

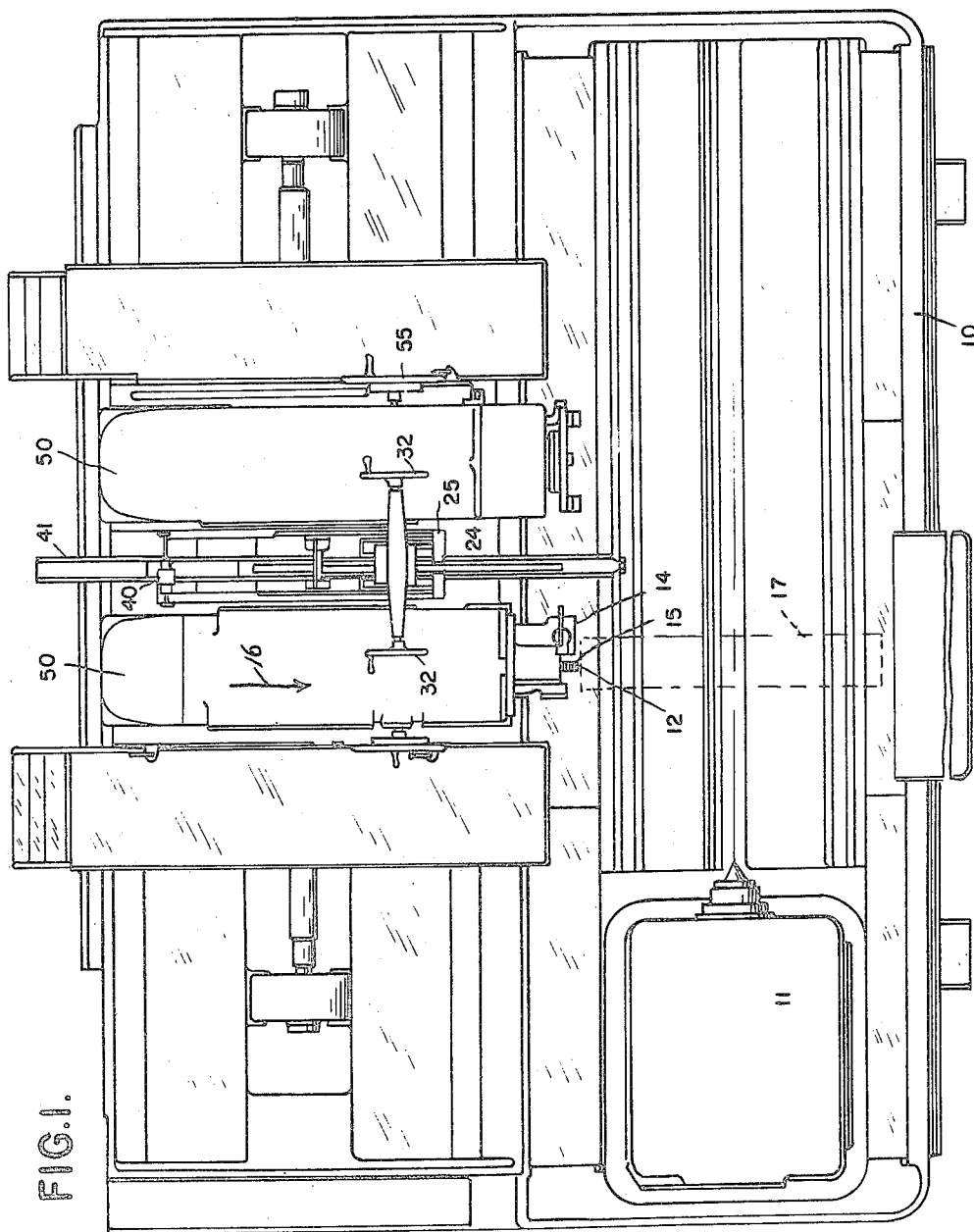
June 13, 1950

W. A. SCHULTE
GEAR FINISHING MACHINE

2,511,418

Filed Aug. 16, 1944

7 Sheets-Sheet 1



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June 13, 1950

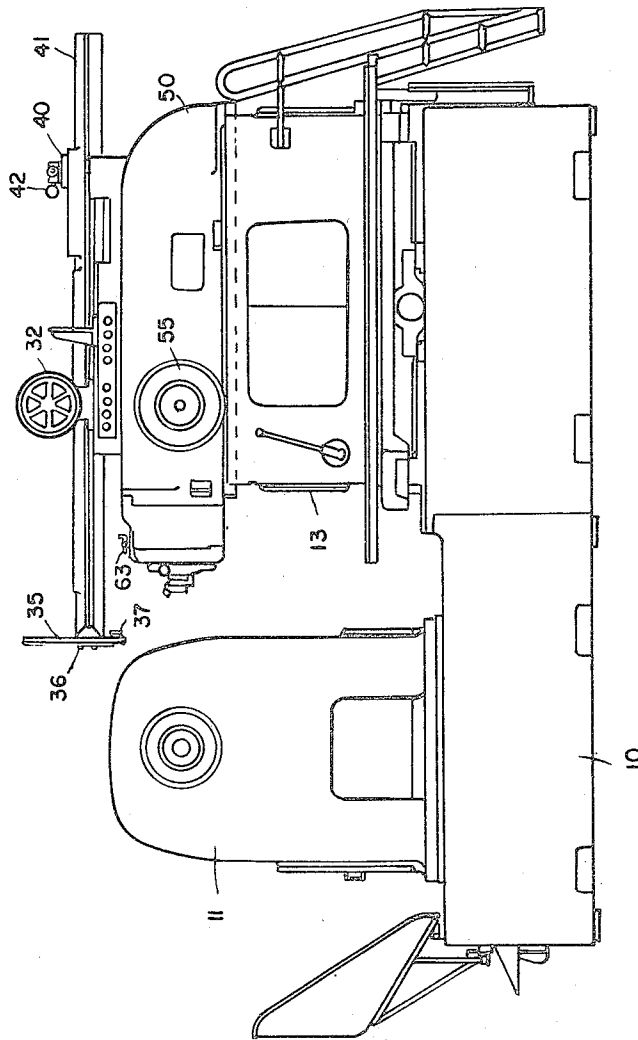
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FIG.2.



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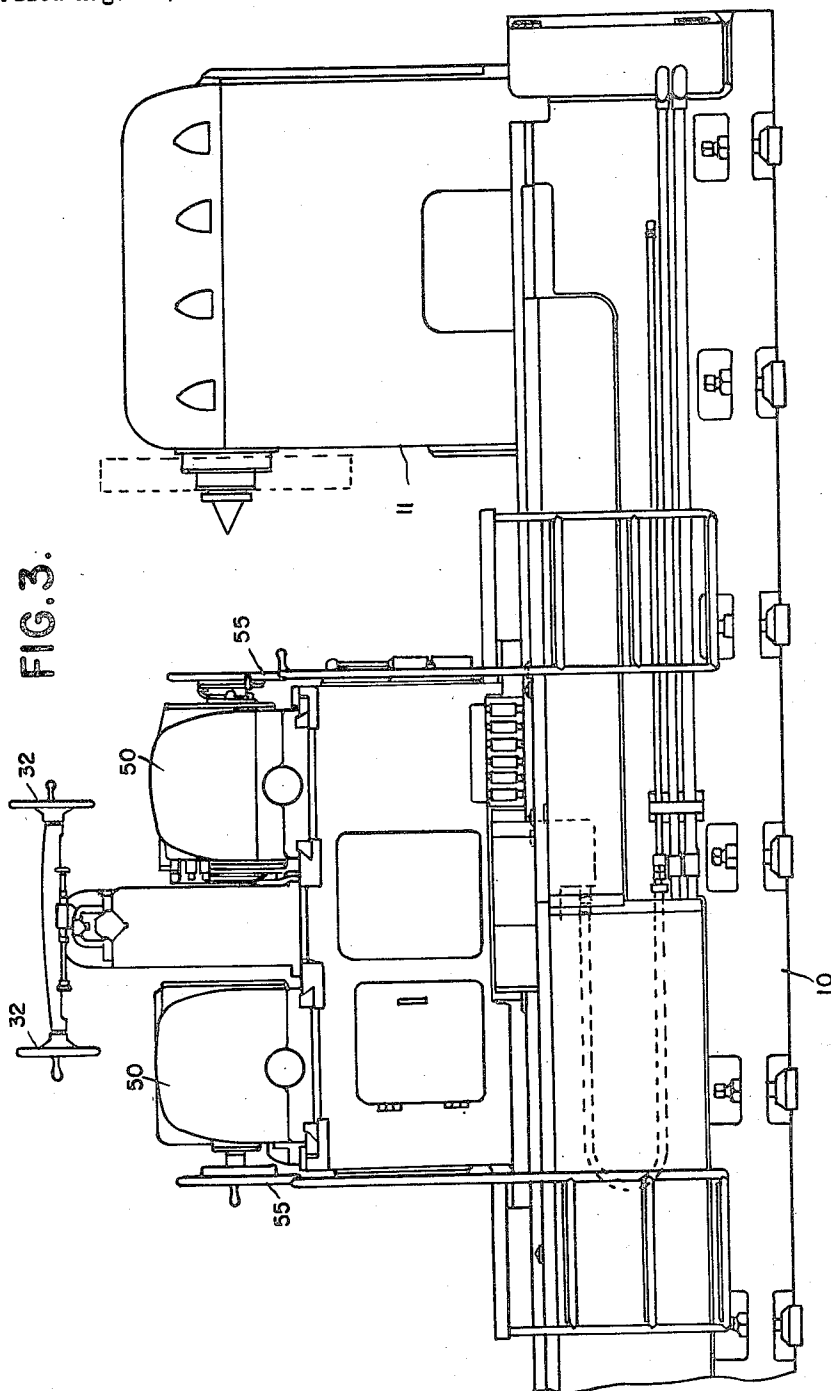
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7 Sheets-Sheet 3



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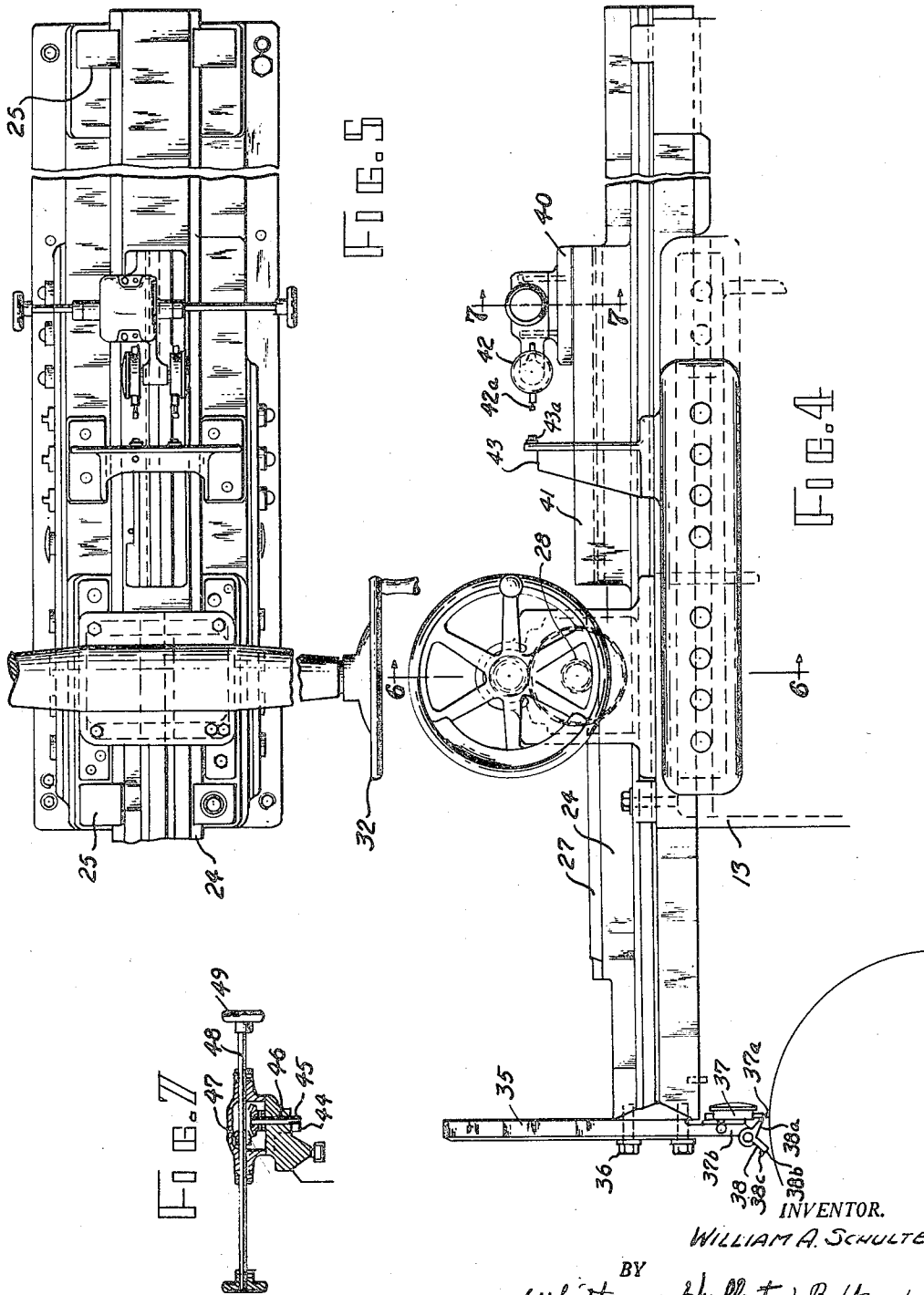
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7 Sheets-Sheet 4



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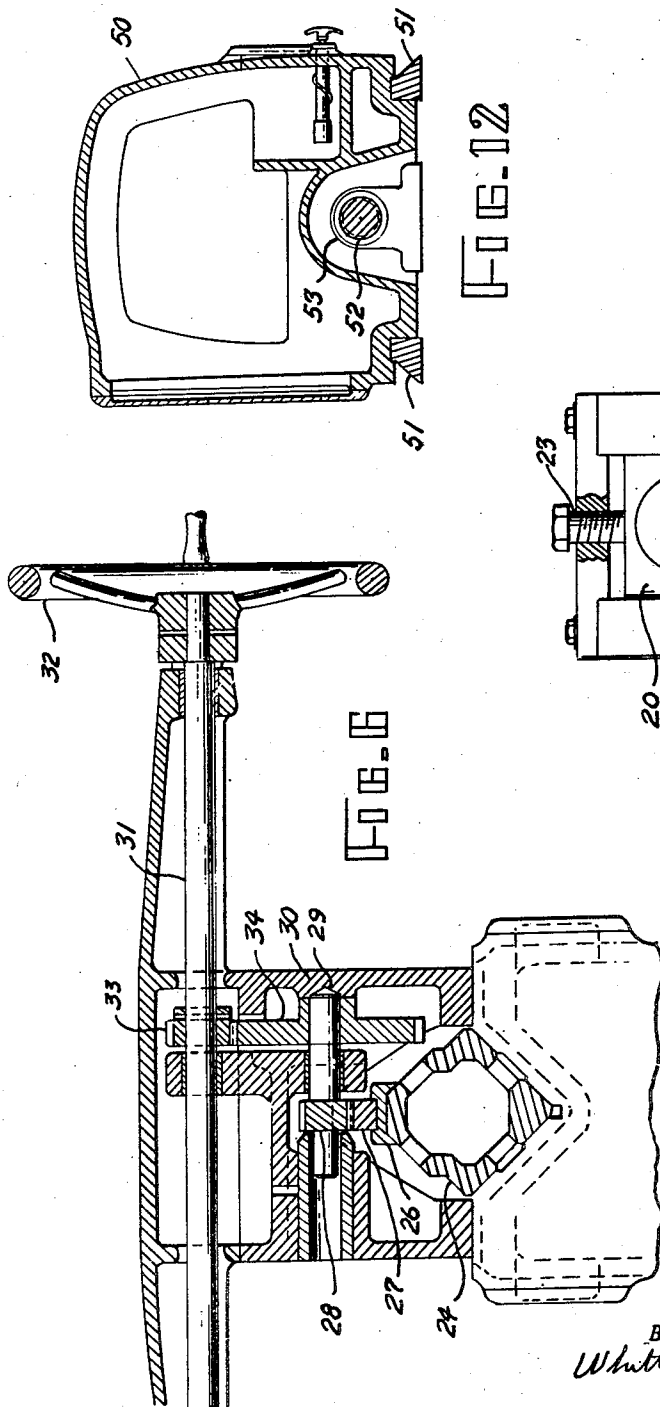


FIG. 12

FIG. 13

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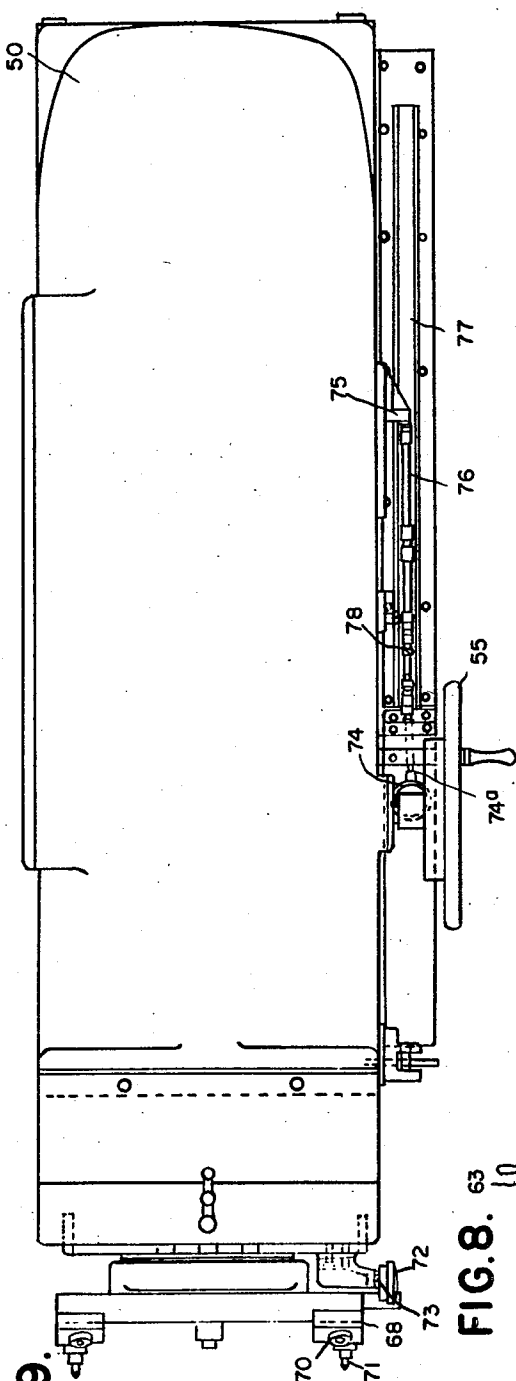


FIG. 9.

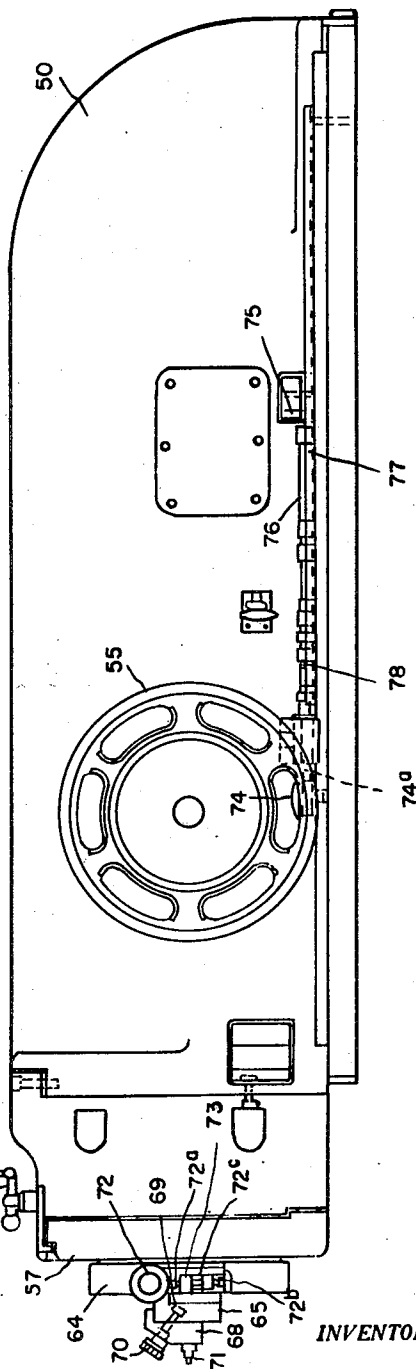


FIG. 8.

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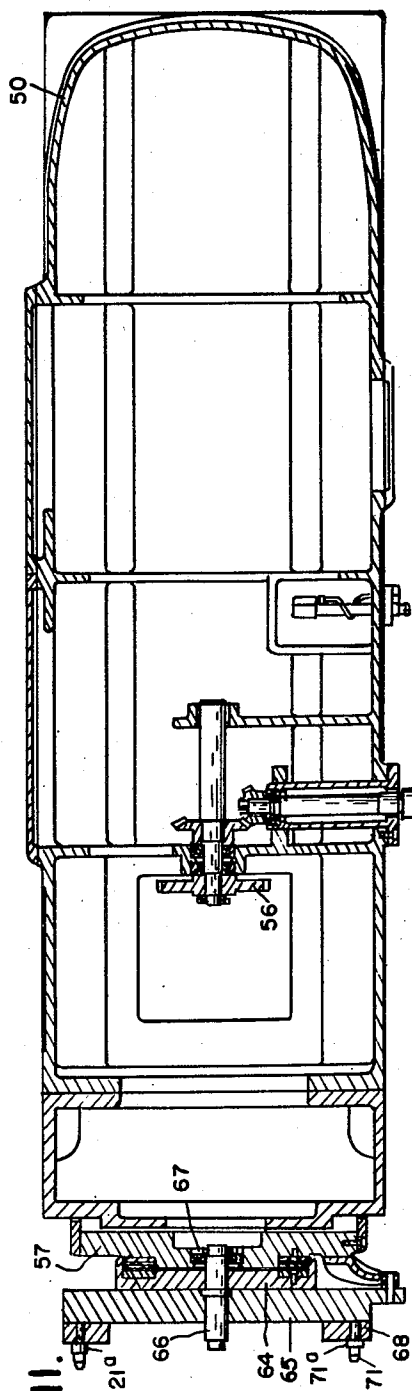


FIG. 11.

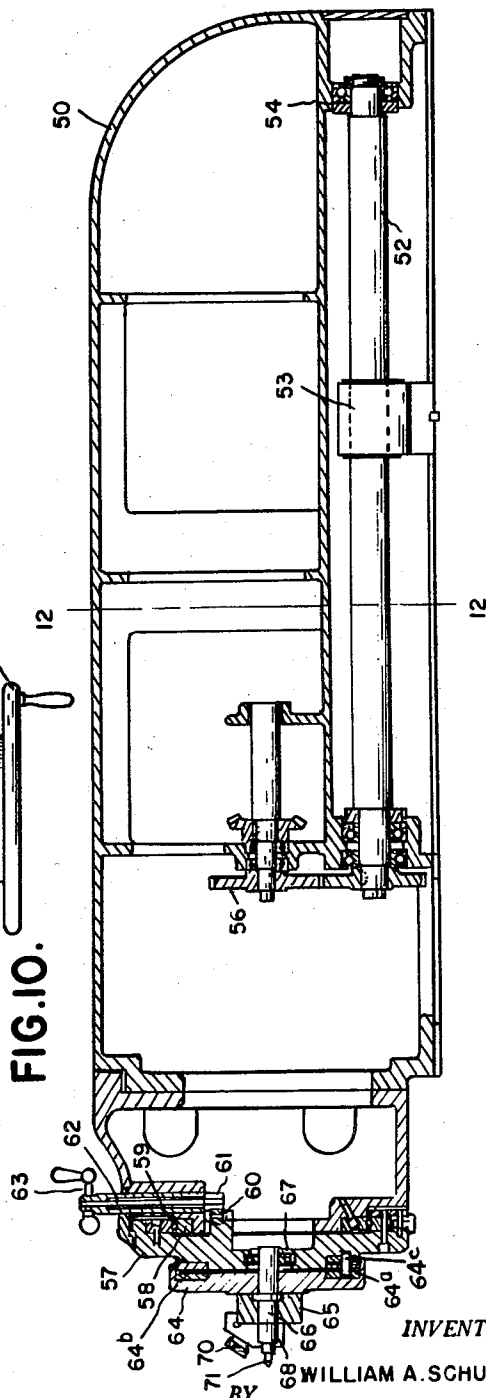


FIG. 10.

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UNITED STATES PATENT OFFICE

2,511,418

GEAR FINISHING MACHINE

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Application August 16, 1944, Serial No. 549,701

6 Claims. (Cl. 90—1.6)

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The invention relates to gear finishing machines of that type in which the gear to be finished is run in mesh with a conjugate cutter and is simultaneously axially reciprocated in relation thereto. More particularly, the invention relates to heavy duty machines of this type designed to operate on gears of large dimensions and proportionate weight.

It is the object of the invention to provide means permanently mounted on the machine facilitating accurate setting of the work so as to obtain a high degree of perfection in the finished product.

It is a further object to provide means for testing the accuracy of the setting during the progress of the work so that correction can be made before the finishing cut. With these objects in view the invention consists in the construction as hereinafter set forth:

In the drawings:

Fig. 1 is a plan view of the machine;

Fig. 2 is an end elevation thereof;

Fig. 3 is a rear elevation;

Fig. 4 is an elevation of the work setting indicator;

Fig. 5 is a plan view thereof;

Fig. 6 is a cross section on line 6—6, Fig. 4;

Fig. 7 is a cross section on line 7—7, Fig. 4;

Fig. 8 is an elevation of the helix angle and pitch diameter testing means;

Fig. 9 is a plan view thereof;

Fig. 10 is a vertical section;

Fig. 11 is a horizontal section;

Fig. 12 is a cross section on line 12—12, Fig. 10; and

Fig. 13 is a diagram of the work mounting means.

The specific construction of the gear finishing machine to which my improvements are applied is not the subject matter of the instant invention and I will, therefore, only make general reference to the same. Essentially such machine comprises a bed 10 on which the work is mounted, a headstock 11 on said bed for imparting rotary movement to the work, a suitable tailstock (not shown) opposite the headstock for supporting a work piece in conjunction with the headstock, a reciprocatory carriage 13 mounted for movement on the bed 10 in a direction parallel to the axis of the head and tailstocks, a pair of slides 50 mounted on the carriage 13 for movement toward and away from the axis of the head and tailstocks, and a separate gauge slide 24 also mounted on the carriage 13 for adjustment

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toward and away from the axis of the head and tailstocks.

One of the slides 50 constitutes a tool slide and includes an angularly adjustable head 14 for providing angular adjustment of a cutter 12 carried thereby with respect to the axis of a work piece mounted between the head and tailstock. The cutter 12 is in the form of a gear having teeth 15 adapted to mesh with the teeth of a work gear 17 so as to perform a shaving action thereon when the gear and tool or cutter are rotated in mesh and a relative traverse is provided between the parts in a direction parallel to the axis of the gear.

In the operation of such a machine it is first necessary to adjust the rotary head 14 so that the axis of the cutter tool 12 is at the proper angle. The gear 17 to be operated upon is then mounted upon the supporting bed 10 so that its axis is parallel to the plane of the carriage 13 and also the direction of movement thereof. The work gear is then coupled to the headstock 11 which communicates rotary movement thereto and which through the intermeshing relation of the work and cutter will also rotate the latter. Mountings of various designs may be employed for holding the work according to the specific construction of the latter. In some instances the gear to be finished must be mounted on an arbor and the latter journaled in bearings. In other cases the gear and the axle therefor are integral and the latter is journaled in bearings which are in alignment with the headstock. In every case the mounting must be such that the bearings for the opposite ends of the shaft or arbor can be relatively adjusted vertically and horizontally to secure exact alignment of the axis. As illustrated, I have diagrammatically represented the mounting for the work gear as comprising a pair of column members 17^a laterally adjustable on base plates 18 secured to the bed 10, such adjustment being effected by screws 19. At the upper ends of these columns are vertically adjustable bearings 20 for receiving the arbor or shaft 21 for the work gear 17. Screws 23 are provided for independently vertically adjusting the bearings 20 in the columns 17^a. This illustration is only diagrammatic but represents any suitable construction of mounting which provides for both lateral and vertical adjustment of the arbor bearings.

The subject matter of the instant invention is the construction of the means associated with the machine above described for facilitating and expediting the accurate setting of both the work

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and the cutter tool. This means includes, first, a means for accurately setting the work in its mounting so that its axis is exactly parallel to the direction of relative reciprocation of the work and the cutter; and, second, means for testing from time to time during the operation of the machine the accuracy of setting of both the work and the cutter with respect to (a) the helix angle, (b) the pitch diameter.

Work mounting means

As previously described, the work is mounted on the bed 10 in bearings 20 which are independently adjustable vertically and horizontally. The work gear either on an integral axle or on an arbor is mounted in these bearings after which they must be adjusted to arrange the axis of the work exactly parallel to the direction of movement of the reciprocatory carriage in both horizontal and vertical planes. The means for effecting such accurate adjustment comprises the following construction.

Work setting means

Slide 24 is an arm slidably mounted in bearings 25 on the reciprocatory carriage 13 so as to be movable transversely of said carriage parallel to the horizontal plane thereof and perpendicular to the direction of reciprocation. The arm 24 is of sufficient length to extend to the vertical plane of the axis of the work and is preferably in the form of a hollow beam possessing a high degree of rigidity. As shown, the beam is substantially rectangular in cross section and is arranged with a diagonal thereof extending vertically and the lower two sides engaging V-shaped ways of the bearings 25. Caps 26 overlapping the upper sides of the beam retain the same in the bearings. Extending along the upper corner of the beam is a rack bar 27 which is in mesh with a pinion 28 on a transverse shaft 29 journaled in a bracket member 30. In this same bracket member is journaled an operating shaft 31 which extends to opposite sides of the carriage and is provided with hand wheels 32 at each end. A pinion 33 on the shaft 31 meshing with the gear wheel 34 on the shaft 29 forms a step-down transmission through which the rotation of either hand wheel 32 will revolve the pinion 28 to move the rack bar 27 and arm 24. At the free end of the arm 24 is a vertically extending arm 35 which is secured by clamping bolts 36 passing through a longitudinal slot in said arm 35 to threadedly engage the arm 24. The plane of the arm 24 is sufficiently above the axis of the work to clear an arbor of maximum dimensions and the length of the arm 35 is sufficient to permit of downward adjustment to the work axis. An indicator gauge 37 is mounted on the lower end portion of the arm 35 so that its actuating member 37^a may be moved into contact with a registering point in the work arbor. The gauge has a shank 37^b which is engageable alternatively with two recesses in the arm 35 so as to mount the gauge in two positions thereon. The arm 35 has also mounted at its lower end a bell crank lever 38 having the arms 38^a and 38^b. When the gauge is mounted in its upper position on the arm 35, the arm 38^a of the bell crank lever will extend horizontally beneath the actuating member 37^a while the arm 38^b will extend vertically downward. In this position of the parts a bearing 38^c on the arm 38^b may be moved laterally into contact with the side of the work arbor to effect an indication on the gauge. On the other hand, when the gauge is in its lower position on

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the arm 37, the bell crank lever 38 will be out of the path of the actuator 37^a so that the latter may directly contact with the arbor. Thus, to set the axis of the work in exact parallelism to the direction of movement of the carriage, the procedure is, as follows. First, the arm 24 is projected over the work arbor to bring the member 37^a of the gauge substantially into the vertical plane of the axis of the work, this being accomplished when the carriage 13 is in a position to arrange said gauge near one end of the arbor. The arm 35 is next adjusted downward to bring the member 37^a of the gauge into contact with the surface of the arbor while the gauge registers zero. The bolts 36 are tightened to hold the parts in this position after which the arm 24 is retracted so that it may be moved with the carriage 13 to the opposite side of the work and near the opposite end of the arbor. The arm 24 is then again projected to bring the member 37^a into the same vertical plane which will indicate by the gauge whether or not the axis of the work is parallel to the horizontal plane of the carriage. If out of alignment, then the bearing 20 at the corresponding end of the arbor may be raised or lowered until the gauge registers zero. The same procedure may be followed to determine whether the axis of the work is parallel to the direction of movement of the carriage. In this case, the gauge 37 is in its upper position on the arm 35 and the latter is lowered until the point 38^c of the bell crank lever 38 is substantially in the horizontal plane of the work axis. The arm 24 is then moved until the bearing 38^c on the bell crank lever 38 contacts with the side of the work arbor with the gauge indicating zero. The test is then made at the opposite end of the arbor and, if alignment is not correct, then the bearing 20 at this end is adjusted laterally until zero is indicated on the gauge.

With the construction as thus far described, it has been stated that the arm 24 is projected and retracted by operation of the hand wheel 32. It is, however, necessary to indicate the amount of this movement so that after retraction of the arm it can be again projected to precisely the same position. This is accomplished by the following construction. 40 is a member mounted on a slideway 41 which latter is integral with the arm 24. 42 is an indicator gauge mounted on the member 40 with its actuating member 42^a extending horizontally. 43 is a yoke mounted on the carriage 13 to embrace the arm 24 and slideway 41, said yoke having a bearing 43a in alignment with the member 42^a. The member 40 is adjusted in the slideway 41 by means of a rack member 44 secured to said slideway and a pinion 45 engaging said rack. This pinion is on a vertical shaft 46 journaled in the member 40 and connected by beveled gear wheels 47 with a transversely extending shaft 48 also journaled in the member 40 and having hand wheels 49 at opposite ends thereof. Thus, by rotating the shaft 48 the member 40 may be moved towards or away from the yoke member 43. When the arm 24 is projected into operative relation to the work arbor, the member 40 is in a position where the gauge actuator 42^a is separated from the yoke 43. As soon, however, as the arm 24 is properly positioned and the gauge 37 indicates zero, the member 40 is moved towards the yoke 43 to contact the members 42^a and 43^a and to indicate zero on the gauge 42. After this setting the arm 24 may be retracted and, when it is again projected to a position where the gauge 42 registers zero,

this will be the same position as that which it previously occupied.

Means for testing the pitch diameter and helix angle

Mounted on the carriage 13 adjacent to the mounting for the arm 24 is the second transversely movable slide 50. This comprises a hollow member which is guided in ways 51 and is actuated by a screw 52 engaging a stationary nut 53 on the carriage 13. The screw 52 is mounted in bearings 54 at opposite ends thereof and is rotated by a hand wheel 55 through an intermediate transmission mechanism 56 located within the hollow member. At the front of the slide 50 is a head 57 which is transversely adjustable for a limited distance on ways 58 and ball bearings 59. A horizontal rack 60 on the inner face of the head engages a pinion 61 on a vertically extending shaft 62 which at its upper end has an actuating handle 63. 64 is a plate having a swivel mounting on the head 57 and 65 is a sine bar extending horizontally across the face of the plate 64. A pin 66 extends centrally through both the plate 64 and bar 65 being journaled at its inner end in a radial and end thrust ball bearing 67. The sine bar 65 has mounted thereon a pair of slides 68. These are secured in different positions of adjustment by headed bolts 69 engaging a longitudinally extending T slot in the bar and provided at their outer ends with clamping nuts 70. Each of the slides 68 has secured thereto to project outward therefrom a conical nose piece 71 which is adapted to engage the opposite faces of adjacent gear teeth in the work gear to be trimmed. If the teeth of this gear are helical, then by proper setting of the slides 68 one of the nose pieces 71 will enter the space between one pair of teeth, while the other nose piece will correspondingly enter the space between an advance pair of teeth. However, to bring the nose piece into full contact with both teeth of each pair and without the necessity of shifting the position of the work gear, the head 57 can be slightly shifted laterally by rotation of the handle 63. An indicator gauge 72 is mounted on the head 57 and a bearing pin 73 projecting rearward from the sine bar 65 registers with the actuating member 72^a of said gauge. By this means it may be determined whether or not the sine bar is exactly horizontal and, if not, the amount of its angular displacement from the horizontal.

It will be understood from the above description that the transverse slide 50 may be moved by operation of the hand wheel 55 so as to bring the nose pieces 71 into engagement with the teeth of the work gear. This may be used to determine whether or not the helix angle of the teeth is correct but another important function is to determine whether the pitch diameter is correct. For the latter purpose it is necessary to exactly measure the distance between the points of bearing of said nose pieces on the gear teeth and the axis of the gear. To accomplish this result, an indicator gauge 74 is mounted on the way 51 adjacent to the cross slide 50 and a cooperating finger 75 is secured to the carriage. The relative positioning of these members is such that the space between the actuating member 74^a of the gauge and the finger 75 exactly corresponds to the radial dimension between the axis of the work gear and the point of bearing of the nose piece 71 on the gear teeth. Consequently, to set the nose pieces for a gear or predetermined pitch diameter, it is only necessary to space the mem-

bers 74^a and 75 a corresponding distance. Such spacing may be effected by the use of a series of gauge bars 76 which may be laid end to end within a channel member 77 mounted on the way 51.

A series of bars of different lengths may be built up which, together with a micrometer member 78, will produce the exact dimension. If the nose pieces contact with the gear teeth before the gauge is at the zero point, the pitch diameter will be too large and will require further shaving of the gear to bring it to the proper dimension. Accuracy in such measurement is also dependent upon eliminating all lost motion between elements of the structure, such as between the swivel plate 64 and the head 57. This I accomplish by placing annular hardened plates 64^a in recesses in the members 64 and 57 with hardened balls 64^b therebetween. I also preferably limit the amount of angular movement permitted to the plate 64 and sine bar 65 by means of a pin 64^c seated in the member 57 and projecting through an arcuate slot of limited length formed in the outer hardened plate 64^a carried by the plate 64, and concentric with pin 66. The length of the slot in the outer of these members will determine the amount of movement permitted to the plate 64.

Method of operation

The method of positioning the work on the bed 10 so that its axis is parallel to the plane of the carriage 13 and direction of movement thereof has already been fully explained. In testing for correctness of helix angle and pitch diameter the procedure is as follows. The linear pitch LP of the gear is the distance from the center line of one tooth to the center line of an adjacent tooth measured parallel to the center line (axis) of the work gear. The nose pieces 71 should be set a distance apart which is approximately $\frac{2}{3}$ of the face of the gear teeth but is an exact multiple of LP. Also, these nose pieces should be equally spaced from the swivel center. Such setting may be effected by the use of gauge blocks placed between a projecting cylindrical portion 66^a of the pin 66 and cylindrical portions 71^a of the nose pieces 71. To set the sine bar exactly horizontal, an anvil 72^b is arranged beneath the gauge 72. On this anvil a gauge block 72^c is placed and by resting the pin 73 of the sine bar on this block, the latter will be positioned horizontal. At the same time, the actuator 72^a contacts with the pin 73 and the indicator of the gauge stands at zero. The parts thus positioned are ready for testing the helix angle of the gear teeth. This is accomplished by moving the carriage 50 and also laterally adjusting the head 57 by rotation of the handle 63 until each of said nose pieces is in full contact with teeth on opposite sides thereof. If the gauge indicates a displacement of the sine bar from the horizontal, then the helix angle is not correct and the rotary head of the cutter must be slightly adjusted to correct this angle in a succeeding cut.

To test the gear for pitch diameter, the procedure is as previously set forth including, first, measuring a dimension corresponding to the pitch radius by use of the rod 76 and micrometer 78 in the channel 77, and then by adjusting the slide 50 towards the work. If the gauge 74 then indicates zero, the pitch diameter is correct. On the other hand, if the gauge is not at zero, the degree of error is indicated.

The sine bar and its associated parts may also be used for testing spur gears or gears in which the

helix angle is too small for testing by the method previously described. For such tests the gauge is first set to indicate the correct angle for the teeth and the two nose pieces are engaged with the same interdental space. The nose pieces also gauge the width of an interdental space at the pitch circle of the gear.

What I claim as my invention is:

1. A machine tool comprising a frame, a tool carriage reciprocable on said frame along rectilinear ways, a work support for a rotary work piece of such size that serious deflection of the work support under the load of the work piece cannot be avoided, means for adjusting said work support under load to bring the axis of the work piece into parallelism with the ways on which said tool carriage is slidable, and gauging means carried directly by said tool carriage for gauging parallelism between said ways and the axis of said work piece to facilitate adjustment of the work support under load into parallelism with the ways on which said tool carriage is slidable.

2. A gear finishing machine comprising a frame, a tool carriage reciprocable on said frame along rectilinear ways, a work support for a rotary work gear of such size that serious deflection of the work support under the load of the work gear cannot be avoided, means for adjusting said work support under load to bring the axis of the work gear into parallelism with the ways on which said tool carriage is slidable, and gauging means carried directly by said tool carriage for gauging parallelism between said ways and the axis of said work gear to facilitate adjustment of the work gear under load into parallelism with the ways on which said tool carriage is slidable.

3. A machine tool comprising a frame, a tool carriage reciprocable on said frame along rectilinear ways, a work support for a rotary work gear of such size that serious deflection of the work support under the load of the work gear cannot be avoided, means for adjusting said work support under load to bring the axis of the work gear into parallelism with the ways on which said tool carriage is slidable, and gauging means carried directly by said tool carriage for gauging parallelism between said ways and the axis of said work gear to facilitate adjustment of the work gear under load into parallelism with the ways on which said tool carriage is slidable, and additional gauging means on said tool carriage for measuring the helix angle of the work piece.

4. A machine tool comprising a frame, a tool carriage reciprocable on said frame along rectilinear ways, a work support for a rotary work gear of such size that serious deflection of the work support under the load of the work gear cannot be avoided, means for adjusting said work support under load to bring the axis of the work gear into parallelism with the ways on which said tool carriage is slidable, and gauging means carried directly by said tool carriage for gauging parallelism between said ways and the axis of said work gear to facilitate adjustment of the work gear under load into parallelism with the ways on which said tool carriage is slidable, and additional gauging means on said tool carriage for measuring the helix angle of the work piece, said last named means comprising a slide movable toward and away from the work piece, a

swiveled sine bar having members contacting tooth spaces of the gear on the pitch line, and means for gauging the position of said slide when said members are seated in the tooth spaces to indicate the pitch diameter of the gear.

5. A gear finishing machine comprising a frame, rectilinear ways on said frame, a carriage reciprocable on said ways, a work support for a rotary work gear of such size that serious deflection of the work support under load cannot be avoided, adjusting means for said work support for adjusting said work support under load to bring the axis of a work gear carried thereby into parallelism with the ways, a tool slide and a pair of gauge slides on said carriage, all movable along paths at right angles to the said ways, a gear finishing tool on said tool slide operable to correct helix angle errors in the gear and to reduce the pitch diameter thereof, gauging means on one of said slides effective to determine parallelism between the axis of said work gear and said ways, and gauging means on the other of said slides effective to determine the helix angle of the work gear when the axis of the work gear is parallel to said ways.

6. A gear finishing machine comprising a frame, rectilinear ways on said frame, a carriage reciprocable on said ways, a work support for a rotary work gear of such size that serious deflection of the work support under load cannot be avoided, adjusting means for said work support for adjusting said work support under load to bring the axis of a work gear carried thereby into parallelism with the ways, a tool slide and a pair of gauge slides on said carriage, all movable along paths at right angles to the said ways, a gear finishing tool on said tool slide operable to correct helix angle errors in the gear and to reduce the pitch diameter thereof, gauging means on one of said gauge slides effective to determine the helix angle and pitch diameter of the work gear when the axis of the work gear is parallel to said ways, and gauging means on the other of said gauge slides effective to determine parallelism between the axis of said work gear and said ways.

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