

Feb. 20, 1934.

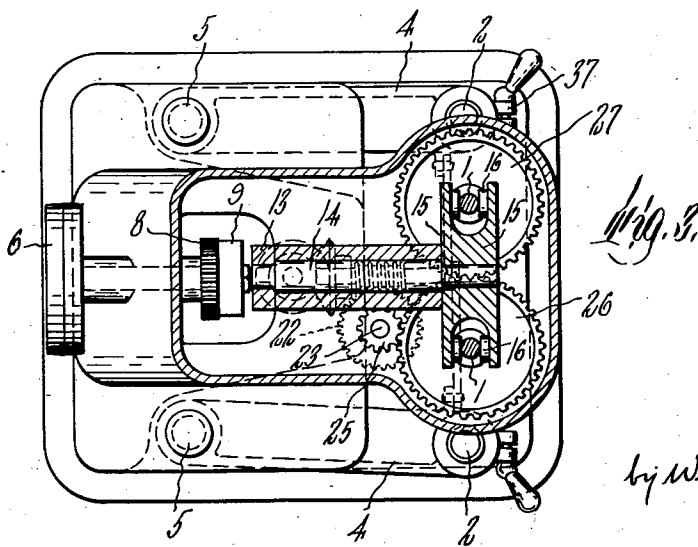
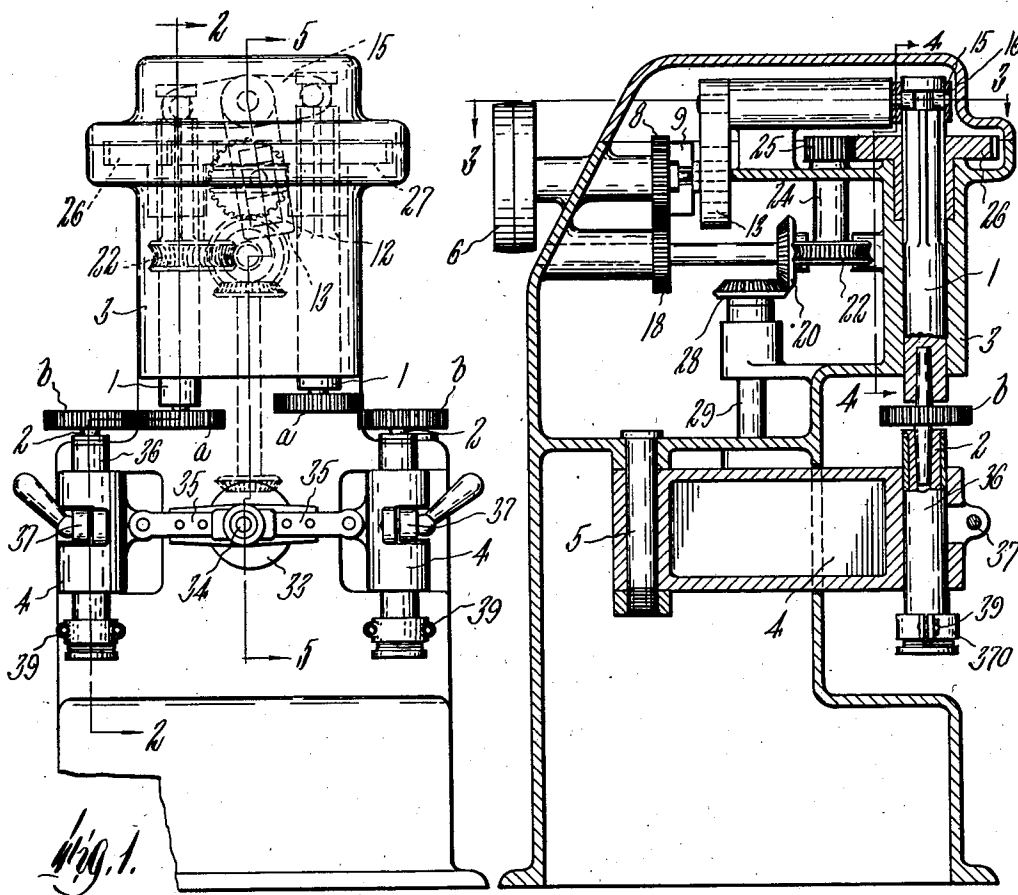
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1,948,071

METHOD AND EQUIPMENT FOR LAPPING SPUR-HELICAL AND INTERNAL GEARS

Filed April 15, 1929

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

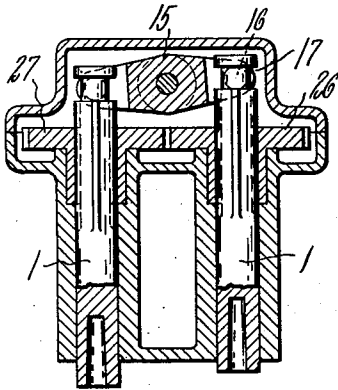


Fig. 4.

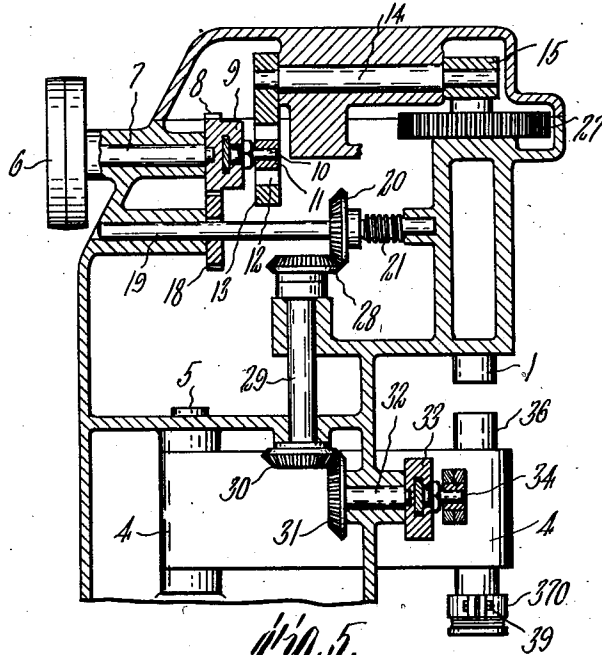


Fig. 5.

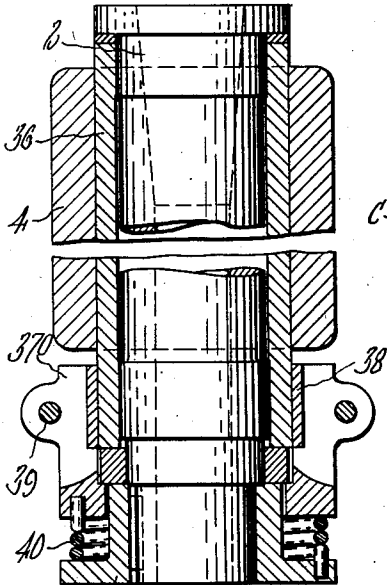


Fig. 6.

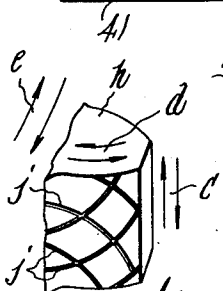


Fig. 9.

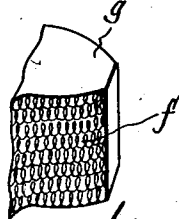


Fig. 10.

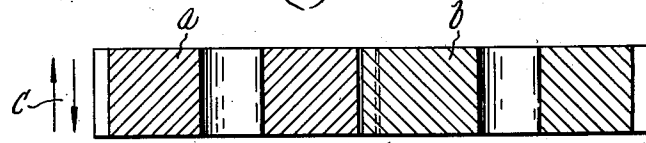


Fig. 7.

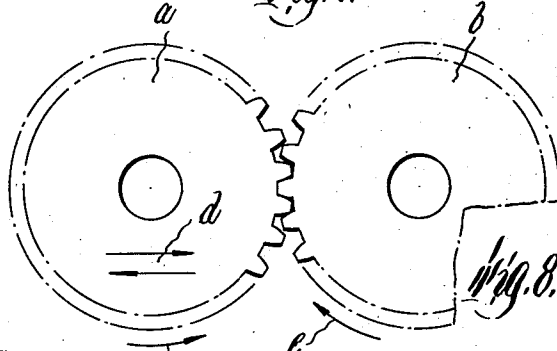


Fig. 8.

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UNITED STATES PATENT OFFICE

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METHOD AND EQUIPMENT FOR LAPPING
SPUR-HELICAL AND INTERNAL GEARSFelix C. Hofmann and Fritz F. Rohl, Berlin,
GermanyApplication April 15, 1929, Serial No. 355,240, and
in Germany April 16, 1928

13 Claims. (Cl. 51—278)

This invention relates to the finishing of gears, whether spur, helical or internal gears, and more particularly to lapping gears after heat treatment. The demand for practically noiseless gears has necessitated a further finishing treatment after they have been cut and heat treated in the ordinary manner. Various methods, including lapping, have been used to make the tooth faces adequately smooth to meet this demand.

One long known mode of lapping is to rotate a pair of meshing gears at high speed in a running-in machine, with no other motion than that of rotation, while feeding finely divided abrasive between their teeth, but this method is unsatisfactory because it results in destruction of the correct tooth form. The slip between the contacting teeth is unequal and continuously changing, being greatest at the point and root extremities of the teeth, and diminishing toward the pitch line where there is little or no slip, but only rolling contact. Thus if gears are lapped by rotation only, the different rates of sliding motion will result in great inequality of lapping effect. Gears lapped in this way lose their correct tooth form by being too much abraded toward the addenda and dedenda, whereby the length of tooth contact is seriously shortened, being limited to narrow areas contiguous to the pitch line.

Another known gear lapping method is to give a slow rotation to a pair of gears for feeding only, while the lapping effect is obtained by moving the gears relatively to one another in an axial direction at much greater speed. While this latter method does not destroy the tooth form, it is nevertheless ineffective because it also fails to remove the surface irregularities which exist to a greater or less degree in all cut gears.

The failure of this lapping method will be understood by considering the methods of gear cutting. These methods comprise milling, hobbing, or shaping. In any case the tool is passed lengthwise through the tooth spaces, and in so passing it leaves longitudinal tool marks in the faces of the teeth thus cut. Also gears which are cut by generation, with a coarse rotary feed, exhibit under minute examination somewhat of a polygonal structure, with angles or ridges between successive paths of the cutter. Roughness from these causes makes noise when the gears are run. But such longitudinal cutter marks or ridges cannot be removed by the method of lapping with axial motion only, because in this method the abrasive grains travel in

the same directions as the cutter marks, etc., and do not remove, but rather tend to deepen, them.

Our invention has for its object to avoid the disadvantages of the above mentioned prior methods and to obliterate cutter marks and ridges, as well as other roughnesses, from the tooth faces of cut gears, in a substantially uniform manner over their entire contact areas, while maintaining substantial accuracy of form. We accomplish these objects by giving to the gears being lapped a complex relative movement, which includes a radial component as well as axial and rotary components, whereby a circular character of rubbing motion between the surfaces in contact is effected. Naturally the speed of the component movements may be varied. If they are varied so that the period of contact between intermeshing gear teeth is only momentary, a complete circular rubbing motion consequently cannot be effected during a single period of contact. When this is the case only a short curvilinear rubbing path will be traversed. However, each time there is contact on a particular gear tooth another short curved path is traversed. The direction of these curved paths varies and as this procedure is continued every portion of the toothed surface will be rubbed. The final result of this rubbing by a series of short curved paths which run in every direction is substantially the same if not equal to the circular rubbing motion described. The invention consists in a new method and a new machine, the principles and a practical embodiment of which are described in the following specification, with reference to the drawings, for carrying the foregoing object into effect.

In the drawings,—

Fig. 1 is a front elevation of a machine embodying one phase of the invention;

Fig. 2 is a longitudinal vertical section of the machine taken on line 2—2 of Fig. 1;

Fig. 3 is a horizontal section taken on line 3—3 of Fig. 2;

Fig. 4 is a sectional view of part of the machine taken on line 4—4 of Fig. 2;

Fig. 5 is a vertical section taken on line 5—5 of Fig. 1;

Fig. 6 is a sectional detail view, on a larger scale, of one of the driven spindles of the machine;

Fig. 7 is an axial sectional view, and Fig. 8 a plan view, of a pair of gears being lapped according to this method;

Fig. 9 is a perspective view of a single tooth

of a master or tool gear which may be used in the performance of our method;

Fig. 10 is a perspective view of a single tooth of a gear being lapped by this method.

5 Like reference characters designate the same parts wherever they occur in all the figures.

Referring first to Figs 7-10, *a* and *b* represent two gears in mesh with one another and being lapped. These may both be machine gears intended to be installed in a machine after being lapped, or one of them may be such a gear and the other may be a master or tool gear. One of these gears, as the gear *a*, is given a back and forth reciprocation in the axial direction, as indicated by the arrows *c* in Fig. 7; one of them is moved radially toward and away from the other, as indicated by the arrows *d* in Fig. 7; and both are rotated as indicated by the arrows *e*. The axial and radial motions may be imparted exclusively to one gear, or the axial motion to one and the radial motion to the other exclusively, or either or both characters of motion may be given in partial degree to both. Rotation is necessarily imparted to both simultaneously and equally. It is preferably very slow in proportion to the speed of the other motions, and applied for the purpose of progressively shifting the line of contact across the faces of the contacting gears (from point to root and vice versa) and of bringing successive teeth into mesh and lapping engagement. The effect of these motions is graphically indicated by looped lines on the surface *f* of a typical tooth *g*, shown in Fig. 10, such lines indicating by their loops the relative circular rubbing movement between the tooth faces in contact, and the progression of such movement across the faces. Where one of the gears is a master or tool, a tooth of which is shown at *h* in Fig. 9, its tooth faces may be provided with grooves *j* for retention and guidance of the abrasive. Incidentally, Fig. 9 shows by arrows identified as above, all the components of motion described.

45 A machine which we have developed for carrying out the foregoing process is illustrated in Figs. 1-6 inclusive. This machine is duplex, having two driving spindles 1, 1, each carrying one member, as *a*, of a gear pair to be lapped, and two driven spindles 2, 2, each carrying the other, as *b*, of the gear pair. The driving spindles 1 are both adapted to slide endwise and rotate in bearings in a superstructure 3 of the frame. The driven spindles 2 are each rotatable in a swinging holder or arm 4 pivoted by a vertical pivot stud 5 to the base part of the frame in a lateral recess.

Power is transmitted by a pulley 6 on a shaft 7, which also carries a combined gear 8 and slotted crank disk 9 on its inner end. In the diametral slot across the face of the crank disk is adjustably clamped a crank pin 10 rotatable in a slide block 11 which fits a slot or guideway 12 in an arm 13 secured to the rear end of a shaft 14. 65 A cross beam or rocker 15 is secured to the forward end of the shaft 14 and has studs 16 on each of its forked ends flanking the respective driving spindles 1 and entering encircling grooves 17 in the sides of said spindles. Thus the two driving spindles are reciprocated oppositely to one another.

75 Gear 8 meshes with a gear 18 on a shaft 19 which carries a bevel gear 20 and a worm 21. The worm drives a worm gear 22 on an upright shaft 23, which is contained in a bearing 24, and

on the upper end of which is a pinion gear 25 meshing with a gear 26 which surrounds and is splined to one of the spindles. A similar gear 27 is in like manner splined to the other driving spindle and meshes with gear 26, whereby the 80 spindles are driven in unison.

Bevel gear 20 drives a mating bevel gear 28 on an upright shaft 29 which, through bevel gears 30 and 31, drives a shaft 32. On the latter shaft is a slotted crank disk 33 carrying an adjustably positioned crank pin 34 which is connected to the swinging arms or holders 4, 4 by links 35, 35. Thus the driven spindles are moved in unison back and forth radially of their 90 complementary driving spindles.

The gear *b* is driven by the gear *a* in each instance, and its rotation is resisted by a brake in order to obtain the desired lapping pressure. For this purpose, as well as also to permit of endwise adjustment to accommodate gears of 95 different characteristics, each spindle 2 is rotatably mounted in a quill or sleeve 36 (best shown in Fig. 6) which passes through, and protrudes at both ends from, the carrier 4, and is adjustable endwise, being secured by a clamp 37 of any suitable character. The brake is a divided sleeve 100 370 which embraces the lower end of quill 36, carrying a friction shoe 38 in contact therewith, and having clamp bolts 39 by which its parts may be pressed with any desired force against 105 the quill. This brake element is coupled by a spring 40 on a collar 41 made fast and keyed to the lower end of the spindle.

Further details of construction and arrangement, clearly shown in the drawings, are not described verbally herein; and neither are refinements and modifications which may be applied by machine designers for increasing the efficiency of the machine and for applying its principles in specifically different forms. 115

It will be understood from the description and drawings that, while each driving spindle is moved endwise up and down, the corresponding driven spindle is simultaneously moved sidewise back and forth radially of the driving spindle; in 120 other words, that, due to the use of suitable gear ratios, the timing of both kinds of movement is the same; while the rotational movement being effected through reduction gearing, is relatively much slower. It follows then that the axial and 125 radial movements effect a circular rubbing action between the tooth surfaces in contact, which action is gradually shifted across these surfaces and transferred from tooth to tooth. After the teeth have been sufficiently lapped on one side, 130 they may be lapped on the other side by reversing the direction of drive, or by removing them and reversing them on their spindles.

We claim:

1. The method of lapping gears which consists 135 in rotating a pair of intermeshing gears about their respective axes at a relatively slow speed and imparting relative movements of recession and approach radially, and of axial reciprocation, between said gears at a more rapid rate, 140 and with such timing of the radial and axial movements that a rotary rubbing action between contacting teeth is effected during the progression of such contact between the roots and extremities of the contacting teeth. 145

2. The method of lapping gears which consists in effecting a rotary rubbing action between contacting teeth of intermeshing gears compounded of relative axial and radial reciprocations with shifting of the area of contact between said teeth 150

outwardly from the root of one of the teeth and inwardly from the extremity of the other tooth.

3. The method of lapping gears which consists in effecting a relative rotary movement compounded of axial and radial reciprocations, each of less extent than the axial and radial dimensions of the teeth, between the contacting teeth of two intermeshing gears, while rolling said gears in mesh.

4. The method of lapping gears which consists in rotating two gears in rolling mesh with one another, causing exertion of pressure between contacting teeth of said gears, and at the same time effecting a rotary relative motion between said gears compounded of axial and radial reciprocations, approximately equal in length, and of less linear extent than the dimensions of the teeth.

5. The method of finishing gears which consists in rolling two mating gears in mesh with one another and effecting a relative bodily translation between said gears in an orbit compounded of radial and axial reciprocations approximately equal to one another in distance, and of linear extent less than the dimensions of the teeth.

6. A gear finishing machine comprising spindles adapted to carry intermeshing gears, means for automatically rotating one of said spindles, means for automatically reciprocating one of said spindles axially, and means, which in timed relation thereto automatically reciprocate one of said spindles transversely to its axis toward and away from the axis of the other spindle, said rotational movement and both of said reciprocal movements being carried out simultaneously, whereby a curvilinear rubbing contact is effected between the gears.

7. The method of lapping gears which consists in rotating a pair of intermeshing gears about their respective axes, and simultaneously imparting to both of said gears relative movements of recession and approach radially and of axial reciprocation between said gears at such a rate and with such timing of the radial and axial movements that a rubbing action between contacting teeth is effected during the progression of such contact between the roots and extremities of the contacting teeth, the area of contact between the teeth following a curvilinear path.

8. A gear finishing machine comprising two spindles arranged with their axes parallel to one another and located in position to carry mating gears in mesh with one another, means for rotating one of said spindles, a brake associated with the other spindle for causing pressure exertion between the teeth of such intermeshing gears, means for reciprocating one of said spindles axially, and means for reciprocating one of said spindles transversely to its axis.

9. A gear finishing machine comprising two spindles arranged with their axes side by side and parallel, adapted to carry two mating gears in mesh with one another, positive driving means coupled with one of said spindles for rotating it, retarding means applied to the other spindle for causing exertion of pressure between the teeth of such intermeshing gears, adjustable means for reciprocating one of said spindles axially through a distance normally less than the axial length of such intermeshing gears, and adjustable means for reciprocating one of said spindles transversely to its axis toward and away from the axis of the other spindle through a distance normally less than the radial length of the teeth of such intermeshing gears.

10. A gear finishing machine comprising two spindles arranged with their axes substantially parallel, adapted to carry mating gears, one on each spindle, in mesh with one another, positive means for driving one of said spindles rotatively, means for reciprocating said spindle axially, retarding means applied to the other spindle for causing exertion of pressure between the contacting teeth of such intermeshing gears, and positive driving mechanism connected with the last named spindle for moving it sidewise toward and away from the first spindle in such timing with the before named reciprocating movements as to cause a rotary rubbing effect between the gear tooth faces in contact.

11. A method of lapping gears which consists in rotating two mating gears in mesh with the exertion of pressure between contacting teeth, and simultaneously imparting relative bodily movement to the axes of said gears, said relative movement being such that points of contact between respective meshing gear teeth move on a path which continuously varies in direction.

12. A method of operating a gear grinding machine having spindles adapted to carry intermeshing gears comprising, rotating one of the spindles, moving one of the spindles axially backward and forward, and moving one of the spindles transversely to its axis toward and away from the axis of the other spindle at such speeds that a plurality of such movements occur during the period in which any pair of mating teeth remain in contact.

13. In the method of lapping gears which consists in rotating two mating gears in mesh with the exertion of pressure between contacting teeth, and at the same time causing the axes of said gears to perform a relative motion in which the axes remain parallel to each other, the step of continuously varying the direction of said motion in such a manner that said motion occurs along a closed curve.

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