Feb. 18, 1941. S. M. SHAW 2,232,408

GEAR FINISHING MACHINE

Filed Nov. 25, 1935 3 Sheets-Sheet 1

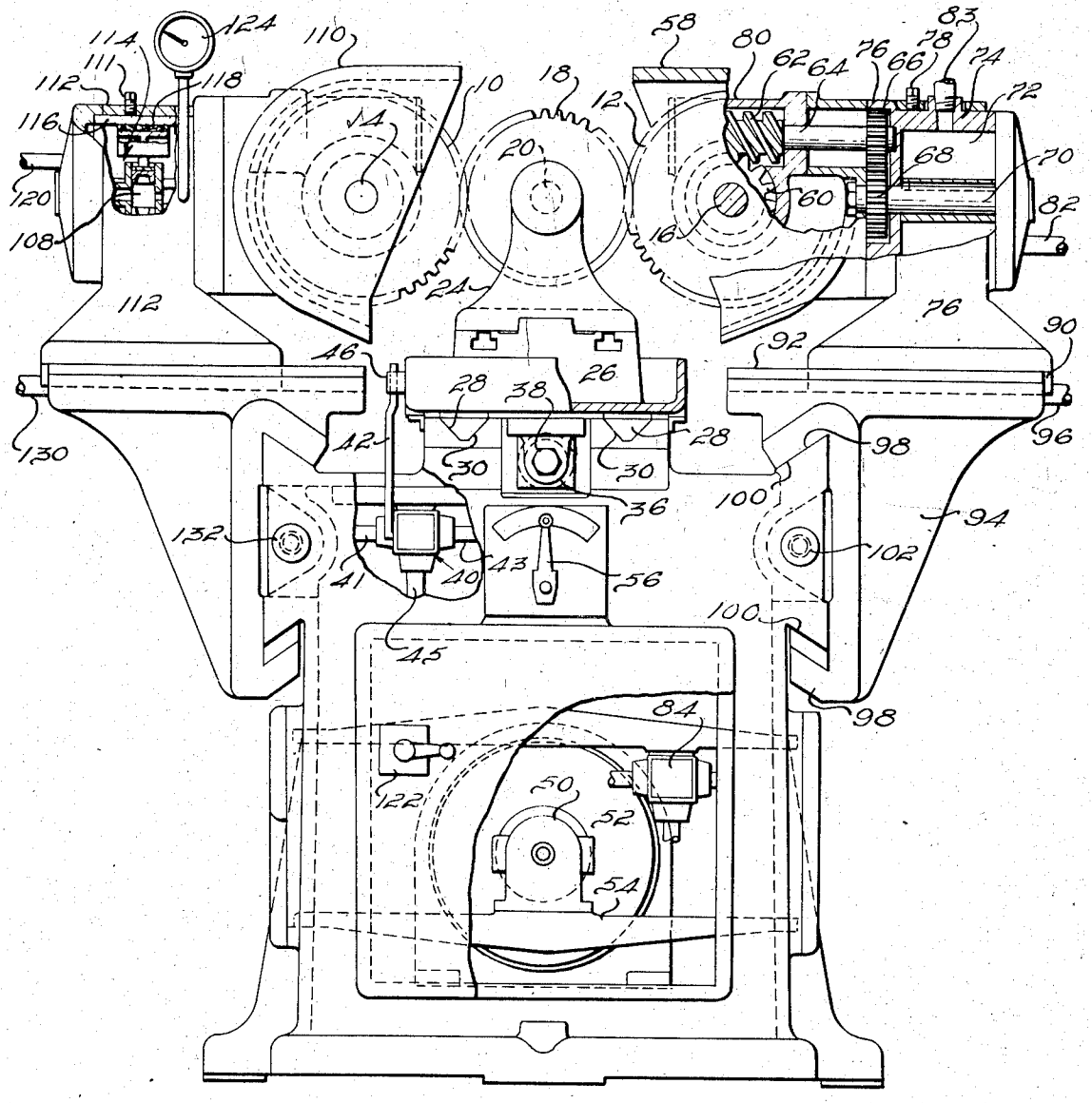

FIG. 1.

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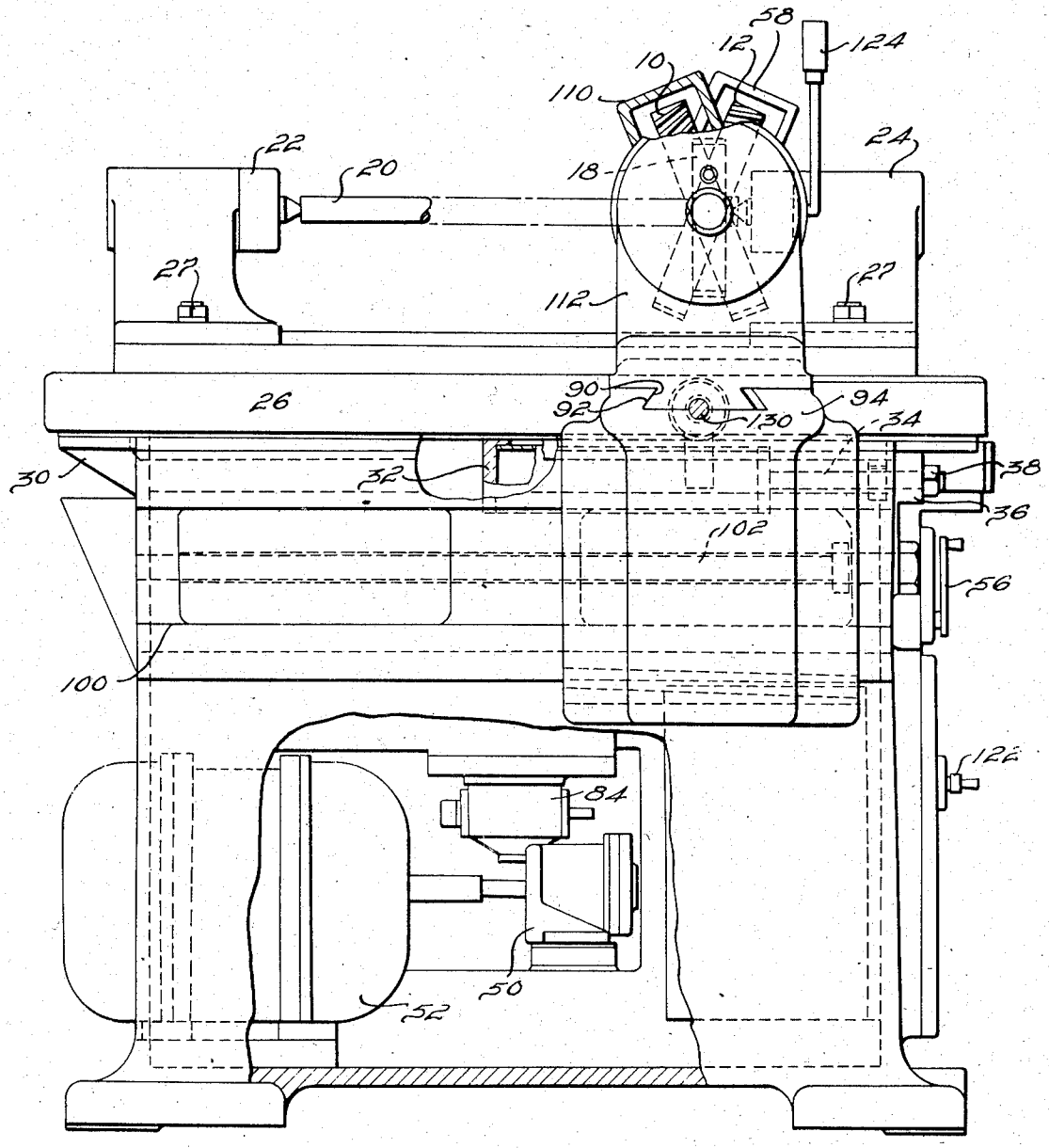

Fig. 2.

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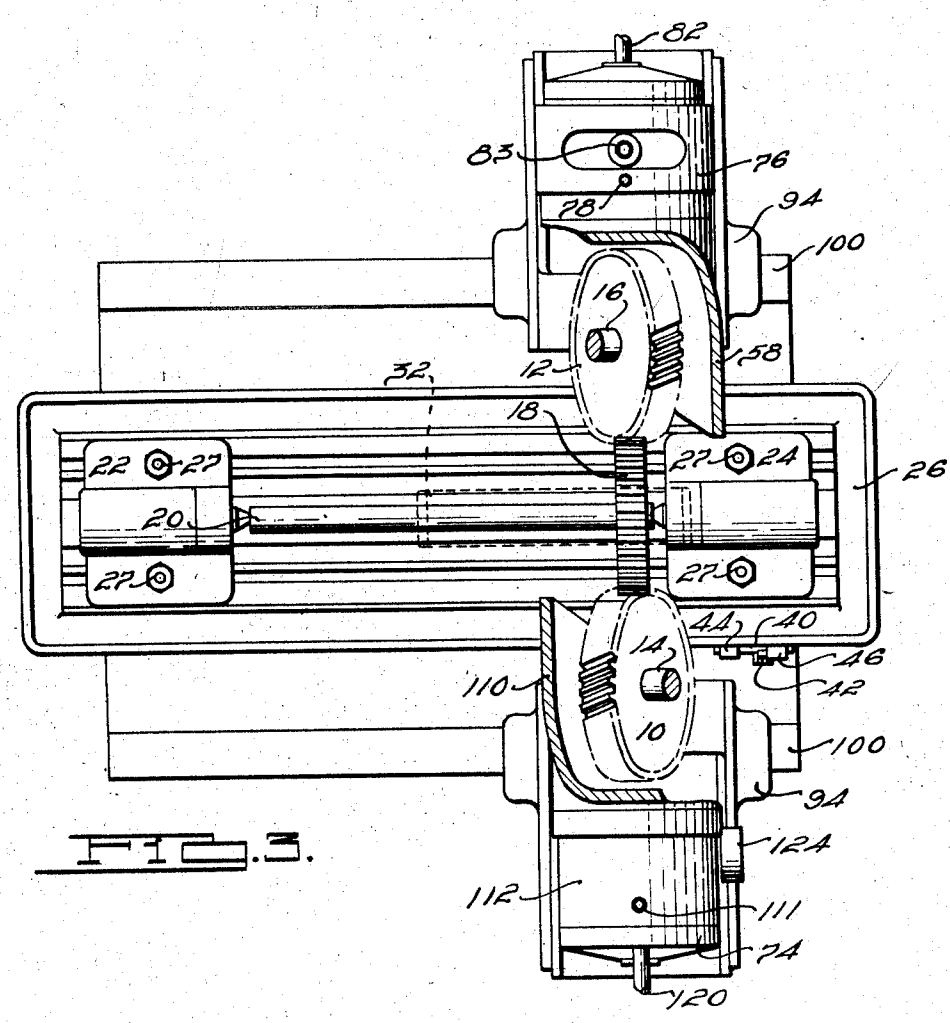


FIG. 3.

FIG. 4.

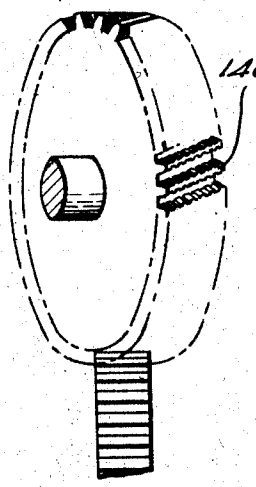


FIG. 5.

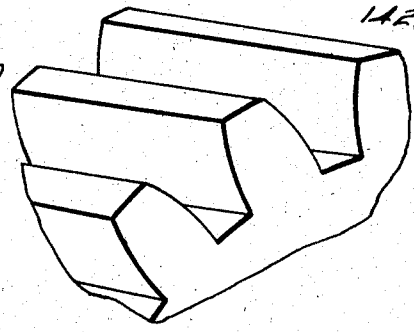
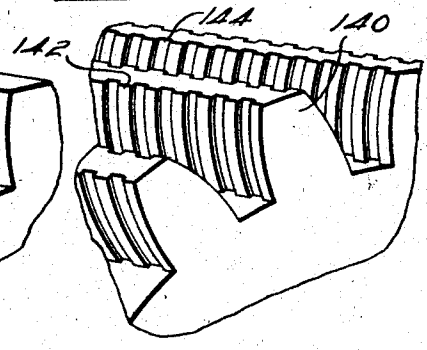


FIG. 6.



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UNITED STATES PATENT OFFICE

2,232,408

GEAR FINISHING MACHINE

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6 Claims. (Cl. 51—26)

The present invention relates to gear finishing machines of the lapping, shaving and burnishing type.

It is an object of the present invention to provide a simplified machine for accurately machining and finishing gears to proper tooth form and diameter.

It is a further object of the present invention to provide a machine embodying means to feed a gear transversely across the plane of rotation of a finishing tool to thereby accurately machine the teeth of such gear and to effect uniform wear throughout the surface of the tool teeth.

It is a further object of the present invention to provide a machine of the last mentioned type which embodies a pair of spaced finishing tools, between which the gear is moved across the face of the tool teeth.

It is a further object of the present invention to provide a finishing machine embodying two rotating finishing tools spaced apart such a distance that a gear passing therebetween transverse to the plane of rotation of such tools may be finished to accurate dimensions.

It is a further object of the present invention to provide a machine of the last mentioned type in which one of the tools may be driven to correspondingly drive the gear and the second tool and embodying means to suitably load or brake such second tool.

It is a further object of the present invention to provide a gear finishing machine embodying means to tilt one or both of the tools to positions in which the axes of the tilted tool or tools and the gear are at an angle to each other, and embodying additional means to move the gear transversely across the face of the tools.

It is a further object of the present invention to provide a gear finishing machine which is simple in construction, accurate in machining and economical of manufacture.

Other objects and advantages of the present invention appear in the following description and in the appended claims.

In the drawings, throughout the several views of which corresponding reference characters are used to designate corresponding parts,

Figure 1 is a view in side elevation of an illustrative gear finishing machine embodying the present invention;

Fig. 2 is a view in end elevation of the structure shown in Fig. 1;

Fig. 3 is a top plan view of the structure shown in Figs. 1 and 2;

Fig. 4 is a detail view illustrating a form of finishing tool;

Fig. 5 is a fragmentary view illustrative of a lapping tool which may be used in the practice of the present invention; and

Fig. 6 is an enlarged fragmentary view corresponding to Fig. 4.

It has been found, in connection with the finishing of gears of either spur or helical type, through lapping, shaving or burnishing operations, that the deformation of the gear teeth caused at the pitch line thereof by the slipping between the gear teeth and the tool teeth which occurs on each side of the pitch line, may be compensated for or eliminated by running the gear with a tool having an axis at an angle to the axis of the gear, which angle varies somewhat in accordance with the type of gear being finished. By disposing the axes of the gear and tool at an angle in this manner, a lateral component of movement is introduced between the tool teeth and the gear teeth which compensates for and prevents the deforming of the gear teeth at the pitch line. In connection with shaving operations, the co-pending application of W. F. Dalzen, Serial No. 554,193, filed July 13, 1931, assigned to the same assignee as the present application, discloses tools through use of which any cutting action or finishing action due to the roll of the gear and of the tool may be eliminated, and the machining effected entirely through the lateral component of movement between the tool and the gear. In accordance with this application, the gear teeth comprise a series of spaced lands, separated by grooves, and the lateral forward edges of the lands are formed as cutting edges which are effective to cut entirely due to the lateral component of movement.

The improved gear finishing machine of the present invention provides for introducing an additional component of lateral movement between the gear and the finishing tool, which has been found to make any wear on the teeth of the lapping, burnishing or shaving tools uniform over the tooth surfaces, thus prolonging the effective life of the tool and improving the finishing action as a whole.

In the form illustrated, the gear finishing machine of the present invention comprises generally a pair of rotatably supported finishing tools, which may be of either the spur or helical type, and a table disposed to reciprocate a gear between said tools in a path transverse to the plane of rotation thereof. The two finishing tools may be positioned in spaced co-planar re-

lationship and in a plane parallel to the plane of the gear being finished, but preferably are tilted respectively at a predetermined angle to the plane of the gear, thus introducing the above mentioned lateral component of movement between the gear teeth and the tool teeth, and compensating for the tendency to deform the gear teeth due to the roll of the gear. In finishing gears of the spur type, the teeth of the cutting tools are formed at an angle equal to such tilting angle. Where the gear being finished is of the helical type, the angles of the teeth on the cutting tools are preferably greater than and less than the angle of the teeth on the gear by the amount of the tilting angle. That is to say, if the teeth of the gear are disposed on a forty-five degree angle, the one cutting tool may have the teeth disposed at an angle of thirty degrees and the other tool may have the teeth disposed at an angle of sixty degrees, the tilting angle of the axes of the tools with respect to the axis of the gear being fifteen degrees. As mentioned above, this angular difference varies, depending upon the type of the gear and teeth to be finished.

The gear to be finished is supported in mating relation to the tools and between them, and is preferably continuously reciprocated in the previously mentioned transverse path. This transverse or lateral motion introduces a continuous and additional lateral component of movement between the teeth of the gear and of the tools and renders the wear on the tool teeth uniform over the surface thereof, and also produces an accurate finishing of the gear teeth from the crown, through the root and pitch lines thereof.

The transverse or lateral movement of the gear may be effected in various ways. Preferably, and as illustrated, this movement is effected automatically and continuously in timed relation to the rotation of the tools. With this arrangement, an entirely automatic machine results.

In the form illustrated, the tool supports are adjustable both inwardly and outwardly with respect to the gear support, to thereby accommodate the machine to different sizes of gears, and are also adjustable in a direction parallel to the path of movement of the gear. With this arrangement, a plurality of individual gears, or a gear cluster, may be operated upon. The tilting of the tools may also be effected in either direction with respect to the axis of the tool, in the illustrated form of the present invention. Because of this feature, the gear may be selectively rotated in either direction, and either right or left-handed tools may be used.

Considering the above mentioned elements in more detail, and referring to the drawings, a pair of similarly formed finishing tools 10 and 12 are rotatably supported upon shafts 14 and 16 respectively, for effecting a finishing operation upon an illustrative gear 18.

Gear 18 is rotatably carried on a shaft 20 which is supported between stocks 22 and 24. Stocks 22 and 24 are slidably supported upon ways formed in a supporting bed 26 and may be locked in position thereon by the usual lock nuts 27. Bed 26 is also provided with guides 28 through which it is slidably supported on ways 30 formed in the machine frame, along which bed 26 and consequently gear 18 may be laterally moved, preferably automatically, and in timed relation to the rotation of tools 10 and 12.

The details of the mechanism for accomplishing the automatic lateral movement of gear 18 and bed 26 form no part of the present invention, and may be arranged in various ways. As illustrated, a fluid pressure controlled cylinder 32 is suitably supported within the machine frame and is provided with a piston rod 34 which is secured by nut 38 to a boss 36 extending downwardly from the underside of bed 26. Reciprocating movement of piston rod 34 effects a corresponding reciprocating movement of bed 26 and of gear 18.

The fluid connections for cylinder 32 preferably include a valve 40 of conventional reversing type, having lines 41 and 43 for connecting to cylinder 32 and concentric supply and exhaust lines 45 for connection to a source of fluid pressure which may comprise a pump 50 driven by a motor 52. Valve 40 is supported on the machine frame with the control arm 42 thereof in cooperative relation to a pair of cams 44 and 46 which are secured to bed plate 26. The relation is such that as bed plate 26 reaches one limit of travel, the cam 46 engages arm 42 and swings it to a position in which valve 40 is effective to complete fluid pressure connections to cylinder 32 to cause bed plate 26 to travel in the opposite direction. Upon reaching the opposite limit of travel, cam 44 engages arm 42 and swings it to the first position, completing fluid pressure connections through valve 40 for cylinder 32 effective to cause the original direction of movement of bed plate 26. With this arrangement, it will be understood that bed plate 26 and consequently gear 18 may be caused to reciprocate continuously along the horizontal path illustrated, and may be stopped at any desired point by interrupting the fluid supply. This may be accomplished, for example, by opening the illustrative control switch 56 for motor 52.

It will be understood that the spacing between cams 44 and 46 is such that the travel of bed 26 is slightly less than the width of the tools 10 and 12, so that the latter are maintained in continuous mating relation with the gear 18. One or both of cams 44 and 46 are adjustable to accommodate the machine to gears of different width as well as to gear clusters.

The shaft 16 upon which the finishing tool 12 is secured for rotation thereby also carries a worm wheel 60 which mates with a worm gear 62. Worm gear 62 is supported on a shaft 64 which also carries a spur gear 66 positioned in mating relation with a corresponding spur gear 68. Spur gear 68 is mounted on the outer end of the shaft 70 of a suitable fluid motor 72, the frame 74 of which is rotatably supported within a bracket 76. A suitable locking stud 78 is provided to lock frame 74 in any predetermined rotative position with respect to bracket 76. It will be noted that the shell 58 within which shaft 16 and tool 12 are supported, as well as the housing 80 which forms a support for the worm gear shaft 64, are both rigidly connected to the motor frame 74 so that rotation of frame 74 results in tilting finishing tool 12 with respect to the plane of gear 18.

Motor 72 may be driven in any suitable manner from pump 50, illustrative connections including the lines 82 and 83, and the reversing valve 84. The intermediate connections form no part of the present invention and have not been illustrated. It will be understood that the lines 82 and 83 may include flexible portions in order to permit the above mentioned rotative movements of the frame 74 of motor 72 within bracket 76.

Bracket 76 is provided with a dove-tail 90, which rides in a corresponding guide-way 92 formed in a supporting bed 94. The position of

bracket 76 along guide-way 92 may be suitably adjusted by lead screw 96, in a well known manner, to thereby properly position finishing tool 12 for cooperation with a gear 18 of selected variable size. Bed 94 is correspondingly adjustable in a direction parallel to the path of movement of gear 18 through cooperation of the guides 98 formed integrally therewith, and a guide-way 100 which may be formed in the machine frame. A corresponding lead screw 102 is provided to effect this adjustment.

The shaft 14, which is driven by the finishing tool 10 is connected to the shaft 108 through intermediate gearing in all respects as described in connection with gear 12. Shaft 108 carries a fluid brake 114 of conventional construction, the shoes 118 of which cooperate with an associated housing 116. Housing 116, to which the shell 110 for tool 10 and shaft 14 is secured, is rotatably supported in a bracket 112 and may be locked in place with respect thereto by stud 111. A suitable flexible supply line for brake 114 is illustrated at 120 and may be suitably connected to the source of fluid pressure through a suitable adjusting valve 122. The intermediate connections have been omitted to simplify the drawings.

Bracket 112 is adjustable transversely of the path of movement of gear 18 in the manner described in connection with bracket 76 by a suitable lead screw 130. A corresponding adjustment parallel to the path of movement of gear 18 is also provided for bracket 112 in the manner described in connection with bracket 76, by the lead screw 132.

With reference to the operation of the machine as a whole, it will be understood that in beginning a finishing operation, tools 10 and 12 are adjusted through transverse movement of their supporting brackets 112 and 76 to a position of proper radial spacing with gear 18. In finishing a single gear 18, it will also be understood that tools 10 and 12 are adjusted in a direction parallel to the path of reciprocation of gear 18 so that both tools engage gear 18. In finishing a plurality of gears, such as clusters, it will be understood that tools 10 and 12 may be offset through their independent adjustments, so that one of them acts upon one of the gears of the cluster, and the other acts upon a second gear of the cluster.

Upon the starting of motor 52, pump 50 effects continuous reciprocation of gear 18 on bed 26, through the reversing valve 40, and drives tool 12 continuously, through reversing valve 84 and motor 72.

Tool 12 drives gear 18, and the latter correspondingly drives tool 10. In certain operations, such as shaving operations, the tool teeth are thinner than required for usual mating with the teeth of gear 18, and in such instances, it is considered desirable to impose a braking load on the driven tool 10. This may be accomplished, as previously described, through the adjustable brake 114, the adjustment of which may conveniently be read upon an indicating meter 124.

The machine may be operated with the parts in the relative positions shown in Figure 1, in which tools 10 and 12 and gear 18 rotate in parallel planes. Preferably, however, and as previously mentioned, the tools 10 and 12 are tilted with respect to the axis of gear 18, to positions such as shown in Figures 2 and 3. As also previously stated, the angle of tilt varies with the type and size of gear being operated upon, and is preferably such as to produce a substantial balance between the amount of cutting due to the roll, and due to the lateral component of slippage introduced by the tilting, to thereby lap or burnish substantially a uniform shape to the gear teeth. As will be understood, a lapping or burnishing operation may be effected through use of tools having the tooth form illustrated in Figure 5. A shaving operation, however, is preferably effected through use of a tool having the tooth form shown in Figures 4 and 6, in which the individual teeth 140 of the tool each comprise a series of spaced lands 142 separated by grooves 144. The lateral forward edges of the lands 142 are formed as cutting edges, so that the entire machining action effected by the tool occurs due to the lateral component of slippage, and no machining action is effected due to the roll of the gear.

The reciprocating movement of gear 18, the limits of which are determined by the positions of cams 44 and 46, preferably occurs at a substantially lower rate than the rate of rotation of the gear and the tools. The continuous reciprocation of gear 18 laterally of the gears brings the teeth of gear 18 successively into cooperating relationship with the entire length of the teeth of the tools 10 and 12, and makes the wear thereon due to the finishing action uniform over the entire tooth faces. This uniform wear, as will be understood, prolongs the life of tools 10 and 12 and also improves the accuracy of the finishing action upon gear 18.

In finishing gear clusters, as previously mentioned, the machine is preferably operated with one of the tools 10 and 12 in engagement with one gear of the cluster and the other tool in engagement with another gear of the cluster. With this arrangement, the tooth faces of the gears are finished one side at a time, and a complete finishing operation may conveniently be effected by reversing the direction of rotation of the parts. This may be accomplished by reversing the connections to motor 72 through the reversing valve 84.

It will also be noted that the arrangement of tools 10 and 12 so that they may be tilted independently of each other and in either direction permits the use either of two right handed or two left handed tools, or of a left handed and a right handed tool. In the latter instance, as will be understood, both tools 10 and 12 would be tilted in the same direction with respect to the gear 18.

Although a specific embodiment is shown, it will be evident that various changes may be made in the form, number and arrangement of parts within the spirit and scope thereof.

What is claimed is:

1. In a gear finishing machine, the combination of a pair of finishing tools, means for rotatably supporting said tools with their axes in spaced relationship, means for driving one of said tools and for braking the other of said tools, means for supporting a gear to be finished between said tools and in mating relation therewith respectively for rotation thereby, said gear and tool supporting means being arranged to support said gear and tools in such relation that the axes of the tools and gear intersect a common line which line lies in the planes of rotation of said tools, and means for effecting continuous reciprocatory motion of said gear in a path

transverse to the plane of rotation of said gear and during the rotation of said gear.

2. In a gear finishing machine, the combination of a pair of finishing tools, means for rotatably supporting said tools with their axes in spaced relationship, means for supporting a gear between said tools in mating relation therewith respectively, said gear and tool supporting means being arranged to support said gear and tools in such relation that the axes of the tools and gear intersect a common line which line lies in the planes of rotation of said tools, a drive member, a braking member, means connecting one of said tools to said drive member so that said one tool drives said gear, said gear acting to drive the other of said tools, means connecting the other said tool to said braking member, and means for effecting relative motion between said gear and said tools in a path transverse to the plane of rotation of said gear during the rotation thereof.

3. In a gear finishing machine, the combination of a work arbor for rotatably supporting a gear to be finished; means for effecting reciprocation of said work arbor in a path parallel to the axis of said gear, said arbor and spindles being arranged to support the tools and gear in such relation that the axes of the tools and gear intersect a common line which line lies in the planes of rotation of the tools; first and second tool spindles for rotatably supporting first and second tools in diametrically opposed mating positions relative to said gear; a drive member connected to one of said tools for driving the same to rotate said gear, said gear acting to rotate said second tool; and a braking member connected to said second tool.

4. In a gear finishing machine, a pair of tools, heads mounted for rotational movement about their axes, shafts in said heads for supporting said tools therein, driving means connected to said shafts carried by said heads so disposed as to permit the rotation of said heads for tilting said shafts and tools without interrupting the driving connections, means for mounting a gear to be finished between said tools, said tool heads and gear mounting means being arranged to support the tools and gear in such relation that the axes of the tools and gears intersect a common line which line at all times lies in the planes of rotation of the tools, power means for operating the driving means of one of said tools, and load means operated by the driving means of the other of said tools, whereby the driving of one tool operates on one side of the gear teeth for driving the gear to have the opposite side of the teeth effective for driving the other tool against the load which provides uniform pressure between opposite sides of spaced teeth of the gear and the tools while driving the gear in a single direction.

5. In a gear lapping machine, means for supporting a pair of tools with their axes in spaced relation, means for supporting a gear between said tools in meshed relation therewith, said gear and tool supporting means being arranged to support said gear and tools in such relation that the axes of the tools and gear intersect a common line which line lies in the planes of rotation of said tools, means for driving one of said tools, means for loading the other of said tools to resist rotation, and means for moving said gear relative to said tools while in operating relation for spreading the engaging area over the tooth surface, whereby said gear teeth are simultaneously lapped on one side by one of said tools and on the other side by the other of said tools while driven in a single direction.

6. In a gear finishing machine, the combination of a pair of finishing tools, means for rotatably supporting said tools with their axes in spaced relationship, means for driving one of said tools and for braking the other of said tools, means for supporting a gear to be finished between said tools and in mating relation therewith respectively for rotation thereby, said gear and tool supporting means being arranged to support said gear and tools in such relation that the axes of the tools and gear intersect a common line which line lies in the planes of rotation of said tools, means for rocking said tools relative to said gear about said line as a center so as to dispose said gear and tools in crossed axes relation, and means for effecting continuous reciprocatory motion of said gear in a path transverse to the plane of rotation of said gear and during the rotation of said gear.

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