Sept. 18, 1945. F. W. DAVIS 2,385,129

GEAR LAPPING MACHINE

Filed Sept. 25, 1943 2 Sheets-Sheet 1

Fig. 1.

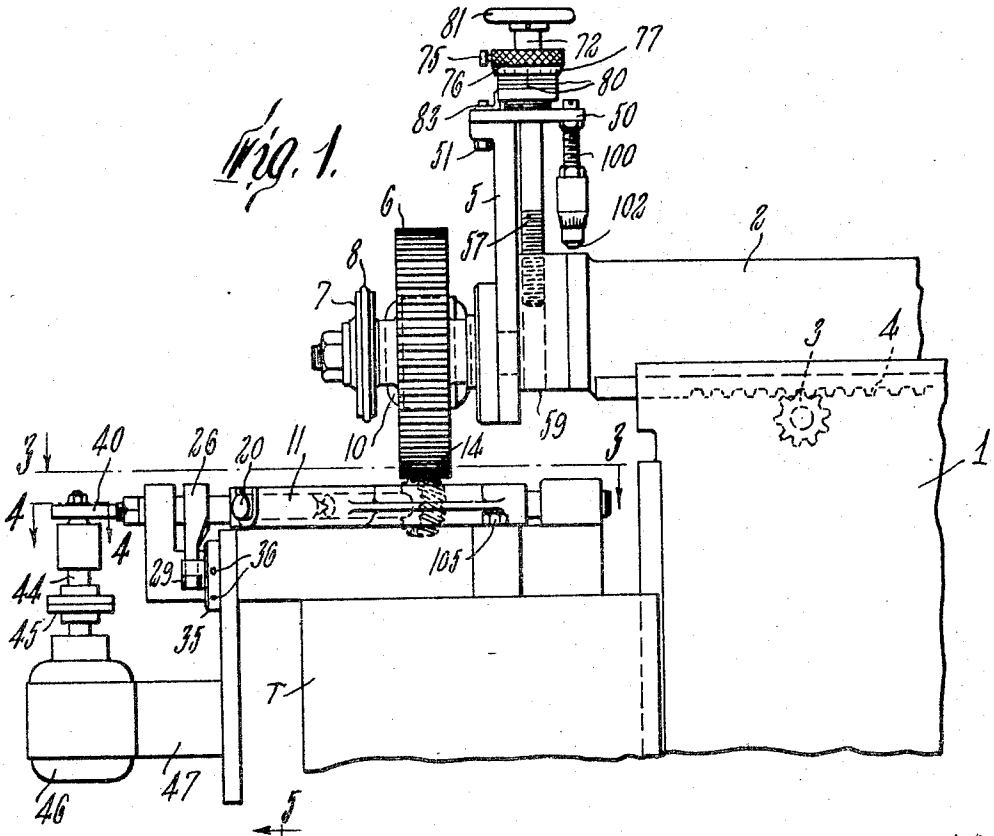


Fig. 2.

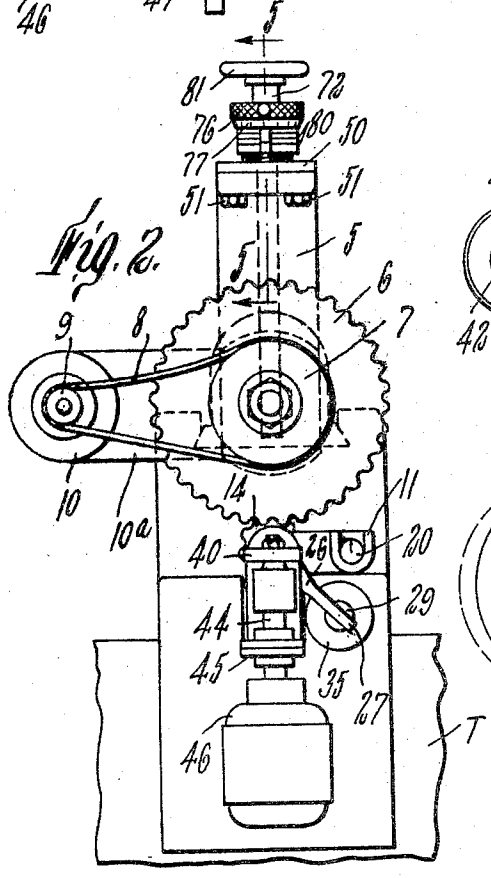


Fig. 3.

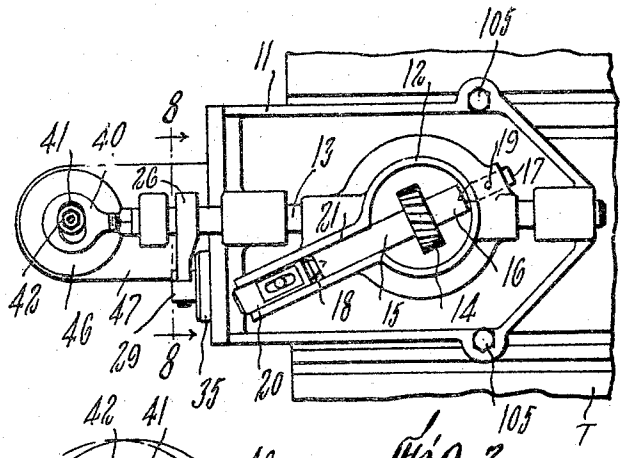
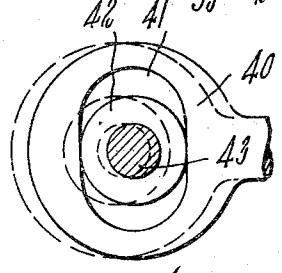


Fig. 4.



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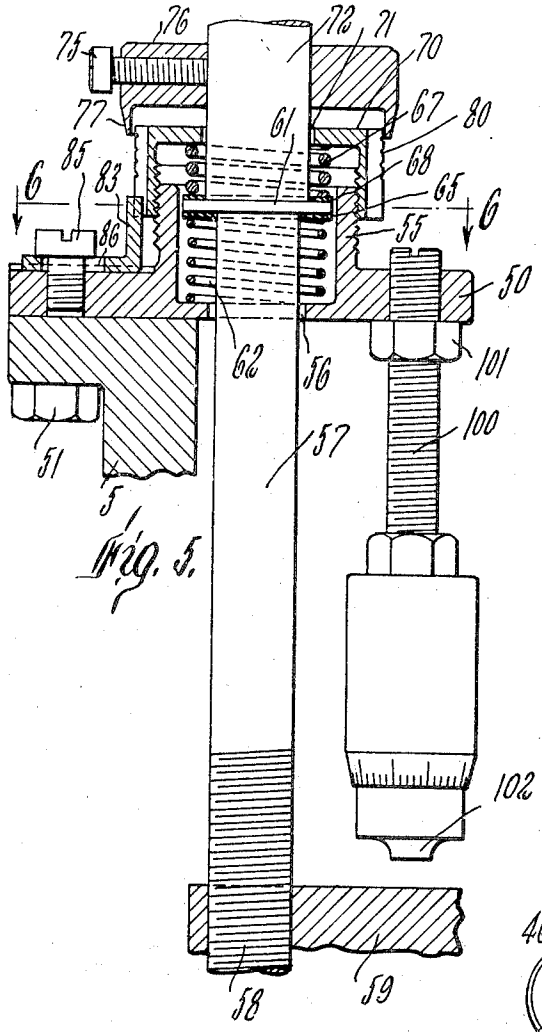


Fig. 5.

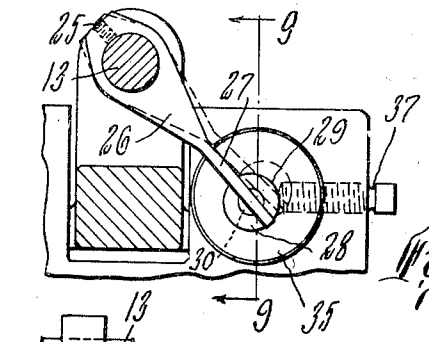


Fig. 8.

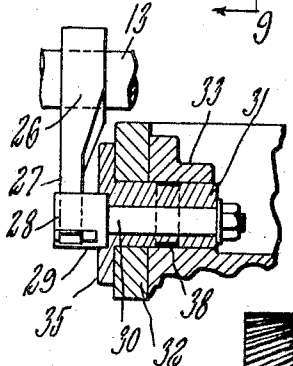


Fig. 9.

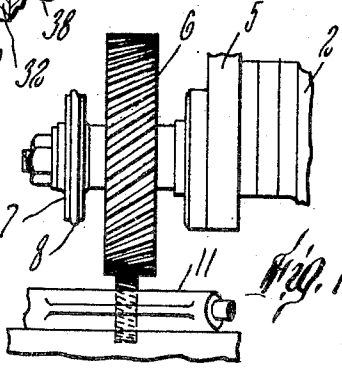


Fig. 10.

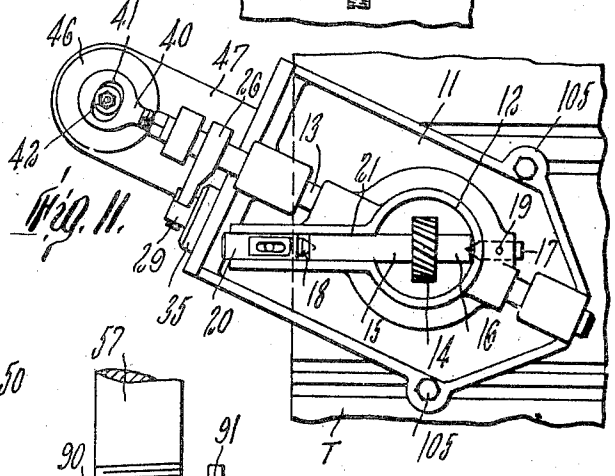


Fig. 11.

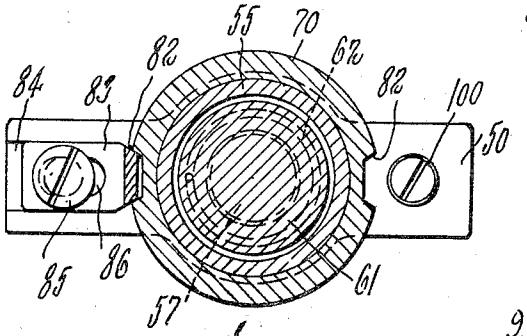


Fig. 6.

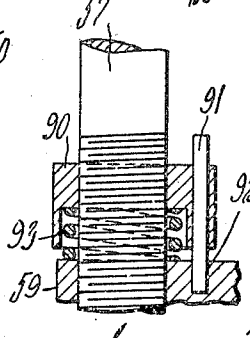


Fig. 7.

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UNITED STATES PATENT OFFICE

2,385,129

GEAR LAPPING MACHINE

Francis W. Davis, Belmont, Mass.

Application September 25, 1943, Serial No. 503,776

10 Claims. (Cl. 51—45)

This invention relates to the lapping of gears, this operation being of particular utility when the gears are to be used as impellers in pressure pumps in order to reduce leakage between the intermeshing gears and to increase accuracy and to reduce noise.

One of the methods heretofore used and known as the "cramp" method of lapping gears, consists in supporting the gear to be lapped for rotation about its axis, and employs a toothed lap in mesh with the gear and which is pressed radially against the gear. The lap and the gear are then traversed axially of the gear teeth and are rotated while in mesh to produce the lapping action. A serious drawback to this method as heretofore practiced resides in the fact that should the gear periphery be eccentric to the bearing axis of the gear, this is not corrected during the lapping operation. Under some conditions, also, eccentricity might even be increased by the lapping operation.

The present invention, therefore, has for an object to so modify this method that in the fully lapped gear, concentricity of the gear axis and the pitch circle of the tooth face of the gear is insured.

This modification consists in providing a micrometer stop limiting the motion of the lap toward the work axis so that the lapping is finished with the lap at a fixed distance from the gear axis for all angular positions of the lap and gear.

A further object of this invention is to provide a gear lapping mechanism in which the pressure between the lap and the gear is yieldable and adjustable.

Still another object is to provide such a machine in which a lap wheel of greater width than the gear may be used and with full advantage of the greater lap wheel width.

A further object is to provide an improved fixture for supporting the gear by which the gear may have free rotation about its axis, which is adjustable accurately to parallelism with the direction of traverse so that the lapped gear will not be tapered.

Yet another object is to provide for a rapid traverse of the gear being lapped, together with a slower traverse motion of the lap, which is found to be of advantage in rapidly producing a uniform lapped surface.

A still further object is to provide for rapid traverse motion between lap and gear in line with the tooth axis, thus avoiding inertia loads on the tooth face which would tend to destroy the tooth shape.

For a more complete understanding of this invention reference may be had to the accompanying drawings in which

Figure 1 is a fragmentary side elevation of a machine for lapping gears according to the method of this invention.

Figure 2 is a front elevation of the same.

Figures 3 and 4 are detail sectional views on the correspondingly numbered section lines of Figure 1.

Figure 5 is a detail vertical sectional view to a larger scale on line 5—5 of Figure 2.

Figure 6 is a detail sectional view on line 6—6 of Figure 5.

Figure 7 is a view similar to a portion of Figure 5, but showing a lost motion take-up.

Figure 8 is a detail sectional view to a larger scale on line 8—8 of Figure 3.

Figure 9 is a detail sectional view on line 9—9 of Figure 8.

Figure 10 is a view similar to a portion of Figure 1, but illustrating the use of a helical instead of a straight toothed lapped wheel.

Figure 11 is a view similar to Figure 3, but showing the position of the parts where lapping is accomplished in accordance with Figure 10.

Referring to Figure 1 of the drawings, the lapping operation is shown as accomplished on a shaper somewhat modified for the purpose. At 1 is indicated the frame of the shaper, and at 2 the reciprocating ram which is caused to move back and forth as by rotation in opposite directions of a gear 3, the teeth of which mesh with a rack 4 on the shaper ram. In place of the usual tool-carrying clapper of the ram, this ram carries at its forward end a vertical slide 5 mounted in ways. This slide 5 has fixed thereto a forwardly extending shaft on which is journaled a gear lap wheel 6, and also journaled on the shaft and fixed to rotate with the lap 6, is a belt pulley 7 about which may be passed a belt 8 which also engages about a small pulley 9 of a reversible low speed motor 10. This motor 10 is mounted on an arm 10a extending laterally from the slide 5, and the belt 8, as shown, is of the twisted type which engages about the pulleys with light friction, so that slippage may take place whenever resistance to the turning of the gear lap 6 is at all substantial.

The gear 14 to be lapped is mounted on the table T of the shaper in a fixture 11. As shown best in Figure 3, this fixture comprises a ring shaped member 12 secured to an axially movable

shaft 13 which is also mounted for angular adjustment. The gear to be lapped, and which as shown has shaft extensions 15 and 16, is supported within the ring 12, and its shaft portions 15 and 16 are arranged preferably at an angle corresponding to the helix angle of the gear relative to the shaft 13. This causes the relative reciprocation between the gear and the lap to be in line with the gear teeth so that this reciprocation does not cause the gear to be rocked back and forth with the traverse. Rotation of the gear is then produced by rotation of the lap and not by the relative reciprocation. This is advantageous, particularly where lapping is to be on the entire tooth surface, as for gears for a gear pump, since not only does it avoid undue wear of the gear faces at the pitch line area, but it also permits faster traverse with corresponding faster lapping. As shown the shaft portions 15 and 16 are journaled between the cone centers 17 and 18. The cone center 17 is fixed as by the pin 19, while the cone center 18 is adjustable axially, being fixed to a block 20 which is adjustable in ways 21 of the fixture. With this arrangement of the gear within the fixture, angular adjustment of the shaft 13 will produce endwise tilting of the axis of the gear to be lapped, and by such angular adjustment this axis may be brought into exact parallelism with the direction of motion of the lap 6 so that the gear in its lapped condition will be exactly straight or parallel instead of tapering.

The angular adjustment of the shaft 13 may be effected by mechanism shown best in Figures 8 and 9. To this shaft is secured as by a set screw 25, a rock arm 26, the outer end of which is shown as flattened as at 27 and rides between the jaws 28 of the head 29 of a pivot bolt 30. This pivot bolt is journaled eccentrically in a bushing 31, which, in turn is journaled in a frame member 32 on the work table T. It is also journaled in a coaxial opening in a supporting member 33 (see Figure 9). The bushing 31 is provided with a head 35 of enlarged diameter which engages the outer face of the member 32, and as shown best in Figure 1, it may be provided with peripheral holes 36 for the reception of a pin or spanner wrench by which the bushing 31 may be angularly adjusted. Such angular adjustment moves the pivot bolt 30 in an arcuate path (see full and dotted lines in Figure 8) and correspondingly adjusts the angularity of the shaft 13, this adjustment being exceedingly fine. The bushing 31 may be held in the bore in which it is journaled and also held in adjusted angular position, as by means of a set screw 37 engaging at its inner end in a peripheral groove 38 in the bushing.

As shown the lap wheel 6 is of greater axial length than is the gear to be lapped. It is given a relatively slow traverse through the traverse of the ram 2 so as to bring all portions of its axial length into operative relation to the gear being lapped, and at the same time it is desirable that the gear itself be given a more rapid reciprocation axially of the rock shaft 13. To this end, the outer end of the shaft 13 may have secured thereto a yoke 40 having a transverse slot 41 within which rides a roller 42 on a crank pin 43. This crank pin is eccentrically disposed to a drive shaft 44 shown as rotated through a coupling 45 from a motor 46. The motor 46 is suitably supported from the table of the machine as on a bracket member 47. During this relative reciprocation between the lap and the gear to be lapped, these two parts are pressed together by a force which may be made adjustable and to a definite minimum spacing between the axis of the lap and the axis of the gear.

Means for producing the desired pressure between these parts is shown best in Figure 5. The slide 5, as shown therein, has a cap plate 50 secured thereto as by the bolts 51 and this cap plate 50 has an upwardly extended socket portion 55 having a centrally reduced diameter opening 56 through its base. Through this socket and the opening 56 extends a rod 57 threaded at its lower end, as at 58, in a member 59 carried by the forward end of the ram 2. Within the socket portion 55 and secured on the rod 57 is a flange 61, and between this flange 61 and the base of the socket member 55 is positioned a relatively light coil spring 62. This coil spring at its upper end bears against a washer 65 beneath the flange 61. Above the flange 61 is a heavier coil spring 67 which bears on a second washer 68 resting upon the flange 61, and supported on the spring 67 is a cap member 70. This cap member 70 has a central opening 71 through which the enlarged diameter upper portion 72 of the rod 57 extends, and it is internally threaded for engagement with external threads on the socket portion 55.

To the upper portion of the enlarged diameter part 72 there is secured, as by a set screw 75, an externally knurled indicator member 76. This member 76 has a downwardly extending rim 77 extending outwardly of the cap member 70 and cooperates with peripheral horizontal and vertical index markings 80 on the member 70 to indicate adjustment of the relative tensions of the springs 67 and 62 by reason of the turning of the rod 57 to adjust the extent of the threaded engagement of its lower end and the angular adjustment of the cap 70. This rod 57, as shown in Figure 1, may have a hand wheel 81 at its upper end by which it may be turned.

It will be noted that the slide 5, together with the parts carried thereby, including the lap wheel, is supported by the spring 67 from the rod 57, and also that the spring 62 imparts a downward thrust to the slide 5 and the parts carried thereby, which acts in addition to the weight of these parts. By turning the hand wheel 81 and the cap member 70, the pressures exerted by these springs 62 and 67, respectively, may be adjusted as desired so as to determine the pressure exerted downwardly which presses the lap wheel 6 against the gear to be lapped. The cap member 70 may be locked in adjusted angular and axial relation with respect to the socket member 5. For this purpose it is shown as provided with two external longitudinal slots 82 into either of which may be engaged an angle stop member 83, the base of which is slidable in a groove 84 in the upper face of the member 50 and which may be secured in adjusted locking relation as by a screw 85 passing through a slot 86 of the stop and threaded into the member 50.

In Figure 7 means for taking up any lost motion between the threads of the head 57 and the member 59 is illustrated. Referring to this Figure, there is threaded on the lower portion of the rod 57 a nut 90 which may be fixed in any desired position of adjustment as by a pin 91 extending therethrough and engageable in one or more sockets 92 in the upper face of the member 59. This nut 90 is shown as recessed in its under face for the reception of a coil spring 93 which reacts between the nut 90 and the

member 59 and acts to produce an upward thrust on the rod 57 which takes up any such lost motion. The amount of this upward thrust may be adjusted as required by pulling the pin 91 out of the socket 92 and then adjusting the nut 90 in the proper direction to adjust the tension on the spring 93 to the amount desired, after which the pin 91 can be returned into one of the sockets 92 to hold the parts in adjusted position. The strength of the spring 93 must be sufficient to support all of the weight of the shaft 57 and all the parts carried thereby.

Means are provided, in accordance with this invention, by which the minimum approach between the lap and the axis of the gear to be lapped may be accurately fixed. Thus as the lapping proceeds under the pressure of the lap against the gear wheel, and the lap is rotated, which also rotates the gear wheel, the lapping proceeds until at least one portion reaches the desired minimum size at the pitch circle of the gear. The lap is then prevented from moving further toward the axis of the gear, although it may move away therefrom if the desired pressure between these parts would otherwise be exceeded, and the lapping proceeds until the remaining part of the gear is reduced to the same minimum diameter, thus to produce concentricity in the lapped gear of its pitch circle and its rotational axis. In order to produce this limit of motion, a micrometrically adjustable stop is employed. Such a stop of any suitable construction and shown at 102 is adjustably secured to the lower end portion of a rod 100, which at its upper end is shown as threaded through the member 50 and is provided beneath the member 50 with a lock nut 101 by which it may be secured in adjusted position.

As shown in Figure 3, the fixture 11 which supports the gear is secured to the top of the table T, as by bolts 105, in such an angular relation that the teeth of the gear to be lapped where they are engaged by the teeth of the lap wheel are parallel to the line of motion of the ram 2. Since the gear itself is shown as a helical gear, the axis of the gear is then arranged at an angle to the direction of travel of the ram 2 at least approximately that of the helix angle of the gear, the lap being a spur gear.

In Figures 1 to 3, the gear is shown as a helical gear while the lap is a spur gear. In Figures 10 and 11 the proper arrangement where the lap is also helical and of opposite hand is illustrated, the axis of the shafts 15 and 16 as then arranged being parallel to the line of traverse.

As is well known, the table of a shaper is provided with parallel T slots and this construction facilitates securement of the gear holding fixture in any angular position desired.

It is also preferable that the motor 10 be a reversible motor so that it may be rotated part of the time in one direction and part of the time in the other during a lapping operation in order to insure gear teeth symmetrical on opposite faces. This facilitates the gear being run with a mating gear in either direction with substantial equal smoothness of operation.

From the foregoing description of an embodiment of this invention, it should be evident to those skilled in the art that various changes and modifications might be made without departing from the spirit or scope of this invention.

I claim:

1. A gear lapping machine, comprising a fixture for supporting the gear to be lapped for rotation about its axis, means for supporting a gear lap of greater axial length than said gear in meshing relation to said gear, means for reciprocating said lap axially with a stroke of predetermined length and rate, said length being sufficient to contact substantially the whole length of said lap with said gear, means for reciprocating said gear with a different amplitude and rate while in contact with said lap, means for rotating said lap to thereby rotate said gear, said lap supporting means permitting said lap to move toward and from the axis of said gear, means for adjusting the pressure with which such lap may be so moved, and means for adjustably limiting the minimum distance between said lap and said gear axis.

2. A gear lapping machine, comprising a fixture for supporting the gear to be lapped with its axis horizontal, a horizontal reciprocating head, a gear-shaped lap supported for vertical motion on said head to engage and lap said gear as said head is reciprocated, means for applying adjustable yielding pressure between said lap and gear, a stop determining the minimum distance of said lap from the axis of said gear, and means for reciprocating said head.

3. A gear lapping machine, comprising a fixture for supporting the gear to be lapped with its axis horizontal, a horizontal reciprocating head, a gear-shaped lap supported for vertical motion on said head to engage and lap said gear as said head is reciprocated, means for applying adjustable yielding pressure between said lap and gear, a stop determining the minimum distance of said lap from the axis of said gear, means for reciprocating said head, and means for yieldingly rotating said lap to thereby rotate said gear.

4. A gear holding fixture, comprising a holder, means for journaling for rotation about its axis the gear to be lapped within said holder, means journaling said holder about an axis angularly disposed to the axis of the gear, and means for adjusting the said gear about the journal axis of said holder.

5. A gear holding fixture, comprising a holder, means for journaling for rotation about its axis the gear to be lapped within said holder, means journaling said holder about an axis angularly disposed to the axis of the gear, means for adjusting the said gear about the journal axis of said holder, and means for reciprocating said holder in the direction of said angularly disposed axis.

6. A gear holding fixture, comprising a holder, means for journaling in said holder about the gear axis a gear to be lapped, and means for angularly adjusting said gear about an axis out of parallelism with said gear axis.

7. A gear holding fixture, comprising a support, a gear holder, a shaft supporting said holder and journaled in said support, and means carried by said holder supporting said gear for rotation about its axis angularly disposed to said shaft.

8. A gear holding fixture, comprising a support, a gear holder, a shaft supporting said holder and journaled in said support, means carried by said holder supporting said gear for rotation about its axis angularly disposed to said shaft, and means for angularly adjusting said shaft.

9. A gear holding fixture, comprising a support, a gear holder, a shaft supporting said holder and journaled in said support, means carried by

said holder supporting said gear for rotation about its axis angularly disposed to said shaft, means for angularly adjusting said shaft, and means for reciprocating said shaft to thereby reciprocate said gear.

10. A gear holding fixture, comprising a support, a gear holder, a shaft supporting said holder and journaled in said support, means carried by said holder supporting said gear for rotation about its axis angularly disposed to said shaft, an arm fixed to said shaft, a bushing journaled in said support, a pin eccentrically journaled in said bushing and a yoke carried by said pin and engaging said arm, and means facilitating angular adjustment of said bushing to thus effect a fine adjustment of the angularity of said gear axis.

FRANCIS W. DAVIS.