June 15, 1948. S. S. COOK ET AL 2,443,227

GRINDING OR POLISHING OF GEARS OR OTHER WORK

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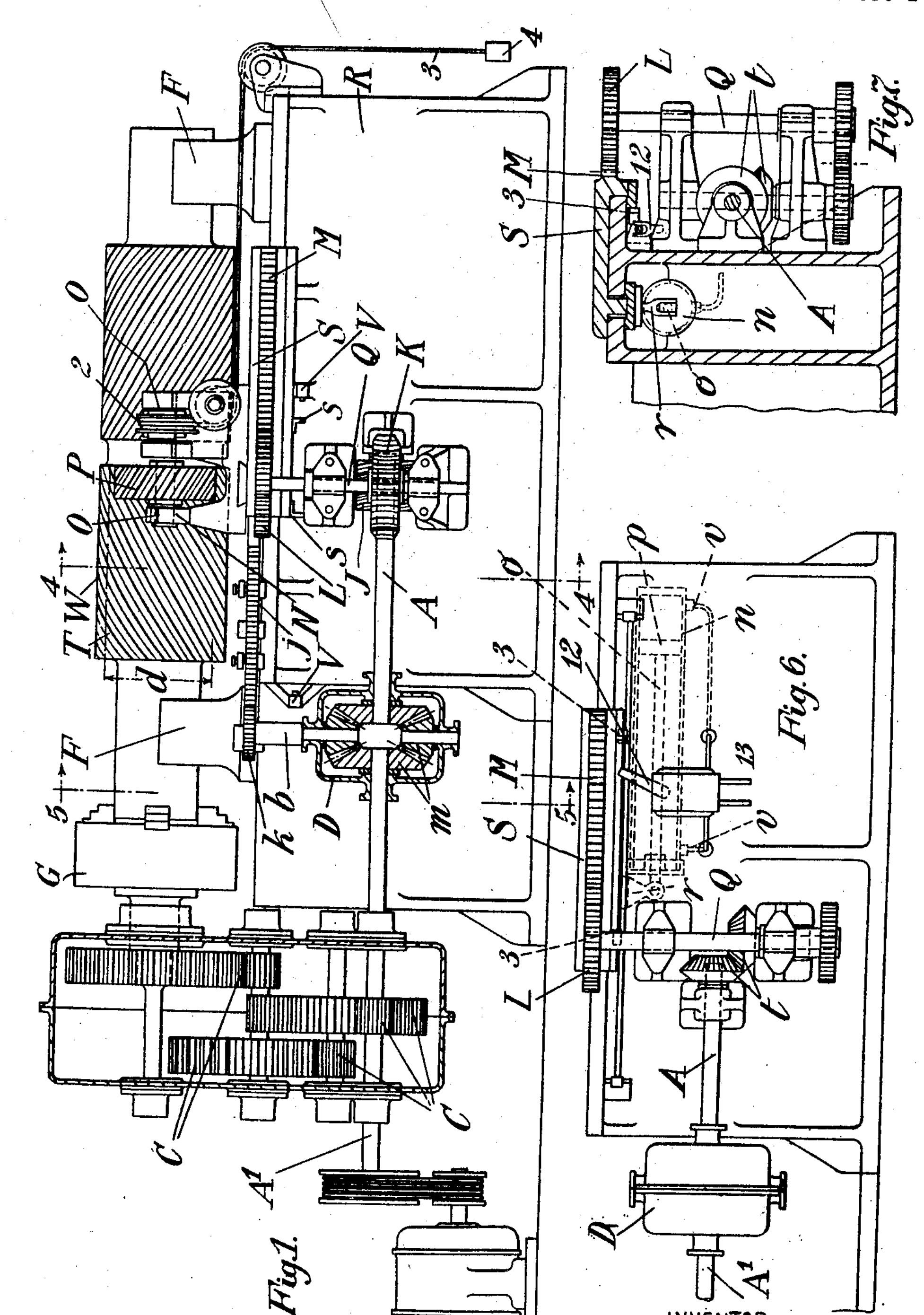

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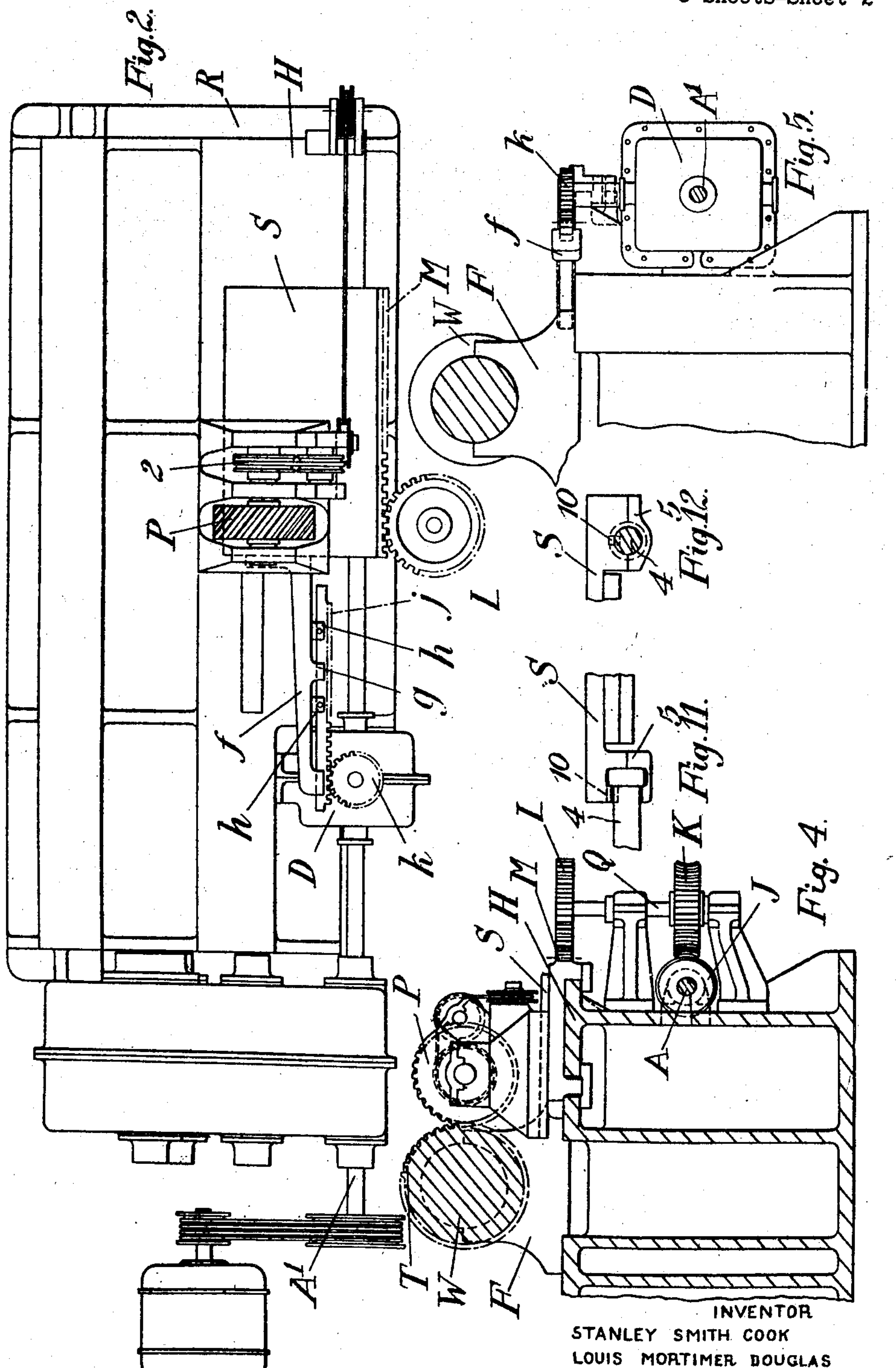

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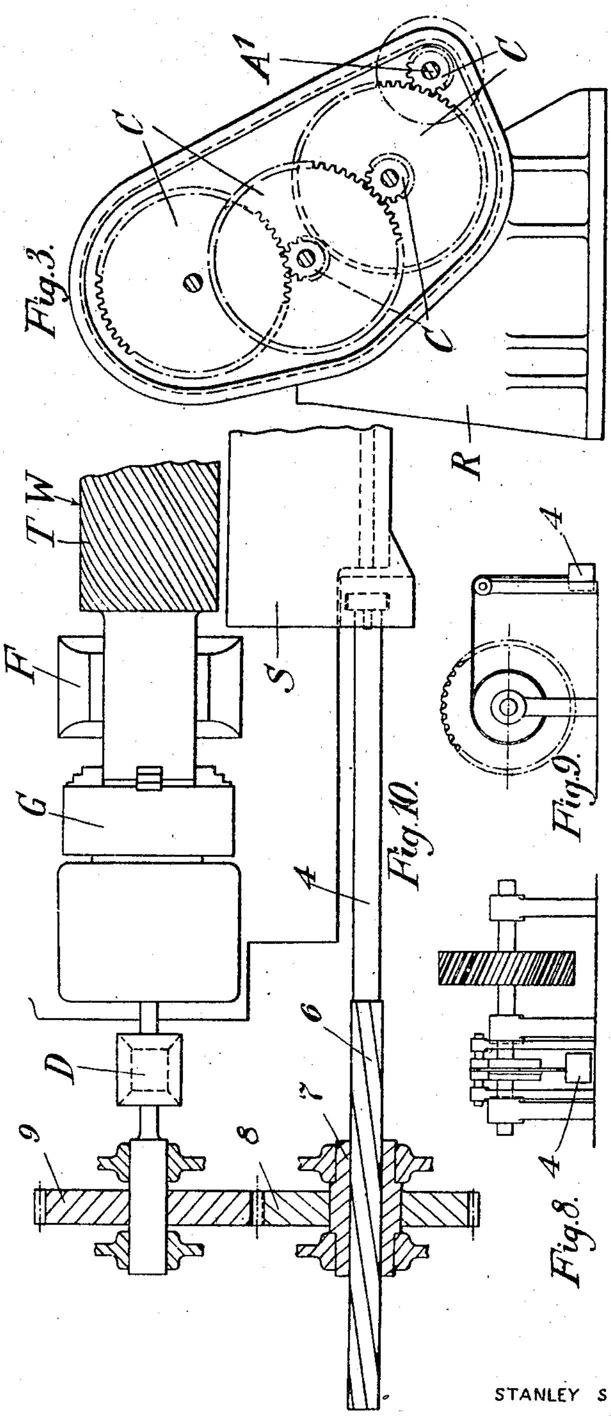

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GRINDING OR POLISHING OF GEARS OR OTHER WORK

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10 Claims. (Cl. 51—31)

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This invention relates to the grinding or polishing of surfaces of helical gears or other work having a circular series of helical radiating surfaces.

In any polishing process, however fine the abrasive used, there must be scratches following the direction of the relative motion between the surfaces of the polishing and polished members. In our British Patent Specification No. 403,092, the direction of motion of the engaging surfaces in the polishing process is exactly the same as it is in the finished gears in subsequent operation. The consequence is that a chord in one element tends to wear a groove in the engaging surface of the other member so that irregularities of this character tend to persist and are not polished out by the interengagement of the gears in operation.

The object of the present invention is to provide a process, and a machine for carrying it out, for polishing, or grinding helical teeth of gears or other work, wherein the above irregularities resulting therefrom are such that they tend to become polished out by interengagement of the gears in actual operation.

The invention consists in methods of and apparatus for grinding or polishing surfaces of gears or other work as set forth in the claims appended hereto.

Referring to the accompanying diagrammatic drawings:

Figure 1 is a side elevational view partly in section of one convenient construction of apparatus embodying the present invention.

Figure 2 is a plan view thereof.

Figure 3 is an end view with gear cover removed.

Figure 4 is a sectional view on the line 4—4 of Figure 1.

Figure 5 is a fragmentary section on the line 5—5 of Figure 1.

Figure 6 is a fragmentary side elevation of a modified construction.

Figure 7 is a fragmentary sectional view of the modified construction illustrated in Figure 6.

Figures 8 and 9 are views of details of the apparatus shown in Figure 7.

Figure 10 is a fragmental plan view partly in section of a further modified construction, and

Figures 11 and 12 are views of details of the apparatus shown in Figure 10.

In carrying the invention into effect according to one example illustrated in Figures 1 to 5 as applied to the polishing of a helically-toothed gear wheel, we mount the gear wheel W having

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helical teeth T on a shaft carried in a fixed bearing F, F and driven by a driving chuck G. A polishing wheel or pinion P having external helical teeth corresponding with the teeth T on the gear wheel is mounted on a spindle N carried in bearings O, O by a saddle S adapted to slide longitudinally on a slide H in a direction parallel to the axis of the gear wheel; the teeth of the polishing wheel being in mesh with the teeth of the gear wheel.

The saddle S is adapted to be reciprocated by the main drive shaft A and A' which has a worm J driving the worm wheel K on the same shaft Q as a pinion L engaging rack M on the saddle S. The motor driving the shaft A' is reversed by adjustable stops *s* on the saddle S engaging, at each end of its stroke, contacts V to operate an electric reversing switch.

The main drive shaft A, A' is connected to the work shaft by a series of gear wheels C so chosen that when the polishing wheel reciprocates from one end of the stroke to the other, the work rotates sufficiently in the appropriate direction to maintain the same phase of contact with the polishing wheel. That is to say, when the polishing wheel is moved longitudinally at a distance equal to the length of the helix the work would have rotated an amount corresponding to a movement *d* at its periphery. This ensures that the direction of polishing movement follows the lines of the teeth T, that is to say, the direction of polishing is along the teeth from one end to the other.

An arm *f* attached to the saddle has a stop *g* which engages adjustable stops *h* on a bar *j* having rack teeth engaging a wheel *k* containing a uni-directional clutch by which means each double reciprocation of the saddle S communicates rotary motion in one direction only to the shaft *b*. This rotation of the shaft *b* operates the bevels *m* of the differential device D to cause relative rotation between the shafts A and A'. This, through the change wheels C effects a slight rotation or feed of the work.

To provide the necessary pressure, preferably constant, between the interengaging teeth of the polishing wheel and the teeth of the gear wheel a pulley 2 is mounted rigidly on the spindle N carrying the polishing wheel P and a rope 3, flexible cable or the like is wrapped around the pulley and passing over guide pulleys is connected to a weight 4 upon which gravity is free to act. The direction of the torque on the polishing wheel can be reversed by reversing the direction in which the chord is wound on the drum 2 on the polishing wheel shaft.

In a modified construction illustrated in Figures 6 and 7, the saddle is reciprocated hydraulically. In a cylinder *n* is a piston *p* with rod *o* engaging an arm *r* attached to the saddle S. The reversal is effected by stops 3 on the saddle engaging lever 12 operating the valve 13 controlling the supply and leak off of fluid under pressure to and from the cylinder *n* through the pipe connections *v*. The rotation of the work relative to the reciprocation of the saddle is effected by the rack M on the saddle S engaging pinion L on shaft Q, this rotary motion being communicated through the bevels *t* to shaft A and through the differential D and change wheels C to the work.

The means of applying the pressure between the interengaging teeth of the polishing wheel and the work may take the form of a weight 4 and pulleys as indicated in Figures 8 and 9.

In a further modification the change wheels are replaced by helical splines on a spindle rigidly carrying the polishing wheel. These splines engage external splines on a gear wheel engaging a further gear wheel on the driving chuck shaft. The helical angle of the splines and the speed ratio of the two gears are chosen to correspond with the helical angle of the gear wheel teeth.

Figures 10, 11 and 12 illustrate a further modified construction in which the relative rotation of the work and polishing wheel is effected by a splined bar 4 secured to the saddle S by a clamp 5 (Figures 11 and 12). The helical splines 6 of this bar engage complementary grooves in the member 7 on which is mounted a gear wheel 8 engaging a gear wheel 9 mounted on the work shaft. The bar 4 is secured by a key 10 against rotation and reciprocates with the saddle S. This motion causes the splines 6 to give a rotary motion to the gear 8 which is transmitted by gear 9 to the work W.

For simplicity only a single pair of wheels 8 and 9 between the bar 4 and the work shaft have been shown, but preferably change wheels are provided as in Figure 1, so that with the same spline bar different helical angles of the teeth T may be accommodated by varying the change wheels and teeth of the opposite hand helix may be accommodated by the introduction of an idler in the change wheel train.

If change gear wheels are employed that are in exact correspondence with the helical angle of the gear wheel the polishing wheel will have no rotation whatever during reciprocation and its lines of contact with the gear wheel will therefore remain constant. This would tend to wear a series of facets on the polishing wheel and in order to prevent these facets becoming appreciable it will be necessary to have a very fine rotary feed. It is preferred therefore that the change gears be chosen so that the relation between the longitudinal motion of the saddle and the rotary motion it communicates to the gear wheel is slightly out of correspondence with the helical angle of the gear wheel teeth so that the polishing wheel will have a slight rotary movement during each reciprocation. This will cause its lines of contact with the gear wheel teeth to change slightly during each reciprocation and thus avoid or reduce the liability to the formation of facets.

The feed, which consists of a slight regular rotation of the work to ensure that all the teeth are equally polished, may be given by any suitable means, but we have only shown the differential method D which is one convenient means; also we have only indicated the step-by-step feed effect by the reciprocation of the saddle.

What is claimed is:

1. A method of polishing, or grinding work having a circular series of helical radiating surfaces by means of a continuously interengaging lap having conjugate helical radiating surfaces in which the work is partially rotated alternately in opposite directions whilst the lap is reciprocated in contact therewith, said rotary and reciprocating motions being mutually co-related, a constant pressure is exerted between the helical surfaces on said work and lap, the direction of relative motion of the contacting surfaces being substantially at right angles to the direction of relative motion which the helical surfaces on the work will have when in actual operation, the relative angular position of work and lap being determined by their mutually engaging helical surfaces and being intermittently changed by a slow rotary feeding motion determined by the amount of lapping.

2. A machine for lapping a helically toothed gear wheel comprising a base carrying a gear wheel-supporting head stock and a saddle-carrying a burnishing pinion in constant mesh with said gear wheel, means for partially rotating the head stock alternately in opposite directions, means for reciprocating the saddle in coordinated relationship with said partial rotation to effect relative motion of the contacting tooth surfaces substantially at right angles to the direction of relative motion which the helical surfaces on the gear wheel will have when in actual operation and, means for exerting a constant pressure between said contacting surfaces and means for intermittently changing the phase of engagement between the gear wheel and pinion.

3. Apparatus for polishing, or grinding a rear wheel as claimed in claim 2, wherein said means for exerting a constant pressure comprises is effected by a constant force derived from the pull of gravity upon a weight.

4. A machine as claimed in claim 2, wherein said saddle operates a differential gear in an element co-ordinating the reciprocating motion of the saddle with rotary motion of the gear wheel to effect a slight additional rotation to the gear wheel.

5. A machine as claimed in claim 2, wherein the gear wheel and the saddle are interconnected by gearing to an intermediate gear wheel to which latter power is applied.

6. A machine as claimed in claim 2 wherein said burnishing pinion is rigid on a shaft furnished with helical splines carrying an internally splined change wheel.

7. A machine as claimed in claim 2, wherein relative rotation of said gear wheel and burnishing pinion is effected by a splined bar.

8. A machine as claimed in claim 2, including change wheels chosen such that the longitudinal motion of said saddle and the rotary motion it communicates to a gear wheel is slightly out of correspondence with the helical angle of the gear wheel teeth so that said burnishing wheel will have a slight rotary movement during each reciprocation.

9. A machine as claimed in claim 2 wherein the means for co-ordinating the reciprocating motion of the saddle and the oscillatory motion of the headstock and gear wheel comprises change gears in the interconnection between

said means for reciprocating the saddle and said means for partially rotating the headstock whereby said co-ordination can be effected to suit different helical angles of the helically toothed gear wheel.

10. A method of polishing or grinding a gear wheel having helical teeth which consists in partially rotating the gear wheel in opposite directions whilst in continuous interengagement with a lap having conjugate helical teeth whilst the lap is reciprocated, said rotary and reciprocating motions being mutually co-related, exerting a constant pressure between the teeth on the gear wheel and lap, the direction of relative motion of the contacting surfaces being substantially at right angles to the direction of relative motion which the teeth will have when in actual operation, determining the relative angular position of gear wheel and lap by their mutually engaging helical surfaces and intermittently changing this relative angular position by a slow rotary feeding motion determined by the amount of lapping.

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