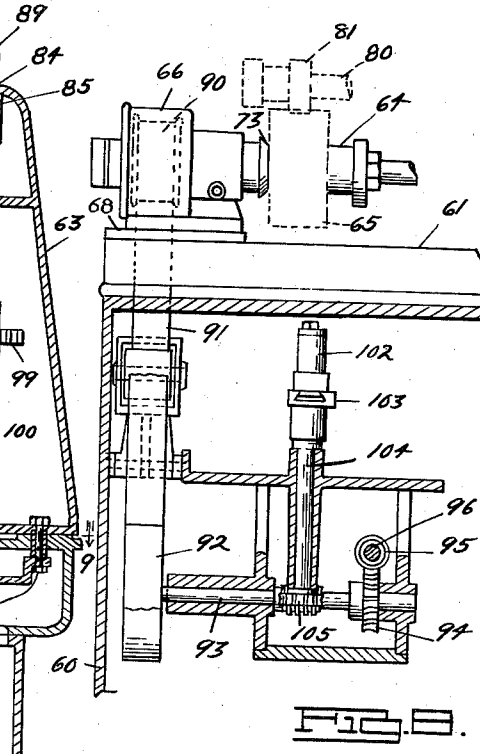


Fig. 8.



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UNITED STATES PATENT OFFICE

2,121,479

MACHINE FOR FINISHING GEARS

Robert S. Drummond, Detroit, Mich.

Original application April 11, 1932, Serial No. 604,575, now Patent No. 1,989,651, dated January 29, 1935. Divided and this application January 26, 1935, Serial No. 3,663. In Great Britain August 17, 1931

3 Claims. (Cl. 51—26)

The invention relates to machines for finishing gears by lapping, burnishing, cutting or similar methods. This application is a division of my application, Serial No. 604,575 filed April 11, 1932, now Patent No. 1,989,651 and is a continuation in part of my applications, Serial Nos. 547,704, filed June 29, 1931 now Patent No. 1,989,650; 626,769, filed July 30, 1932 now Patent No. 1,989,652 and 626,768, filed July 30, 1932 in which certain novel methods of finishing gears have been claimed.

The principal object of the present invention is to obtain a machine adapted for the lapping, burnishing or cutting of gears by means of a rotary finishing tool, the axis of which lies in no common plane with the axis of the work gear and is crossed at an angle of less than 30° therewith. Other objects reside in the construction by means of which the machine is adapted to produce great accuracy at a high rate of production and with simplicity of operation.

In its broader aspects my invention contemplates various types of machines in which special features have been incorporated making them adaptable for the finishing of gears in accordance with this and my co-pending applications above referred to. Thus my invention may be practiced by modifying certain prior art machines in such a way as to obtain a different organization adapted for producing a new function.

In the drawings:

Figure 1 is a side elevation of one form of gear finishing machine;

Figure 2 is a plan view thereof;

Figure 3 is a sectional elevation showing the relation between the finishing tool and the gear to be finished;

Figure 4 is a section through a portion of the gear and finishing tool engaging each other with cramp action;

Figure 5 is a view similar to Figure 4 showing the modified engagement when a power tail stock is used;

Figure 6 is a perspective view of a modified machine;

Figure 7 is a vertical section through the construction shown in Figure 6;

Figure 8 is a sectional view illustrating the portion of the drive mechanism taken substantially on the line 8—8 of Figure 7;

Figure 9 is a horizontal vertical view taken substantially on the line 9—9 of Figure 7;

Figure 10 is a sectional view through the arbor for the finishing tool;

Figure 11 is a diagrammatic sectional view through the oil pump.

The invention in its broadest aspects may be embodied in a machine which may be considered as a reorganized milling machine. Thus as illustrated in Figures 1, 2 and 3, 30 is a universal milling machine of ordinary construction provided with a bed 31 which may be raised or lowered by suitable mechanism such as the screw 32 controlled by the handle 33. On the bed 31 there is a carriage 34 movable toward and away from the column 35 by a handle 36. 37 is a table universally mounted at 38 on the carriage 34 and adjustable to the desired angularity in the conventional manner. The table 37 may be longitudinally adjusted by means of the screw 39 and handle 40. Above the table 37 is an arbor 41 which projects horizontally from the column 35. The arbor is journaled in a bearing 42 in the column and has its outer end journaled at 43 in an adjustable slide 44 which is supported and projects from the upper portion of the column 35.

Mounted on the table 37 is a fixture 45 comprising a plate 46 adapted to be secured to the table by fastening screws 47 and a vertical portion 48 for rotatably supporting the arbor 49. The arbor 49 is prevented from axial movement by thrust bearings 50 and 51 at the opposite ends of the bearing 52. The arbor 49 projects from the bearing in the fixture and is adapted to have removably mounted thereon the gear D. The arbor 41 is adapted to have mounted thereon the gear I. The gears D and I are selected so as to have a mating engagement when the arbors 49 and 41 are arranged at the desired angle for the finishing operation. One of the gears is the gear which it is desired to finish and the other is in the form of a finishing tool. As shown, the gear D is the gear to be finished and is provided with spur teeth, while the gear I is the finishing tool and is a helical gear. The axes of the gear and finishing tool lie in no common plane and are crossed at the desired angle in accordance with the method outlined in my co-pending applications above referred to. The angle between the axes may be adjusted by the angular setting of the table 37 on its universal mounting. The rotation of the finishing tool and gear is provided by rotating the arbor 41 by suitable mechanism indicated generally by the numeral 53.

In order to adjust the angularity of the axes of the gear and finishing tool, it may also be desirable to adjust the fixture 45 in order to vary

the angle of the arbor 49 with respect to the longitudinal axis of the table 37. In some instances it may be desirable to have the arbor 41 carry the gear to be finished and the arbor 49 support the finishing tool. It will be noted that when it is desired to feed the gear relative to the finishing tool in the direction of the axis of the arbor 41, this may be accomplished by turning the handle 36. When axial feed is required parallel to the axis of the arbor 49 and the longitudinal axis of the table 37, it may be accomplished through the handle 40. For obtaining a predetermined contact pressure between the teeth of the gear and the finishing tool the handle 33 is used.

In the operation of the machine as thus far described, the method described in my co-pending applications should be practiced in order to secure the best results. In accordance with said methods, the gear finishing tool and the gear to be finished have conjugate mating teeth and the angle between the axes is preferably maintained between a lower limit usually more than 3° and an upper limit less than 25° to 30°. If the gear to be finished is a straight spur gear, the finishing tool will be a helical gear having a helical angle within the above limits. On the other hand, if the gear to be finished is helical, the finishing tool may be in the form either of a straight spur gear or of a helical gear, but in each case the difference in helical angle should be such that when in proper mesh the angular difference between the axes is within the limits previously mentioned.

In the machine previously described and illustrated in Figures 1 to 3, an embodiment of the invention has been disclosed, but in order to obtain the best results from my invention it is preferable to provide a machine of a modified type such as is hereinafter described and illustrated in Figures 6 to 11 inclusive. In the modified construction the machine is adapted to automatically perform the principal movements required. The machine is provided with a hollow base 60 which at a convenient height is provided with a table 61. At the rear of the table are segmental ways 62 on which is mounted a vertical column 63. At the front of the table 61 provision is made for carrying the arbor 64 on which the finishing tool 65 is mounted. This consists of a head stock 66 and tail stock 67, the latter being adjustable in the ways 68 on the table 61. These are so located that the horizontal axis of the arbor 64 intersects the vertical axis about which the column 63 is angularly adjustable on the ways 62. For adjusting the finishing tool axially there is provided the square shank 69 which carries at its opposite end the pinion 70 (see Figure 10). The pinion 70 meshes with the rack 71 on the sleeve 72 which in turn has a collar 73 abutting the finishing tool 65. Thus upon rotation of the square shank 69 with a suitable handle, the finishing tool 65 may be axially adjusted in the bearings on the head stock 66 and tail stock 67.

The column 63 is provided with vertical ways 74 for mounting the crosshead 75. The crosshead is in turn provided with horizontal ways 76 on which is horizontally adjustable a carriage 77. This carriage has depending therefrom arms 78 and 79 in which are mounted bearings for the arbor 80 for the gear 81 to be finished. For vertically adjusting the arbor 80, the following mechanism is used. The column 63 is provided at the top thereof with a frame 82 in which a handwheel 83 is journaled. The handwheel carries a worm 84 engaging a worm wheel 85 which in turn is mounted on the adjustment screw 86. This screw threadedly engages a nut 87 on the crosshead 75 while it is provided with suitable thrust collars 88 to prevent axial movement thereof. The screw also carries at its upper end the index wheel 89 for indicating the vertical adjustment of the crosshead.

The arbor 64 is driven by suitable means such as the pulley 90 which is connected by a belt 91 to a pulley 92 on a shaft 93 arranged in the bottom of the hollow base 60. The shaft 93 has a gear 94 engaging worm 95 on a shaft 96 driven by an electric motor 97. The speed of rotation of the arbor 64 for the finishing tool may be suitably regulated by providing the proper ratio of the gears in the driving mechanism. Provision is also made for automatically reciprocating the carriage 77, this comprising a rack 98 on the carriage 77 engaging a gear wheel 99 splined upon a vertical shaft 100 which is oscillated by a rock arm 101 connected to a link 102 engaging an adjustable throw crank 103 on a shaft 104. The shaft 104 is driven through the medium of a reduction worm gearing 105 from the shaft 93. Thus the rotation of the shaft 93 rotates the gear finishing tool 65 and at the same time reciprocates the gear to be finished in the direction of the axis of the latter. The amplitude of movement is determined by the throw of the adjustable crank 103 which may be set according to the width of the gear which is being finished. The rate of axial feed of the gear may be determined by the proper gear ratio.

In carrying out gear finishing methods as outlined in my co-pending applications above referred to, it is sometimes desired to produce a cramp action between the finishing tool and the gear to be finished. This is accomplished in the present machine by operating the wheel 83 to obtain the desired pressure between the axis of the gear and the axis of the finishing tool. The engagement of a gear and finishing tool under conditions of cramp action is illustrated in Figure 4.

In a modified method of gear finishing set forth in my co-pending applications, it is sometimes desirable to develop the desired pressure between the teeth of the finishing tool and the gear to be finished by retarding the rotation of the gear. A suitable mechanism for this purpose will therefore be described.

Mounted on the carriage 77 and preferably upon the adjustable tail stock 106 of the carriage is a gear pump 107 which is driven from the shaft 80 through the medium of intermeshing gear wheels 108 and 109. The oil or other fluid propelled by the pump is supplied by a reservoir 110 and is discharged against the resistance of a spring closed valve. The pressure of the spring may be varied by an adjusting screw 112 so as to produce any desired resistance to the rotation of the pump and consequently to the rotation of the gear. The construction is such as to resist rotation of the gear in either direction. Thus in the operation of the machine, the driving motor 97 may be first operated in one direction for a sufficient length of time to properly finish the faces of the teeth on one side thereof and then by reversing the motor the opposite faces of the teeth are correspondingly finished. In each instance the lag or resistance of the pump 107 will give a substantially constant pressure of contact between the teeth of the gear and those of the finishing tool so as to produce a definite finishing action.

Both of the machines previously described are useful in the finishing of gears which have been previously roughed out to approximate dimensions by other suitable means. In illustrating the machine shown in Figures 1 to 3, I have shown the gear D in mesh with a lapping tool I preferably of cast iron and the finishing action is obtained by reason of the abrasive compound which is spread on the teeth by suitable means such as by permitting the gear D to dip into a tank N containing the abrasive or lapping compound. In operating the machine for lapping purposes the machine is set in motion thus rotating the finishing tool I which in turn causes the gear D to be rotated due to the intermeshing action of the teeth. The lapping action is continued with suitable vertical adjustments of the table from time to time by means of the handle **33** until the desired amount of stock has been removed. During the running of the gear and finishing tool in mesh the gear D is reciprocated axially in order that the finishing action will take place over the entire face width of the gear. In the illustrated arrangement the reciprocation may be obtained by means of the handle **40** or if desired by automatic mechanism, the amount of reciprocation being somewhat in excess of the face width of the gear. If desired a reciprocating movement may also be imparted in the direction of the axis of the lap in order that the wearing action upon the lap may be distributed over the face thereof. This may be obtained by means of the handle **36** which will move the table **37** in the direction of the axis of the arbor **41**. This movement is unnecessary for the uniform finishing of the gear and is used only for distributing the wear on the lap. It should be somewhat less than the face width of the lap so that at no time will the lap run out of contact with the gear. Where there is no appreciable wearing action on the finishing tool the feed movement in the direction of the axis of the finishing tool is not necessary. In cases where the positions of the gear and lap are reversed with the gear to be finished mounted on the arbor **41**, the reciprocating feed motion in the direction of the axis of the gear to be finished may be obtained by the handle **36** which causes the finishing tool on the arbor **49** to be moved in a direction parallel to the axis of the arbor **41**.

The machine illustrated in Figures 6 to 11, is constructed to be of particular utility in carrying out the gear finishing methods described in my copending applications, whether for the purpose of lapping, burnishing or cutting. As illustrated in Figure 6, however, the gear **81** to be finished is shown in operative relation to the lapping tool **65**, the width of which is considerably greater than the width of the gear to be finished. Thus after the lap becomes worn in one portion thereof it may be axially adjusted by means of the square shank **69** to bring a different portion thereof into active use. When desired the machine shown in Figure 6 may be used for lapping by means of cramp action in the same manner as previously described in connection with the machine shown in Figures 1 to 3. In such case the driving of the lapping tool **65** by the electric motor **97** causes the gear **81** to be rotated due to the intermeshing action of the teeth and a reciprocating feed movement is imparted in the direction of the axis of the gear. This movement is obtained through the automatic mechanism including the pinion **99** and rack **98** causing reciprocation of the carriage **77** and the gear **81**. This movement is of sufficient amplitude to spread the finishing action over the entire face width of the gear. The cramp action is obtained by periodically causing a down feed by means of the hand wheel **83** until the desired amount of stock has been removed.

The machine shown in Figure 6 is particularly designed to be used for finishing the gear by a method in which the pressure between the teeth of the gear and the finishing tool is obtained by loading or resisting rotation of the driven member. In this case the finishing tool is provided with a tooth thickness that is less than the interdental spaces in the gear prior to lapping which enables the original setting of the machine with the gear and finishing tool in full mesh, that is, with their axes spaced apart the exact distance for normal operation. When the machine is operated by the resistance method the hydraulic brake mechanism previously described is utilized to retard the rotation of the driven shaft **80** on which the gear **81** is mounted. The driving motor **97** is first operated in one direction to finish the tooth faces on one side thereof and then by reversing the motor the opposite faces of the teeth are correspondingly finished. During the rotation the reciprocation of the gear **81** in the direction of its axis is continuously maintained in order to distribute the finishing action over the entire face width. The resistance to rotation of the driven shaft **80** by the hydraulic gear pump **106** will give a substantially constant pressure of contact between the teeth of the gear and the finishing tool so as to produce the desired finishing action.

Where it is desired to finish a gear by a cutting action rather than by a lapping action a suitable modified form of finishing tool is employed. This is described in detail in my application, Serial No. 3,662, filed on even date herewith and will not be further described in this application. Where the term "rotary finishing tool" is used in the specification and claims, it is meant to include within its meaning constructions useful for lapping, burnishing or cutting.

What I claim as my invention is:

1. A machine for finishing gears comprising a frame, a horizontal arbor mounted thereon, a column extending upward from said frame and adjustable in an arcuate path concentric with the vertical axis passing through said arbor, a crosshead vertically adjustable on said column, a carriage transversely slidable on said crosshead, an arbor mounted on said carriage adjustable into variable angular relation with the arbor on said frame by the adjustment of said column, one of said arbors being adapted to mount a gear to be lapped, a lapping tool having conjugate teeth mounted on the other arbor in intermeshing relation with said gear, means for rotating the arbor on the frame, means for reciprocating said carriage and a hydraulic brake for resisting rotation of the arbor on said carriage to produce a predetermined contact pressure between the teeth of the lap and the gear.

2. A machine for finishing gears comprising a frame, a horizontal arbor mounted thereon, a column extending upward from said frame and adjustable in an arcuate path concentric with a vertical axis passing through said arbor, a crosshead vertically adjustable on said column, a carriage transversely slidable on said crosshead, an arbor-supporting head stock and tail stock relatively adjustably mounted on said carriage, an arbor in said head stock and tail stock adapted to mount a gear to be lapped, a lapping tool hav-

ing conjugate teeth mounted upon said horizontal arbor, means for rotating said horizontal arbor and a hydraulic brake mounted on said tail stock driven from the arbor engaging the same and resisting the rotation thereof to produce a predetermined contact pressure between the teeth of the lap and the gear.

3. A machine for finishing gears comprising a frame, a horizontal arbor mounted thereon, a column extending upward from said frame and adjustable in an arcuate path concentric with a vertical axis passing through said arbor, a cross head vertically adjustable on said column, a carriage transversely slidable on said cross head, an arbor carried by said carriage, said arbors adapted to support an intermeshed gear and a gear like finishing tool, means for rotating one of said arbors, and means for providing pressure contact between meshed teeth of said gear and tool.

ROBERT S. DRUMMOND.