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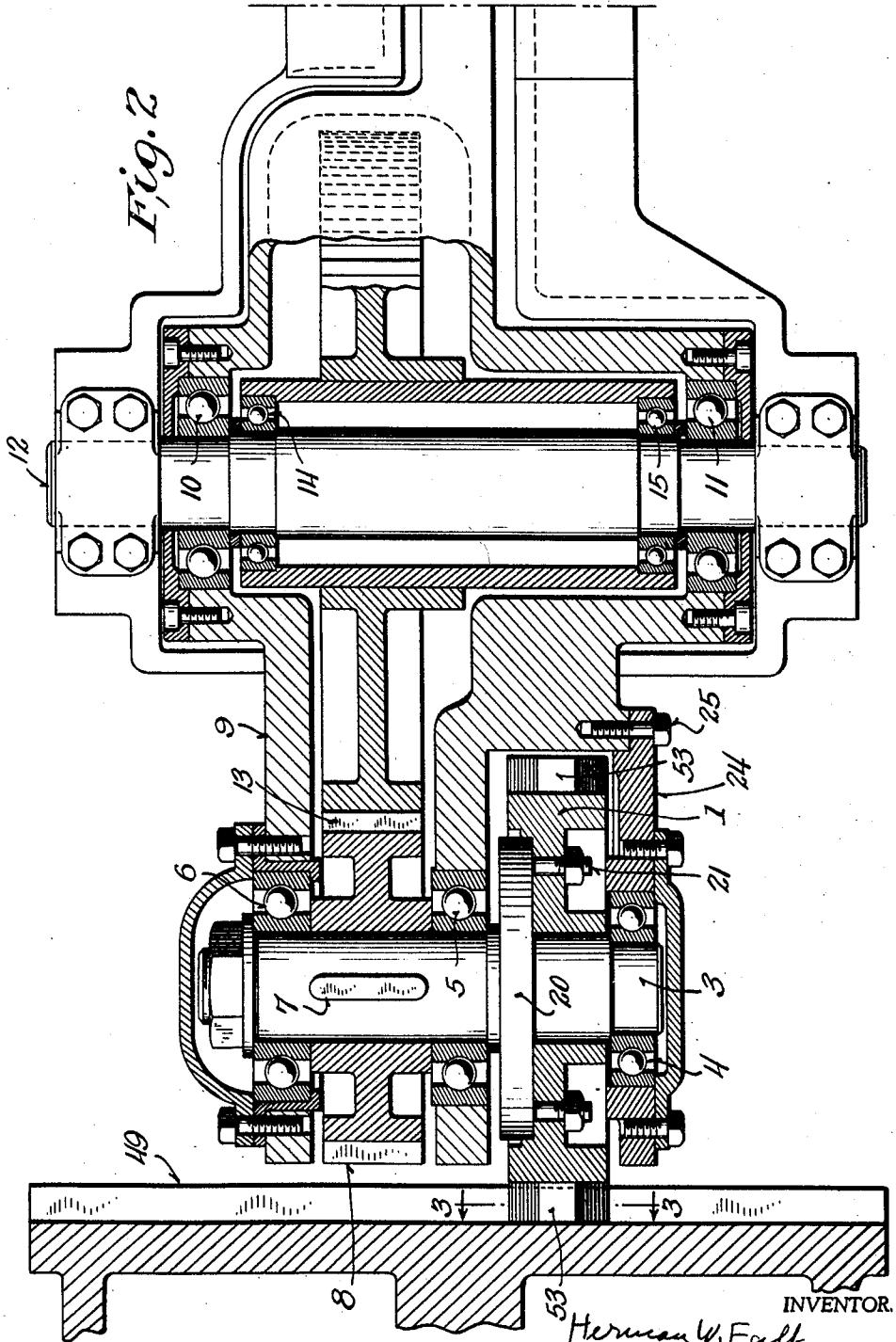
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METHOD OF FINISHING GEAR TOOTH SURFACES

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METHOD OF FINISHING GEAR TOOTH SURFACES

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Continuation of application Serial No. 104,854,
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Serial No. 266,870

1 Claim. (Cl. 29—90)

This application relates to a method for finishing gear tooth surfaces and constitutes a continuation of my application Serial No. 104,854, filed October 9, 1936. The method consists in subjecting a fractional part of the length of a gear tooth face to finishing stresses and successively shifting the zone of said stress over the working surface of the gear. It is thus possible to apply finishing stresses of high unit intensity without dangerous overload of the gear so that burnishing may be rapidly accomplished, or, if it is desired, it is thus possible to apply finishing stresses in conjunction with a fine abrasive to bring about lapping or selective lapping of those areas projecting beyond a selected contour.

The method of this invention makes possible the formation of glazed or burnished finishes on tooth faces in short intervals of time and with the expenditure of very little power. This invention also involves a method of selective lapping of gear teeth in contrast to the general lapping heretofore known, making possible a final correction of tooth contour heretofore unattainable. For the above reasons the application of the method of this invention is useful in the treatment of gears of any size from the gears of precision instruments, such as watches, to gears of the largest size.

In obtaining lapping and burnishing, according to this invention, the gear being treated may be, for example, caused to rotate and to drive an intermeshing, resisting pinion. The resisting pinion is drivingly coupled with the rotating gear so that a driving reaction resulting from the resisting action and equal thereto is communicated to some point of reference on the gear to be treated, in a regenerative manner. This point of reference may be a fixed point on the gear being treated, or may be a movable point, such as successive teeth. The coupling means employed are preferably of such nature that the resistance and reaction are subject to regulation.

Simple and effective forms of apparatus suitable for carrying on the method of this invention are described by reference to the drawings, wherein

Fig. 1 is a side view, with portions broken away, of one form of apparatus suitable for carrying on the method of this invention;

Fig. 2 is a sectional view taken on the plane 2—2 of Fig. 1; and

Fig. 3 is a detail section of a tooth taken at the line 3—3 of Fig. 2.

One form of apparatus suitable for carrying on the method of this invention is shown in Figs. 55

1 and 2 and consists of two pinions, a resisting or opposing pinion 1, having a face width narrower than the face of the gear to be treated and a reacting pinion 2, which pinions are mounted to rotate in synchronism. Synchronism is obtained by carrying pinion 1 upon shaft 3, which, as shown clearly in Fig. 2, is mounted to rotate in bearings 4, 5, and 6. The shaft 3 is rigidly keyed by key 7 to a pinion 8. The bearings 4, 5, and 6 are rigidly attached to a beam 9, which is mounted on bearings 10 and 11, which in turn are carried by a stationary gudgeon shaft 12. A gear 13 mounted on bearings 14 and 15 meshes with pinion 8 and rotates about the center of gudgeon shaft 12 so that pinion 8 remains in constant mesh with gear 13, regardless of the position of beam 9. As a support for the machine and as means for carrying the stationary gudgeon shaft 12, is a bed 16 which carries bearings similar to those which support shaft 3, one of which, numbered 17, is indicated in Fig. 1. These bearings, including bearing 17, support for rotation a shaft 18 which carries rigidly secured thereto the pinion 2. Likewise mounted on the shaft 18 and rigidly secured thereto is a pinion 19, shown in dotted lines, which meshes with the gear 13. The pinion 19 has the same number of teeth and the same diameter as pinion 8 and the opposing and reacting pinions 1 and 2 are of the same diameter and bear the same number of teeth. In this way, as long as beam 9 is substantially stationary, resistor and reactor pinions 1 and 2 must remain synchronized.

As shown clearly in Fig. 2, the shaft 3 carries as an integral part thereof a wide collar 20, into which collar studs 21 are secured. Pinion 1 is provided with a series of slotted holes 22 so that the angular relation between the teeth of pinions 1 and 2 may be adjusted to any position desired by the use of clamping nuts 23. The pinion 2 is secured in similar fashion to the shaft 18 so that replacement of pinions 1 and 2 with others of different tooth form or pitch may be made. To facilitate this change, the beam 9 is provided with a removable portion 24, held in position by means of bolts 25. The bed 16 is likewise provided with a removable portion 26 which is held in place by means of bolts 27.

Extending to the right of the gudgeon shaft 12 is a portion of the bed 16 which serves as a support for the loading mechanism. The loading mechanism comprises standards 28 and 29 upon which the fixed fulcrums 30 and 31 are supported. A graduated beam 32 rests upon fulcrum 31 and through weights 33 and 34 loads the linkage 35

to any definite degree desired. The linkage 35, through pivot 36, loads the lever 37, which in turn is supported on its pivot 38 on the fulcrum 30. Secured to the lever 37 is a counterweight 124, which is properly proportioned and positioned to counterbalance the levers 37 and 32. The lever 37 being loaded a definite, known amount loads the connecting member 39 and exerts a known load upon the pivot 40, which is an integral part of the beam 9. The beam 9 is also counterweighted to offset the heavy weight of the pinions at the working end of the machine. This is accomplished by hanging a properly adjusted weight 125 on the end of the beam 9.

The bed 16 carries a dove-tailed foot 41 which is fitted to slide in a guideway 42. The bed 16 is also drilled and adapted to threadingly receive the screw 43, which is rotatably mounted in a projection of guide 42, not shown, so that the screw will rotate therein without longitudinal movement and traverse the bed 16. Guide 42 is also provided with a dove-tail foot 44 which is fitted to slide in a guideway 45 in the foundation 46. The guideway 42 is drilled and adapted to threadingly receive a screw 47, which is mounted in a projection of the foundation 46 to rotate therein without longitudinal movement and traverse the guideway 42 at right angles to the movement of bed 16. Screws 43 and 47 are provided with means for turning the same, for example, as shown in the hand-wheel 48, which is attached to screw 47.

Means, not shown, are provided for mounting for rotation a gear to be treated, designated 49. Said gear is mounted in such position that through the manipulation of screws 43 and 47 pinions 1 and 2 may be brought into mesh with the gear 49. This operation is facilitated by locking beam 9 against movement with respect to bed 16, loosening nuts 23 and removing all back-lash by adjusting pinion 1 in the slotted holes 22 and then clamping the nuts 23. In order to indicate the movements of beam 9 after adjustment of the pinions 1 and 2 to gear 49, any point of reference in the loading system may be observed. A convenient way of accomplishing this is by means of an ordinary extensometer gauge 50 which is rigidly attached to the support of the loading system. The feeler 51 of the gauge bears upon the lever 37. It may also be convenient to attach an extensometer gauge to the studs 123, shown in Fig. 1. While it is useful to thus measure movement of the parts, the method of this invention is in no way dependent thereon.

It will be observed that the width of pinions 1 and 2 is narrow as compared with the tooth face of the gear 49 and, further, as indicated in Figs. 2 and 3, the teeth of pinions 1 and 2 are relieved or cut away so that a bearing or contacting area 53 bears upon the teeth of gear 49. In this way, without excessive loading of the beam 9, very large stresses per unit length of tooth contact may be obtained. The stresses applied to the gear being treated are thus localized in a small zone and the stress is applied in the form of a rubbing, or combined rubbing and rolling, action cross-wise of the tooth face being treated. The beam 32 projects through a controlling standard 126, which is provided with adjusting screws 127 and 128. The latter may very conveniently be employed as motion-limiting means during the operation of selective lapping.

The smoothness with which the apparatus functions can be enhanced by the addition of a dashpot 129, the latter being connected at 130

with the beam 32 to dampen the movement thereof. The dashpot is preferably adjustable to any degree of dampening desired so that appropriate dampening may be had for any degree of loading. The link 39 is also advantageously provided with a turn-buckle or right hand-left hand coupling 131 so that deflections of the various parts may be compensated for.

In operating the device above described, it is convenient to place a small block of rigid material in the nip 52 between the beam 9 and the bed 16 and to place sufficient weights 33 and 34 upon the loading system to hold the beam relatively stationary with respect to the bed. The proper pinions 1 and 2 for the gear 49 to be treated, which may be any form of gear, helical or spur, involute or cycloidal, etc., are then selected and put into place, as described above. By means of the handwheel 48, the pinions 1 and 2 are brought into mesh with the gear 49 and all back-lash removed at the slotted holes 22, as previously described. The weights 33 and 34 are then reduced so that the block in the nip 52 can be removed. The screw 43 is then manipulated to position the pinions 1 and 2 at either one side or the other of the broad tooth face of gear 49. With the gear to be treated thus prepared, the method of this invention may be employed for either lapping or burnishing.

Lapping is accomplished by the method of this invention as, for instance, in the above-described machine, by inserting a gauge block in the nip 52, placing a moderate load upon the beam 32, and then rotating gear 49 while applying a fine abrasive compound thereto while the gear 49 is rotating the screw 43 is manipulated so that the contact area 53 is applied over the entire face of gear 49. The gauge block is so dimensioned that it supports all of the load placed on beam 32 when the gears 1 and 2 are in mesh with a theoretically perfect gear 49. In other words, the teeth of said gears 1 and 2 will approach gear 49 to contact therewith, but without the imposition of any load thereon. If, however, gear 49 is not perfect, protrusions beyond the prescribed contour will force the gears 1 and 2 apart and open the nip 52 to an extent proportional to the protrusion and, what is more important, transfer the load upon beam 32 to the gear 49. The transfer of the load from the gauge block to the gear 49, whenever a protrusion occurs, and the return of the same to the gauge block whenever the gear lies within the prescribed contour, provides a selective means for causing the abrasive between the gear 49 and the gears 1 and 2 to become active only against protruding parts. In this way a gear 49 having slight imperfections may be quite quickly and easily corrected without the usual objectionable general reduction of sub-contour, as well as protruding areas, which occurs to an appreciable extent in the old form of lapping. It will be seen that selective lapping provides a means for the final correction of minute dimensional errors which heretofore could not be corrected.

Burnishing is accomplished by the method of this invention by simply making the loading of weights 33 and 34 sufficient so that a friction-reducing finish will be produced on the teeth of gear 49 when the latter is rotated for a moderate length of time in contact with pinions 1 and 2, which at the same time are moved transversely across the face of the gear 49. The gauge block is, of course, removed during either burnishing or lapping if a selective effect is to be avoided.

Burnishing as performed by this method of this invention is thus brought about by high local stressing of successive parts only of the length of the teeth of the gear being treated. In this way the method of this invention permits the use of moving contact stresses of sufficient intensity to cause surface metal in the gear to flow out into a very thin, highly polished layer, such as is normally developed after long periods of use under load. In spite of the high unit stress employed by the method of this invention and the rapidity with which the burnished surface is developed, the total loads placed upon the gear being treated are moderate and the method may be carried on without danger of damage to the gear.

The employment of pinions narrower than the face of the gear to be treated makes possible high unit stresses for finishing purposes without the necessity for building a very massive machine. The limited zone of contact is also useful in avoiding dangerous deflections of wide extent in a gear being treated; in localizing the effect of treatment; and in avoiding high hub stresses. Benefit also lies in the fact that treating of the gear is obtained with the expenditure of only a moderate amount of energy. In the same manner the relieving of the sides of the teeth of the contacting pinions to concentrate the stress on a narrow central working area is useful in avoiding excessive stresses in the contacting pinions, but this is not essential.

Herein in the specification and claim the term "finishing" is used to mean the mechanical treatment of tooth surfaces, as by lapping or burnish-

ing, to reduce the tool marks and scratches thereon and to bring about a friction-reducing smoothness.

While instances of the application of the method of this invention have been illustrated, it is intended that the scope of Letters Patent granted hereunder be not unnecessarily limited thereby, but that said protection extend to the full scope of the invention as represented by the claim here-to appended.

What I claim as my invention is:

The method of finishing gear teeth surfaces which consists in meshing with the teeth of a work gear to be finished a tool gear having an effective face narrower than the face of said work gear, maintaining the shaft spacing between said work gear and said tool gear constant, causing the teeth of said tool gear to engage the teeth of said work gear in a driving relationship to establish a finishing pressure between the engaging teeth of said work gear and said tool gear while applying an opposite and tangential torque substantially equal to the torque resulting from said finishing pressure to said work gear at a point on said work gear spaced from the zone of meshing engagement of said tool gear and work gear, and while said finishing pressure and said countertorque is maintained causing said work gear and tool gear to rotate in mesh with one another and to move axially with respect to one another to extend the treating action around and across the face of said work gear.

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