March 26, 1940. D. A. WALLACE 2,195,047

LAPPING APPARATUS

Filed July 22, 1936 3 Sheets-Sheet 1

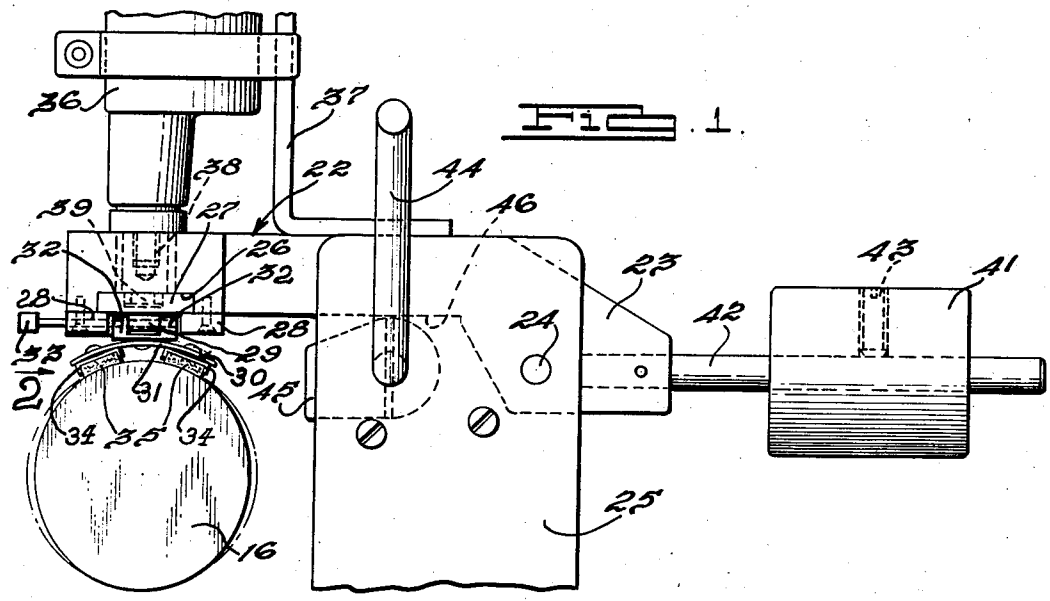


Fig. 1.

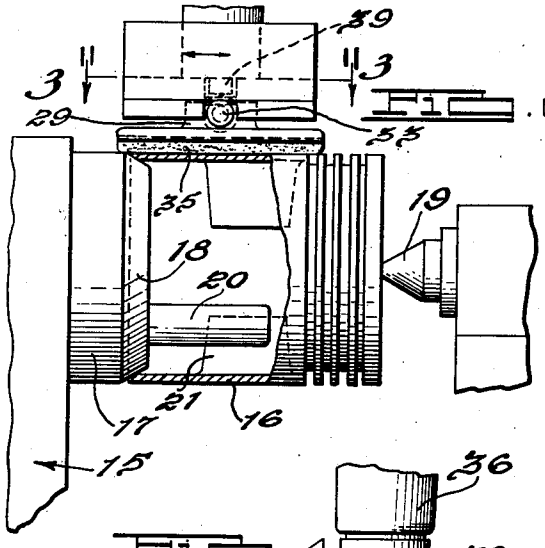


Fig. 2.

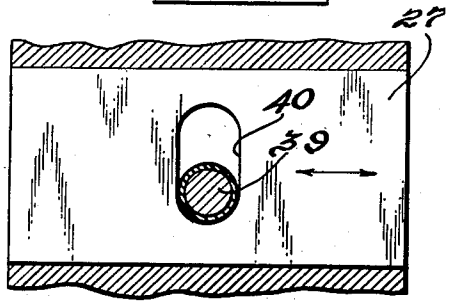


Fig. 3.

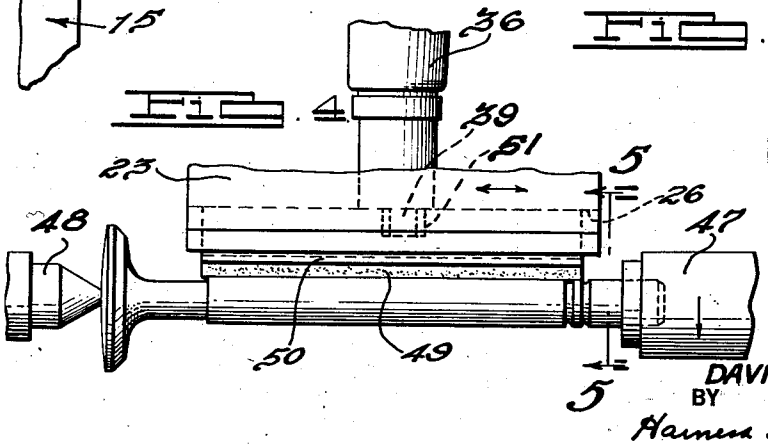


Fig. 4.

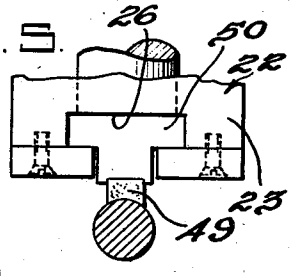


Fig. 5.

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LAPPING APPARATUS

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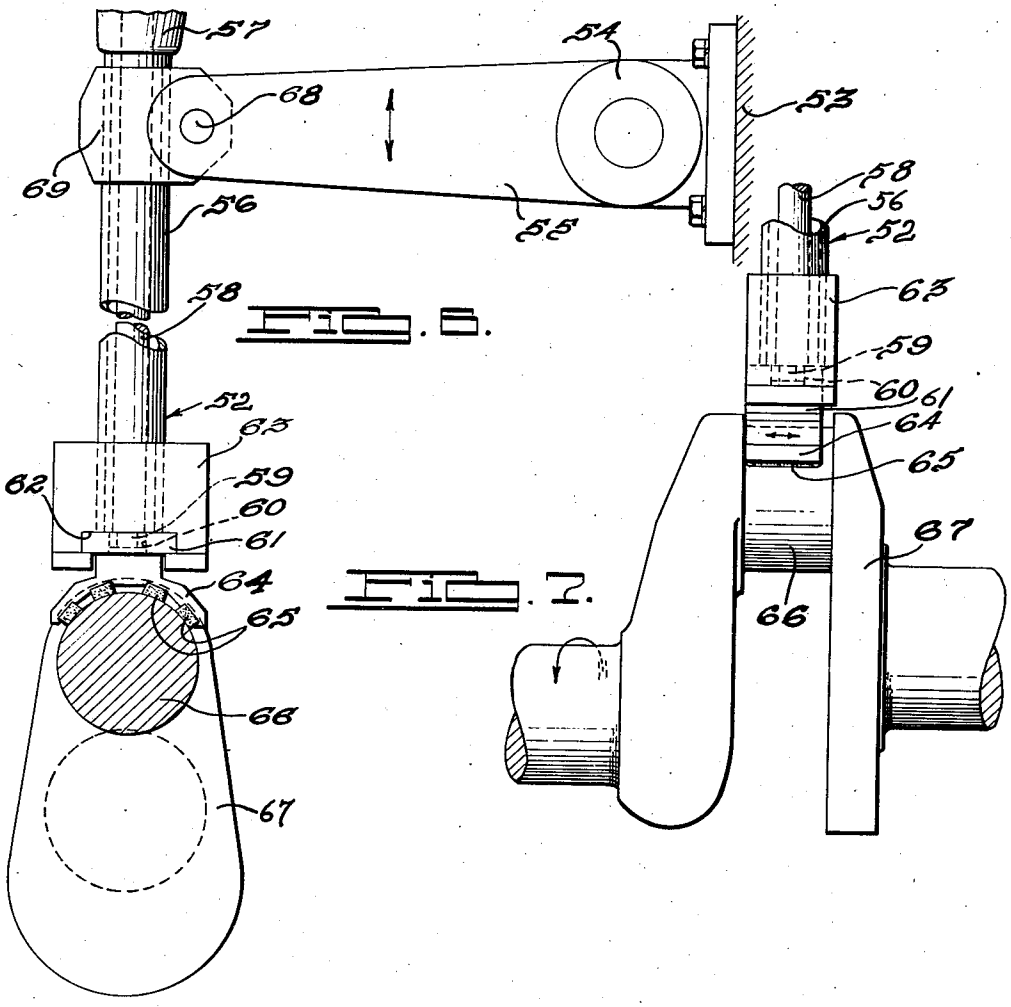


FIG. 6.

FIG. 7.

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LAPPING APPARATUS

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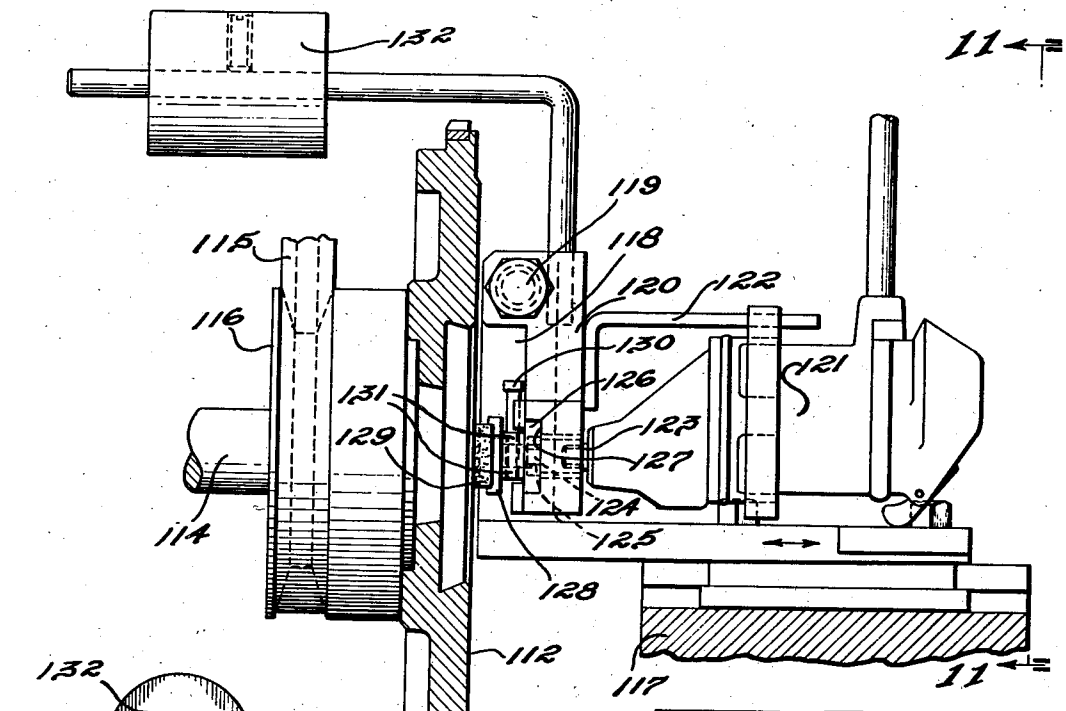


Fig. 8

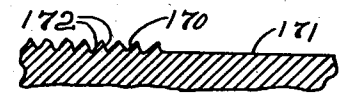


Fig. 10

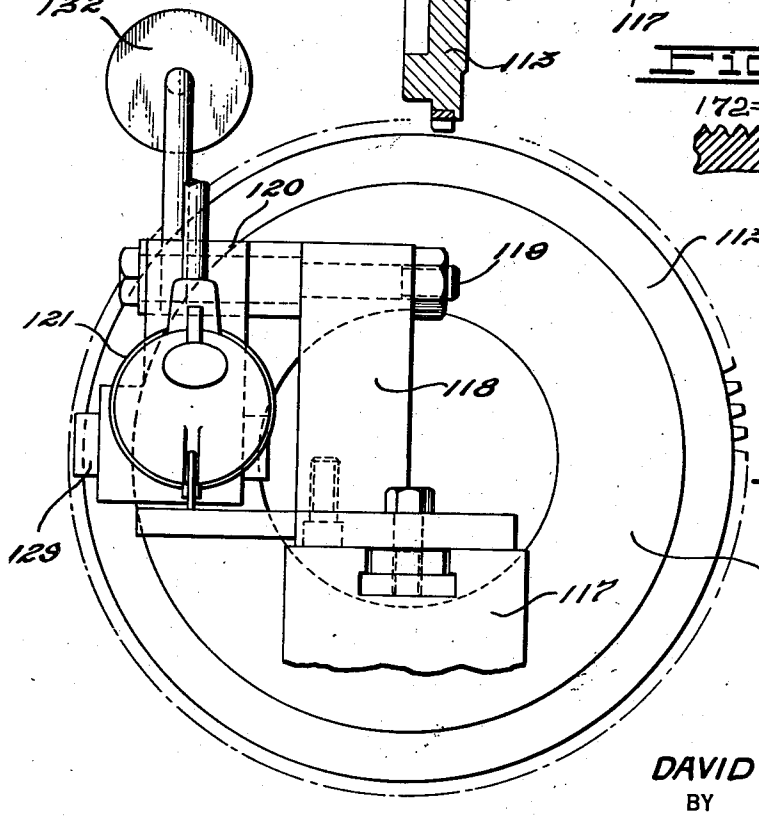


Fig. 9

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UNITED STATES PATENT OFFICE

2,195,047

LAPPING APPARATUS

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Application July 22, 1936, Serial No. 91,851

8 Claims. (Cl. 51—67)

This invention relates to improved apparatus for lapping surfaces as well as to improved lapped surfaces.

More particularly the invention pertains to lapping of surfaces of apparatus and parts thereof which operate in rubbing, sliding or rotative bearing-like, or frictional contact with other parts.

Heretofore, in polishing, lapping or otherwise finishing surfaces, it has been the practice to produce relative movement, mainly in one direction only, between the surfaces of the work and the lapping means. In some instances combinations of different directional movements have been employed in an effort to avoid scoring of the surface operated upon by repeated action of isolated hard particles of the lapping element on substantially the same areas of the work. The relative movement in one direction has, however, been of a relatively low order of velocity as compared to the relative movement in another direction, and consequently, the scratch lines, scores, or inscriptions traced on the work by isolated hard particles in the lapping surface have not been so disturbed and cross-hatched as to provide finished surfaces of actual mirror-like smoothness directly by lapping operations.

Polishing with extremely fine abrasives, such as rouge, has been required after the lapping operation, to produce the desired degree of smoothness and finish. In this connection it should be noted that while polishing of this character improves the appearance of the surfaces it does not materially change its physical smoothness. That this is true can readily be seen by microscopic observation of conventionally lapped and polished surfaces by which it is found that the multiplicity of minute ridges between adjacent scratch lines or scores are not actually removed. The polishing compound merely forms a luster on the sides of such ridges which give the final surface an appearance of much greater smoothness than actually exists.

I have found that by producing relative movements of respectively different ranges of speed and in different directions, preferably at right angles, between the surface operated upon and the lapping surface, actual smoothness is directly obtained by lapping and such smoothness is of a much different and superior kind than that resulting from conventional lapping followed by polishing operations.

Another object of the invention is to provide improved lapping apparatus by which physically smooth and mirror-like surfaces can be directly formed by lapping operations without producing a deceitful luster such as that formed by polishing the side surfaces of ridges of presumably, but not actually, smooth surfaces.

A further object of the invention is to provide apparatus of this character by which the inscriptions traced on the surface operated upon by localized hard particles in the lapping surface can be brought to a desired angular cross-hatched relationship such that the resulting scratch lines are accordingly so repeatedly cross-hatched as to destroy their normal roughness producing effect.

An additional object of the invention is to provide apparatus of this character by which the reciprocating movement of the lapping element is maintained at a sufficiently high velocity and frequency to produce smooth surfaces free from grooves and scores with a limited amount of reciprocatory movement.

A still further object of the invention is to provide apparatus of this character by which a lapping element can be conveniently reciprocated, during application thereof to a rotating piece of work, at a relatively high rate of speed of a vibratory order.

A still further object of the invention is to provide an improved lapping device which will operate a plurality of conveniently attachable and detachable lapping elements so as to facilitate adaptation of the device to the lapping of a plurality of different types of pieces of work.

Another object of the invention is to provide lapping apparatus of this character by which the relative movement between the lapping element and the work in one direction is of a reciprocatory nature and which movement varies in velocity from zero at opposite ends of the stroke while maintaining a substantially high velocity throughout the main portion of the stroke.

Other objects of the invention are to provide lapping devices which permit the working surface of the lapping element to follow the contour of intentionally out-of-round surfaces and to facilitate lapping of said surfaces to a high degree of smoothness without substantially varying the out-of-round contour thereof; to provide improved lapping element holders by which a plurality of lapping surfaces can be held against the work with substantially uniform pressure.

Additional objects of the invention are to provide improved crank shaft lapping apparatus which is adapted to lap crank pin bearing members; to provide a lapping too which is adapted to rest upon and follow the crank pin bearing

members of a crank shaft during rotation of the latter about its normal axis; and to provide a tool of this character with a prime mover which is carried bodily by the tool and which is adapted to reciprocate the lapping elements at a frequency of a vibratory order.

Illustrative embodiments of the invention are shown in the drawings in which Fig. 1 is a fragmentary side elevational view of lapping apparatus embodying the invention and showing an adaptation of the lapping apparatus to the lapping of a piston.

Fig. 2 is an end elevational view showing the lapping apparatus viewed from the left in Fig. 1.

Fig. 3 is a horizontal sectional view taken on the line 3—3 of Fig. 2.

Fig. 4 is a fragmentary side elevational view showing an adaptation of a lapping apparatus illustrated in Fig. 1 to the lapping of a valve stem.

Fig. 5 is a fragmentary vertical sectional view taken on line 5—5 of Fig. 4.

Fig. 6 is a fragmentary side elevational view, partly in section, of lapping apparatus embodying the invention and showing an adaptation thereof to the lapping of a crank bearing member of a crank shaft.

Fig. 7 is a fragmentary end elevational view showing the lapping apparatus as viewed from the left in Fig. 6.

Fig. 8 is a fragmentary side elevational view, partly in section, of apparatus embodying the invention for lapping plane surfaces showing an adaptation of the lapping apparatus to the lapping of a side surface of a fly wheel of an automobile engine.

Fig. 9 is an end elevational view showing the apparatus as viewed from the right on the line 11—11 of Fig. 10.

Fig. 10 is a diagrammatic sectional view, enlarged to a microscopic order, of a machined surface article and illustrating the action thereon of a lapping process embodying the invention.

In the form of the invention illustrated in Figs. 1 to 3, my improved lapping apparatus comprises a support, generally designated by the numeral 15 in Fig. 2, for rotatably supporting a piece of work, such for example as a piston 16. One end of the piston is nonrotatably mounted on a live spindle 17 having a tapered end 18 against which it is firmly held by a dead spindle 19. The live spindle 17 is provided with a pin 20 for engaging a wrist pin bearing boss 21 located internally of the piston to insure driving of the piston by the live spindle which is in turn driven by an electric motor of any suitable means, not shown.

A lapping fixture, generally designated by the numeral 22, is located adjacent the work rotated apparatus. The lapping fixture 22 includes an arm 23 which is pivotally mounted at 24 upon a support 25, the axis of the pivoted mounting being substantially parallel to the axis of rotation of the piston 16. Formed in the left end of the arm 22 is a recess 26 in which a block 27 is slidably mounted. The block 27 is held against displacement from the recess 26 by a pair of cleats 28 which project over the side edges of the block. Provided on the lower side of the block 27 is an apertured lug 29 on which is pivotally and removably mounted a lapping element holder, generally designated by the numeral 30. The holder 30 preferably comprises a flexible and resilient sheet metal backing 31 of arcuate shape on which are provided spaced upstanding apertured lugs 32 between which the lug 29 of the block 27 is receivable. A removable pin 33 serves to detachably and pivotally connect the slide block 27 and lapping element holder together. Provided on the lower side of the flexible backing 31 are a pair of sockets 34 in which lapping elements 35 are held. The lapping elements may comprise a stone structure or any other polishing material. The flexible backing element 31 preferably has a shorter radius of curvature when relaxed than that required to bring the working faces of the lapping elements into conformity with the surface of the work and, therefore, during application of pressure upon the backing at its intermediate portion, the resilient backing is deflected by such pressure so as to uniformly apply both lapping elements to the surface being operated upon. Any desired number of lapping elements may be mounted in accordance with the illustrations shown in Fig. 1.

Driving mechanism, preferably comprising an electric motor 36, is mounted on the fixture 22 by a bracket 37. The motor 36 has a shaft 38 which is provided on its lower end with an eccentric pin 39 by which the motor is operatively so connected with the slide block 27 as to directly reciprocate the slide block and the lapping elements 35 in the general direction of the axis of rotation of the work 16. The eccentric pin 39 is received in an elongated slot 40 formed in the slide block 27 and which extends transversely thereof as illustrated in Fig. 3. Rotation of the motor shaft 38 and eccentric pin 39 reciprocates the lapping elements 35 throughout a comparatively short stroke during which the linear velocity of the lapping elements varies from substantially zero at the ends of the stroke to a maximum velocity intermediate the ends of the stroke. The motor 36 is, however, operated at sufficiently high speed to bring the frequency of the reciprocatory movements of the lapping elements to a substantially vibratory value.

In order to determine the pressure applied on the lapping elements, an adjustable counterbalancing weight 41 is slidably mounted on a stem 42 carried by the right end of the pivotally mounted arm 23. The counter-weight 41 may be releasably fixed in any desired position by a set screw 43. Pivotally mounted in the support 25 is a crank member 44 having a cam 45 thereon which is adapted to engage a lower edge surface 46 of the arm 23 to facilitate manual lowering and raising of the lapping elements 35 into and out of contact with the work, respectively.

During operation of the foregoing apparatus the work is rotated continuously in one direction and the lapping elements are reciprocated in a direction substantially parallel to the axis of rotation of the work. The linear velocity of these respective different directional movements are so predetermined as to bring the resultants of the movements during successive half cycles of the reciprocatory movement into predetermined angular relationship with respect to each other. It is preferable to cause the resultants of the movements produced during successive half cycles of the reciprocatory movement to intersect at substantially right angles of each other. To accomplish this, the linear velocity of the surface operated upon and the linear velocity of the lapping elements must be substantially equal. However, since the velocity of the reciprocatory movement varies, this condition is not maintained at all times but is approached throughout the main portions of the strokes of the lapping elements. Localized hard areas of the lapping surface, therefore, trace inscriptions on the surface

of the work during successive half cycles of the reciprocatory movement which are cross-hatched at a plurality of different angles forming an heterogeneous arrangement of cross-hatched scratch lines, none of which develop into deep grooves or scores. While it is preferable to so predetermine the linear velocity of the movement of the work and movement of the lapping elements as to bring the main portions of the scratch lines to approach right angle relationship with respect to each other, it is found that excellent results are obtained when the angularity of the lines traced during successive half cycles of the reciprocatory movement is such that the minimum angle therebetween is substantially forty degrees. In other words, the resultant of the two directional movements may vary from an inclination of substantially twenty to substantially seventy degrees to the path of reciprocatory movement. For the purpose of illustration, a piston of substantially three and one-eighth inches in diameter would be rotated at approximately sixty R. P. M. and the lapping elements would be reciprocated at a rate of substantially 900 cycles per minute.

The pivotal attachment of the lapping fixture to its support accommodates movement of the fixture and lapping elements carried thereby to permit the working surfaces of such elements to follow the contour of the work. Thus, in lapping an elliptical piston of the type shown in exaggerated manner in Fig. 1, the lapping elements are allowed to bob up and down about the pivotal axis 24 so as to bring the out-of-round surface of the piston to a very smooth finish without substantially varying the desired contour of the piston. This same structure may be used to advantage in lapping cams.

In the adaptation of the apparatus illustrated in Figs. 4 and 5, a valve of the type commonly used in automotive engines is rotatably mounted between a live spindle 47 and a dead spindle 48 during application thereto of a reciprocating lapping element 49. The lapping element 49 is carried by a block 50 slidably mounted in the recess 26 of the arm 23 of the lapping fixture 22. The slide block 50 is provided with a transversely extended elongated slot 51 in which the eccentric pin 39 of the motor shaft 38 is received. The operation of the lapping apparatus in this adaptation of the invention is similar to that described in connection with the apparatus shown in Figs. 1 to 3, there being proper adjustment of the speed of rotation of the valve stem to compensate for its smaller diameter than that of the piston.

In the form of the invention illustrated in Figs. 6 and 7 there is shown an adaptation of my improved lapping process and apparatus to the lapping of crank bearing members of a crank shaft. The same apparatus may be employed for lapping the main bearings of the crank shaft in a manner which is obviously apparent from the disclosure of the crank bearing member lapping application. In the lapping of main bearings and crank bearing members of a crank shaft, the crank shaft is rotatably mounted and drivingly rotated by engagement of live and dead spindles (not shown) with its respectively opposite ends or in any other suitable manner. A lapping tool, generally designated by the numeral 52, is swingably mounted on a support 53 by a bracket 54 to which a link 55 is pivotally attached. The lapping tool employed in this application of the invention comprises a tubular stem 56 on the upper end of which is mounted an electric motor 57 or other suitable driving means. The motor 57 is provided with a shaft 58 extending axially through the tubular stem 56 and having on its lower end an eccentric pin 59 which is received in a recess 60 formed in a slide block 61, in substantially the same manner as that described in the description of the apparatus shown in Figs. 1 to 3. The block 61 is slidably mounted in a recess 62 of a head 63 carried by the lower end of the tubular sleeve 56. Reciprocation of the block 61 in the recess 62 is produced by the operative connection between the eccentric pin 59 of the motor shaft and the slot 60 of the sliding block in which the pin is received. In this illustration of the invention an arcuate shaped, substantially rigid lapping element holder 64 is integrally formed with or rigidly attached to the slide block 61. The holder 64 is provided with recesses in which lapping elements 65 are disposed. In this connection it is to be noted that a pivotally attached lapping element holder of the type illustrated in Fig. 1 may, if desired, be used in place of the rigid lapping holder shown in Figs. 6 and 7 and, if desired, a flexible and resilient lapping element holder may be rigidly attached to the slide block 60.

During operation of the lapping device illustrated in Figs. 6 and 7, the bearing element rests upon either a main bearing of a crank shaft or on a crank bearing member 66 of a crank shaft 67 as illustrated in the drawings. The working end of the lapping tool 52 is permitted to follow the course of movement of the crank bearing member 66 during rotation of the crank shaft by virtue of a pivotal connection at 68 provided between the free end of the link 55 and the lapping tool 52, the free end of the link 55 being pivotally attached to a bracket 69 which is clamped around or otherwise secured to the tubular stem 56. In this type of application of the invention, the reciprocatory movement of the lapping elements and the rotative movement of the crank shaft are so predetermined in velocity as to produce the results set forth in the discussion of the structure shown in Figs. 1 to 3.

In Figs. 8 and 9 of the drawings is illustrated an adaptation of the invention to the lapping of plane surfaces such as the side face 112 of a fly wheel 113 which cooperates with the clutch disc (not shown) of an automobile power plant. In this form of the invention the fly wheel 113 is non-rotatably mounted on a shaft 114 which is in turn driven by any suitable means, such as a belt 115 operating upon a pulley 116 secured to the shaft 114. Mounted adjacent the side face 112 of the fly wheel is a support 117 on which is provided an upstanding post 118. Pivotally mounted on a bolt 119 and carried by the post 118 is a fixture 120 on which an electric motor 121, or other suitable driving means, is mounted by a suitable bracket 122. The motor 121 is provided with a shaft 123 having an eccentric pin 124 on its outer end which is received in a slot 125 formed in a slide block 126. The slide block 126 is slidably mounted in a recess 127 formed in the fixture 120 and drivingly reciprocated by the eccentric pin 124 in the manner described in the discussion of Figs. 1 to 3. A lapping element holder 128 having a lapping element 129 mounted thereon is pivotally and removably attached to the slide block 126 by a removable pin 130 which extends through registering apertures in spaced lugs 131 carried by the holder 128 and through an aperture in a lug carried by the slide block 126.

In order to predetermine the pressure with which the lapping element 129 is applied to the side face of the fly wheel, an adjustable counterbalancing weight 132 is mounted on the fixture 120 on the opposite side of its pivotal axis 119 from which the weight of the motor is applied on the fixture. As in all the foregoing forms of the invention the velocity of the reciprocatory movement of the lapping element 129 is so predetermined with respect to the rotative movement of the fly wheel as to bring the angularity of the cross-hatched lines formed during successive half cycles of the reciprocatory movement to a desired angular relation such that a relatively high degree of smoothness is obtainable.

The surfaces lapped by apparatus embodying the invention and in accordance with my improved lapping process, may be brought to a mirror-like actual physical smoothness much superior to that produced by the combination of a conventional lapping process followed by polishing. Of course, if it is desired to further finish surfaces which have been lapped in accordance with the invention, such surfaces may be subjected to a polishing treatment with rouge or other suitable fine abrasive. Surfaces lapped in accordance with the invention are found to be free from excessive scratches, scores and grooves, such as have resulted in prior lapping operation from repeated action of localized hard areas of the lapping element upon substantially the same areas of the work or areas adjacent thereto. The inscriptions traced upon the work by such localized hard areas of the lapping element are so distributed and cross-hatched as to eliminate their roughness producing effect.

In the lapping of surfaces in accordance with the invention during which the lapping element is reciprocated at a relatively high speed, it is found that the abrasive action of the lapping elements is rapid while the ridges 170, shown in Fig. 10, formed during turning or other machining of the surfaces are being removed. As soon as the ridges are removed to their base line, illustrated at 171 in Fig. 10, the abrasive action decreases materially and further removal of metal is substantially discontinued. By virtue of this characteristic of the improved lapping process surfaces can be brought to a high degree of smoothness in a relatively short time and without danger of removing sufficient material to render the articles undersize. The smoothness resulting from the actual removal of the ridges without introducing other ridges by application of the lapping elements to the surface, is of a much superior order than the mere lustrous finish resulting from polishing the side surfaces 172 of the ridges. The large number of strokes of the lapping elements across the ridges in a direction substantially normal to their lengths, resulting from reciprocation of the lapping elements at a rate of a vibratory order, assures removal of the ridges and not mere polishing or partial flattening thereof.

Although but several specific embodiments of the invention have been herein shown and described, it is understood that various changes of details of construction and operation may be made without departing from the spirit and scope of the invention.

I claim:

1. Lapping apparatus including a support, means on said support for rotatably supporting a piece of work, means for rotating said work, a fixture pivotally mounted on said support including means for reciprocably holding a lapping element in engagement with a surface of said work, a lapping element held by said latter means and movable toward and away from said work by pivotal movement of said fixture and driving means carried by and pivotally movable with said fixture for reciprocating said lapping element in the general direction of the axis of rotation of said work during rotation of the latter out-of-phase relationship with respect to each other, said driving means being operatively connected with said lapping element holding means and so constructed and arranged as to reciprocate said lapping element at a substantially vibratory frequency.

2. Lapping apparatus including a base structure, means on said base structure for rotatably supporting a piece of work, means for rotating said work, a fixture mounted for pivotal movement with respect to said base structure and work and including apparatus for reciprocably holding a lapping element in engagement with a surface of said work, said lapping element being movable toward and away from said surface by said pivotal movement of said fixture, and driving means carried by said fixture including an electric motor for reciprocating said lapping element during but independently of the rotative movement of said work.

3. Lapping apparatus including means for rotatably supporting a piece of work, means for rotating said work, a fixture mounted for pivotal movement with respect to said work and including apparatus on one side of its pivotal axis for reciprocably holding a lapping element in engagement with a surface of said work, driving means carried by said fixture on said side of said pivotal axis for reciprocating said lapping element during but independently of the rotative movement of said work, and means for predetermining the pressure of said lapping element on said surface by balancing a selected portion of the mass of said fixture and parts carried thereby on said side of said axis.

4. Apparatus for lapping a crank bearing member of a crank shaft including means for rotatably supporting a crank shaft on its normal axis of rotation, a support adjacent said means, a lapping fixture bodily swingably mounted on said support having a lapping element shiftably mounted on one end and adapted to rest upon and follow the movement of said crank bearing member, and driving mechanism including a prime mover carried by said fixture for vibrating said element during but independently of the rotative movement of said crank shaft.

5. Apparatus for lapping a crank bearing member of a crank shaft including means for rotatably supporting a crank shaft on its normal axis of rotation, a support adjacent said means, a lapping fixture bodily swingably mounted on said support including a tubular member having a block slidably mounted on one end, a lapping element carried by said block and adapted to rest upon and follow the movement of said crank bearing member, a drive shaft extending through said tubular member and operatively connected with said block for reciprocating the latter and said element, and a motor carried by the opposite end of said tubular member operatively connected with said shaft for driving the latter.

6. Lapping apparatus including a support, means adjacent said support for drivingly rotatably supporting a piece of work having a side face to be lapped extending transversely of the

axis of rotation of said work, a fixture pivotally mounted on said support at a location adjacent said side face of said work, a lapping element reciprocably mounted on said fixture for movement transversely of said axis and swingable bodily in one direction with said fixture under the action of gravity and about the pivotal axis of said fixture into operative engagement with side face of said work, driving mechanism comprising a prime mover mounted on said fixture and operatively connected with said lapping element for drivingly reciprocating the latter, and means for counterbalancing a selected portion of the moment of said fixture in said direction about said pivotal axis for predetermining the force of application of said lapping element to said side surface of said work.

7. Lapping apparatus including a support, means adjacent said support for drivingly rotatably supporting a piece of work having a side face to be lapped extending transversely of the axis of rotation of said work, a fixture pivotally mounted on said support at a location adjacent said side face of said work, a lapping tool fixed to said fixture including a main body portion and a holder and lapping element assembly reciprocably mounted on said main body portion for movement relative thereto transversely of said axis, said assembly constituting only a minor portion of the mass of said tool and being swingable bodily in one direction with said fixture under the action of gravity and about the pivotal axis of said fixture into operative engagement with said side face of said work, and driving mechanism comprising a prime mover mounted on said fixture and operatively connected with said lapping element for drivingly reciprocating the latter during operation of said apparatus.

8. In lapping apparatus, a support including means for positioning work to be lapped and supporting the latter for rotation about a predetermined axis, a fixture pivotally mounted on said support for swinging movement toward and away from said work including an arm having a recess therein extending in the general direction of said axis, a block slidably mounted in said recess for reciprocatory movement relative to said arm during operation of said apparatus, a lapping element holder pivotally attached to said block having a lapping element therein, a driving member mounted on said fixture and operably connected with said block for vibrating said holder and lapping element in said direction, and means for moving said fixture about its pivotal axis for applying said element to and removing it from a piece of work and for accommodating removal of work from and placement of work on said support.

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