March 26, 1940. D. A. WALLACE 2,195,056

LAPPING APPARATUS AND METHOD

Original Filed Sept. 16, 1937

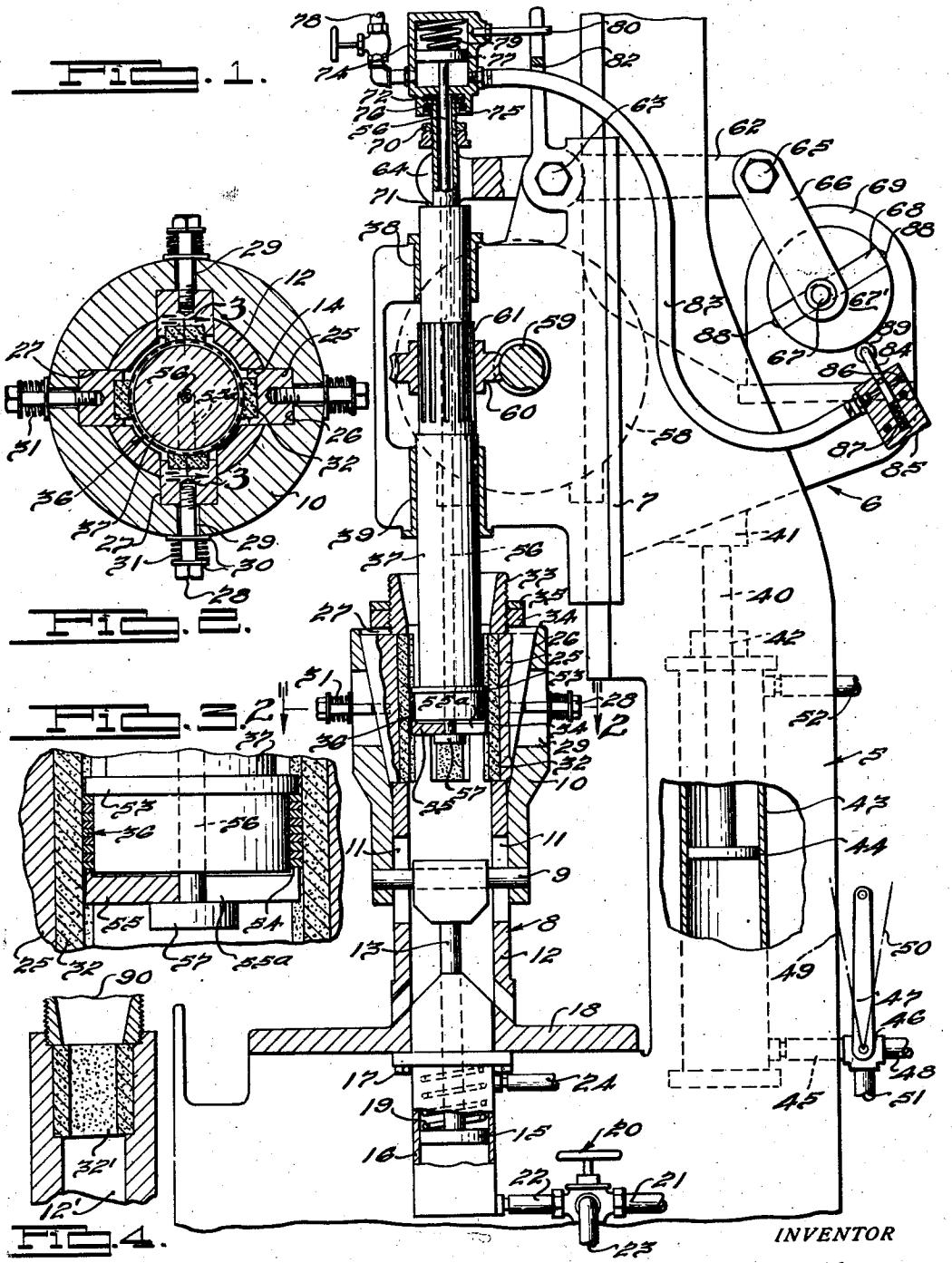


FIG. 1.



FIG. 2.



FIG. 3.



FIG. 4.

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Patented Mar. 26, 1940

2,195,056

# UNITED STATES PATENT OFFICE

2,195,056

## LAPPING APPARATUS AND METHOD

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Application September 16, 1937, Serial No. 164,129
Renewed April 26, 1939

16 Claims. (Cl. 51—157)

This invention relates to improved apparatus and method for lapping annular members.

Particularly, the invention pertains to improvements in the method of and apparatus for lapping piston rings and the like.

It is an object of the invention to provide lapping apparatus by which work can be moved relative to the lapping element and by which the means for holding the work during this relative movement is automatically released periodically to allow the work to expand under its inherent resiliency to substantially its final outside diameter.

Another object of the invention resides in the provision of apparatus of this character by which the work may be reciprocated at a speed of substantially vibratory order while at the same time reciprocated at a slower speed and throughout a longer course and rotated about an axis extending substantially parallel to the course of said reciprocatory movements, and by which the means for holding the work during these rotative and reciprocatory movements is momentarily released at the ends of said first reciprocatory movement to allow the work to expand under its own natural resiliency to substantially its final outside diameter.

A further object of the invention is the provision of lapping apparatus by which is produced relative movements between the piece of work and the lapping element that is the result of a plurality of different component movements in excess of two components, of which each component is confined to one characteristic of the contour desired, and by which the means for holding the work during these component movements is automatically momentarily released at the ends of one of said component movements to allow the work to expand under its own natural resiliency to substantially its final outside diameter.

Additional objects of the invention reside in the provision of an apparatus of this kind by which the work can be moved relative to an expandable segmental lapping device and by which the means for holding the work during this relative movement is automatically released periodically to allow the work to expand under its own natural resiliency in step by step manner ultimately to substantially its final outside diameter, and in the provision of an apparatus of this character by which the work can be moved relative to a solid lapping element.

Other objects and advantages of the invention will be more apparent from the following description taken in connection with the accompanying drawing, in which:

Fig. 1 is a fragmentary side elevational view of a lapping machine embodying the invention, portions of the structure being broken away and illustrated in section to show the details thereof.

Fig. 2 is a horizontal sectional view taken as indicated by the line 2—2 of Fig. 1.

Fig. 3 is an enlarged detail sectional view taken approximately as indicated by the line 3—3 of Fig. 2.

Fig. 4 is a partial side elevational view corresponding to Fig. 1 but illustrating another embodiment of the invention.

In the form of the invention illustrated in the drawing, the improved lapping apparatus comprises a base structure 5 on which is slidably mounted a vertically reciprocable carriage 6 held in position for vertical movement by a plate member 7.

Mounted on the base structure 5 adjacent the reciprocable carriage 6 is a tool fixture, generally indicated by the numeral 8, which is stationary with respect to the reciprocatory movement of the carriage 6.

The fixture 8 includes a tubular vertically upstanding guide member 12 mounted on a horizontal flange portion 18 of the base structure 5, and in which is provided diametrically opposite axially extending slots 11. Slidably mounted in telescoping relation on the guide 12 is a lapping tool holder 10 having apertures in its wall structure registering with the slots 11 of the guide 12. A cross-pin 9 is slidably engaged in the slots 11 and has its end portions fitted in the apertures of the tool holder 10. The upper end portion of the guide 12 is provided with axially extending arcuately spaced slots 14 and an upper threaded extremity 33 which extends thereabove and above the tool holder 10 when the parts of the structure are in the positions shown in Fig. 1.

The tool holder 10 may be reciprocated vertically to bring a lapping tool 32 hereinafter more fully described, into operative engagement with the work by a piston rod 13 connected at its upper end with the pin 9 and having a piston 15 on its lower end. The piston 15 is reciprocably mounted in a cylinder 16 attached by bolts 17 to the flange 18. A spring 19 is housed within the cylinder 16 to yieldingly urge the piston 15 to its lower station when there is insufficient fluid pressure below the piston 15 and in the cylinder 16 to oppose the spring action.

A two-way valve 20 admits fluid pressure, pref-

erably air pressure, from a supply conduit 21 to an inlet passage 22 that communicates with the cylinder 16, the valve 20 also connecting the passage 22 with a relief conduit 23 to evacuate the cylinder 16. The cylinder 16 has a relief passage 24 which carries away any fluid that leaks past the piston 15.

The retaining member 10, which is slidably supported on the guide 12, has a plurality of beveled faces 26 formed at the inner extremities of slots 27 of the member 10 which register with the slots 14 in the guide 12. Blocks 25 slidably mounted in the slots 27 of the member 10 also register with and extend into the slots 14 of the guide member 12. Each of a plurality of bolts 28, best shown in Figs. 1 and 3, extend through a vertically elongated slot 29 formed in the member 10, and is threaded in an aperture of the blocks 25 respectively. Interposed between washers 30 carried by each bolt 26 is a coil spring 31 which yieldingly urges the blocks 25 against the faces 26 of the member 10.

The lapping tool 32 includes a plurality of lapping elements of each of which is carried by one of the blocks 25 and adapted to lap the external surfaces of annular members, such as piston rings, as will presently be more apparent. Upward movement of the tool holder 10 to its illustrated position simultaneously wedges all the lapping elements 32 against the faces 26 of the tool holder 10 in proper position for the lapping operation. A spacer ring 34 and a nut 35 are threaded on the upper threaded end portion 33 of the guide 12. This ring serves to limit the upward travel of the tool holder 10 beyond its illustrated position of Fig. 1.

Work 36, which is illustrated as annular split piston rings, is reciprocated relative to the lapping tool fixture 8 by driving and control mechanism which drives a work-receiving tubular shaft 37. The shaft 37 is supported for vertical reciprocatory rotational movements by bearings 38 and 39 mounted on the vertically reciprocable carriage 6.

Means are provided for drivingly reciprocating the carriage 6 relative to the frame structure 5. This driving mechanism comprises a piston rod 40 having an upper extremity which abuts against a projection 41 of the carriage 6. The lower portion of the rod 40 extends through a closely fitting opening 42 of a pressure cylinder 43 supported by the base structure 5 and carries a piston 44 which is adapted to move in response to fluid pressure introduced through a conduit 45 into the cylinder 43. A valve 46 having a control arm 47 is adapted to control fluid medium admitted from a supply conduit 48. If desired, an automatic mechanical control means may be used, instead of the arm 47, to control the fluid pressure admitted to the cylinder 43 for adjustably moving the carriage 6 vertically. When the control arm 47 is in its illustrated position the fluid does not pass through the valve 46; when at the position indicated at 49 the conduits 45 and 48 are placed in fluid pressure inter-communication; and when at the other indicated position 50 the fluid pressure communication between the conduits 45 and 48 is disrupted by the valve 46 and the conduit 45 is open for fluid passage to a discharge conduit 51 for bleeding the cylinder 43. Any fluid that leaks past the piston 44 will drain through a relief conduit 52.

The shaft 37 carries at its lower extremity the work 36 which reciprocates during the lapping operation. In this embodiment the work 36 comprises annular piston rings which are journaled by the lower portion of the shaft 37, an annular flange 53 on the shaft 37 serving as an upper stop for the work. A vertically adjustable slotted clamping member 55 is normally positioned below and in spaced relationship with the lower extremity of the shaft 37 and has an annular flange 54 that serves as an adjustable lower stop for the piston rings. A piston rod 56 is centrally disposed within the shaft 37 and its lower extremity carries a head portion 57 forming an adjustable holding means for the clamping member 55, as will be presently more apparent. The clamping member 55 has a slot 55a to permit the work to be installed on or removed from the shaft 37 when the work and the lapping elements 32 are out of lapping receiving relationship. When the work is to be installed or removed under this condition the members 57 and 55 are lowered with respect to the work and the member 55 is removed from the rod 56 by means of the slot 55a, and the piston rings are then dropped over the member 57 without receiving surface scratches from the lapping and work clamping mechanisms.

Rotation is imparted to the shaft 37 by a prime mover 58 carried by the carriage 6. A driving shaft 59 of the prime mover 58 is in driving engagement with a gear 60 splined at 61 on the shaft 37.

A relatively short reciprocatory lapping movement is imparted to the work 36, independently of the vertical position of the carriage 6, and independently of vertical reciprocatory movement of the carriage 6. This movement is produced by a yoke lever member 62 pivotally mounted at 63 on the carriage 6. One extremity of the member 62 has an opening in which is journaled a hollow extension 64 of the shaft 37. This extremity of the lever 62 is confined between a shoulder 71 on the shaft 37 and a nut member 70 threaded on the upper end of the extension 64. The other extremity of the lever 62 is pivotally connected at 65 to a link 66 which is pivoted at 67 to an eccentric carrying member 68 carried by a disc 67' which is driven by a prime mover 69 carried by the shiftable carriage 6. As the prime mover 69 drives the eccentric member 68 the work supporting shaft 37 is reciprocated in relatively short strokes by the member 62 independently of the vertical position of the carriage 6.

It is desirable in the illustrated embodiment of the invention to momentarily release the piston rings 36 to allow the rings to expand by their inherent resiliency substantially to an outer diameter desired when the lapping operation is completed. The piston rings may be conveniently automatically clamped and released by operating the rod 56 which controls the clamping member 55 by fluid pressure mechanism. The fluid pressure mechanism includes a cylinder 74 detachably secured to the upper extremity of the extension 64 of the shaft 37 by an internally threaded ring 72 threaded on the upper end portion of the shaft 37 and an overlapping externally threaded ring 76 threaded in a counterbored portion of the cylinder 74. These rings 72 and 76 are loosely engaged together so as to permit rotation of the shaft 37 and its extension 64 relative to the cylinder 74 which is held against rotation by a pin 80 mounted in the wall of the cylinder and engaged in a notch in

the upper end portion of a vertically upstanding post 82 mounted on the carriage 6.

Disposed in the cylinder 74 is a reciprocable piston 77 which is fixed to the upper portion of the rod 56. A spring 79 bears between the upper end wall of the cylinder 74 and the piston 77 so as to normally urge the piston 77 and the rod 56 downwardly. The piston 77 is normally urged upwardly by fluid under pressure admitted to the interior of the cylinder 74 through a supply pipe 78 and under the control of a valve mechanism therein.

Releasing of the work clamping mechanism is produced by automatically exhausting fluid pressure, preferably air pressure, from the cylinder 74. The cylinder 74 is provided with an outlet apparatus which is connected by a flexible conduit 83 with a valve casing 85 of a one-way valve mechanism which includes a reciprocable valve element 84. This valve casing 85 has an outlet 86 leading to atmosphere through which the flow of air is controlled by the valve element 84. The valve element 84 may be adjusted so as to relieve pressure from the interior of the cylinder 74 in any suitable manner but preferably in timed relationship with respect to the operation of the device.

In the apparatus shown in the drawing, this is conveniently accomplished by providing a coil spring 87 between the inner end of the valve element 84 and the end of the passage in the valve casing 85 in which it is mounted to normally urge the valve outwardly toward its closed position. A roller 89 rotatably mounted on the outer end of the valve element 84 rides upon the disc 67' on which the eccentric carrying member 68 is mounted. The eccentric carrying member 68 preferably has projections 88 extending outwardly from the extremities thereof which are adapted to engage the roller 89 and depress the valve element 84 against the action of the spring 87 in order to bring the valve element into open position twice during each rotation of the disc 67'. The projections 88 are preferably so located with respect to the crank pin 67 of the reciprocating mechanism as to cause the valve 84 to open when the shaft 37 is at its respectively opposite ends of its short reciprocatory stroke, thereby releasing the work at the ends of the short reciprocatory strokes imparted thereto by the shaft 37.

With reference to the operation of this embodiment of the invention, when it is desired to remove work from the shaft 37 the prime movers 58 and 69 are shut off and fluid pressure, preferably air pressure, is exhausted from the cylinder 16 to the relief conduit 23 to permit the spring 19 to force the piston 15 downwardly and thereby to move the tool holder 10 away from its illustrated position. Fluid pressure, preferably air pressure, is also admitted from the supply conduit 48, by selective manipulation of the control arm 47, to the cylinder 43 to cause the piston 44 to move the carriage 6 and the shaft 37 upwardly sufficiently to take the work out of lapping receiving relationship with the lapping elements 32. Then the fluid pressure in the cylinder 74 is exhausted by opening the valve 84, preferably manually, or by cutting off the supply of air through pipe 78, so as to allow the spring 79 to force the piston 77 and the piston rod 56 downwardly to lower the members 55 and 57 with respect to the lapped piston rings. The member 55 may then be removed entirely from the rod 56 and the piston rings may be dropped off the member 57 without receiving any surface marks from the lapping or the work clamping mechanisms. When the tool holder 10 is in its lower position the lapping element carrying blocks 25 are not held against the surfaces 26 of the member 10, and the lapping elements 32 may be removed if desired for any reason.

Following the unloading of the piston rings after the completion of the lapping operation, other piston rings to be lapped are slipped over the member 57, as illustrated, and the member 55 is then positioned relative to the rod 56 by means of the slot 55a. The valve 84 is then preferably closed manually to cut off exhausting of fluid pressure from the cylinder 74 so as to urge the member 57 into clamping engagement with the work clamping member 55. Fluid pressure is then admitted from the conduit 21 to the cylinder 16 to force the work holder 10 upwardly to again place the work in lapping receiving relationship with the lapping elements 32. This upward movement of the holder 10 to its illustrated position of Fig. 1 wedges each of the lapping elements 32 against the surface 26 of the holder 10.

The prime movers 58 and 69 are then started to respectively rotate the work carrying shaft 37 and to oscillate in short strokes through the pivoted member 62 the shaft 37. As the projections 88 of the rotating eccentric carrying member 68 contact the valve roller member 89, the fluid pressure within the cylinder 74 is relieved to allow the piston rod 56 and head portion 57 to be urged downwardly by the spring 79 to release the piston rings 36 at the ends of each of these short reciprocatory strokes. This periodical releasing of the piston rings allows them to subexpand under their inherent resiliency to substantially an outer diameter finally desired.

While the prime movers 58 and 69 are in operation it is desirable to control the carriage 6 by imparting comparatively long vertical reciprocatory travel to the carriage to cause the work carrying shaft 37 to also reciprocate with the carriage while maintaining the piston rings 36 in lapping contact with the lapping elements 32. This reciprocatory movement of the carriage 6 is preferably controlled by alternately admitting fluid pressure from the conduit 48 to the cylinder 43 and from the cylinder 43 to the discharge conduit 51 by selective manipulation of the control arm 47. The piston rings 36 will thereby be simultaneously rotated and also reciprocated in short and long strokes during the lapping operation, resulting in a very efficient lapping apparatus.

Referring now to the modified embodiment illustrated in Fig. 4, another form of piston ring lapping element is shown. It will be understood that this modified construction is intended to be substituted for the corresponding parts previously described and the entire mechanism and the operation of the same will not again be duplicated. Parts of similar function but different construction have been indicated by primed reference characters.

Attention is directed to the fact that the lapping elements 32 of the foregoing embodiment of the invention have been eliminated and in their place is a single annular lapping member 32' which is detachably secured in place by a recessed lapping tool guide extension 12' and a threaded collar 90. The annular lapping member 32' may be removed by unscrewing the collar 90 from the internally threaded guide extension 12'.

During the operation of the illustrated lapping apparatus the work is simultaneously rotated, and reciprocated in short and long strokes, as previously described, while bearing against the annular lapping member 32'. The clamping member 55 is periodically lowered in the same manner as was earlier described for allowing the piston rings to expand under their inherent resiliency to substantially their desired final outer diameter.

The illustrated lapping apparatus is equally adapted to use segmental lapping elements, as illustrated in the foregoing embodiment, or a single annular lapping member for convenience as desired without necessitating any major changes in the lapping apparatus.

By virtue of the foregoing lapping apparatus and method the piston rings and other generally cylindrical articles can be accurately brought to a true cylindrical contour and provided with a mirror-like finish by intermittently permitting the article being operated upon, particularly piston rings, to expand during lapping operation under their inherent spring action. The diametrical dimensions of the rings may be closely held to selective predetermined values.

Various modifications and changes may be effected in the illustrated applications without departing from the spirit of the invention or from the scope of the appended claims.

What I claim is:

1. Apparatus for lapping an annular split member having a tendency when contracted to resiliently expand toward its normal relaxed contour comprising a support, means on said support for rotatably supporting and drivingly rotating the work including members for releasably holding said work against expansion from a contracted condition, a tool fixture mounted on said support including a lapping element engageable with said work, and means for releasing said members of said rotatable work supporting means during rotation of said work thereby to allow said work to expand toward said lapping element under its natural resiliency.

2. Apparatus for lapping an annular split member having a tendency when contracted to resiliently expand toward its normal relaxed contour comprising a support, a carriage shiftably mounted on said support, means on said support for rotatably supporting and drivingly rotating the work about an axis substantially parallel to the direction of shifting movement of said carriage including members for releasably holding said work against expansion from a contracted condition, a tool fixture mounted on said support including a lapping element engageable with said work, and automatic means for periodically releasing said members of said rotatable work supporting means during rotation and reciprocation of said work to allow said work to expand toward said lapping element under its natural resiliency.

3. Apparatus for lapping an annular split member having a tendency when contracted to resiliently expand toward its normal relaxed contour comprising a base structure, a lapping element, a work support reciprocable relative to said base structure and rotatable relative thereto about an axis extending generally in the direction of its reciprocatory movement, said support including members for releasably holding said work against expansion from a contracted condition, means for drivingly rotating and reciprocating said work support, and means for automatically releasing said members of said support periodically and to allow said work to expand toward said lapping element.

4. Apparatus for lapping an annular split member having a tendency when contracted to resiliently expand toward its normal relaxed contour comprising a base structure, a lapping element, a carriage shiftably mounted on said base, and reciprocable relative thereto, a work support reciprocable and rotatable relative to said carriage about an axis extending generally in the direction of said reciprocable movement of said carriage, said support including members for releasably holding said work against expansion from a contracted condition, means for drivingly rotating and reciprocating said work support at a speed of substantially vibratory order and for reciprocating said carriage at a lower rate in the same direction as said work support reciprocatory movement, and means for automatically releasing said members of said support periodically to allow said work to expand toward said lapping element.

5. Apparatus for lapping an annular split member having a tendency when contracted to resiliently expand toward its normal relaxed contour, comprising a base structure, a lapping element, a work support reciprocable relative to said base structure and rotatable relative thereto about an axis extending generally in the direction of its reciprocatory movement, said support including members for releasably holding said work against expansion from a contracted condition, means for drivingly rotating and reciprocating said work support, and means operable in timed relationship to said reciprocatory movement of said work support to automatically release said members of said work support at least at one end of said reciprocatory stroke of said work support to allow said work to expand toward said lapping element.

6. Apparatus for lapping an annular split member having a tendency when contracted to resiliently expand toward its normal relaxed contour comprising a base structure, a lapping element, a work support reciprocable relative to said base structure and rotatable relative thereto about an axis extending generally in the direction of its reciprocatory movement, said support including members for releasably holding said work against expansion from a contracted condition, a rotatable eccentric adapted to impart said reciprocatory movement to said work, means for drivingly rotating said work support, and fluid pressure responsive means for releasing said members of said support periodically in response to rotation of said eccentric to allow said work to expand toward said lapping element.

7. Apparatus for lapping an annular split member having a tendency when contracted to resiliently expand toward its normal relaxed contour comprising a base structure, a lapping element, a work support reciprocable relative to said base structure and rotatable relative thereto about an axis extending generally in the direction of its reciprocatory movement, a removable clamping jaw member, a mandrel extending through said work support and said work having an abutment for releasably holding said jaw member to releasably hold said work against expansion from a contracted condition, means for drivingly rotating and reciprocating said work support, and means at the end of said mandrel opposite from said jaw member to periodically release said jaw

member to allow said work to expand toward said lapping element.

8. The method of lapping and bringing to true cylindrical contour the exterior of an annular split member having a tendency when contracted to resiliently expand toward its normal relaxed contour which comprises rotatably and shiftably mounting said work for reciprocatory movement in a course substantially parallel to its rotative axis, drivingly rotating and reciprocating said work, applying a lapping element to the external surface of said work, and alternately holding said work against expansion and releasing said work to allow expansion periodically during such movements of said work.

9. The method of lapping and bringing to true cylindrical contour the exterior of an annular split member having a tendency when contracted to resiliently expand toward its normal relaxed contour which comprises rotatably and shiftably mounting said work for reciprocatory movement in a course substantially parallel to its rotative axis, drivingly rotating and reciprocating said work, applying a lapping element to the external surface of said work, and alternately holding said work against expansion from a contracted contour and releasing said work to accommodate expansion thereof in timed relation to said reciprocatory movement of said work, said work being released at the ends of said reciprocatory strokes of said work.

10. The method of lapping and bringing to true cylindrical contour the exterior of an annular split member having a tendency when contracted to resiliently expand toward its normal relaxed contour which comprises rotatably and shiftably mounting said work for reciprocatory movement in a course substantially parallel to its rotative axis, drivingly rotating and reciprocating said work, applying a lapping element to the external surface of said work, simultaneously rotating said work and reciprocating said work at a speed of substantially vibratory order while reciprocating said work at a slower speed and throughout a longer course, and alternately holding said work against expansion and releasing said work to allow expansion periodically during such movements of said work.

11. Apparatus for lapping an annular split member having a tendency when contracted to resiliently expand toward its normal relaxed contour comprising a base structure, a plurality of annularly arranged lapping elements supported by said base and forming a cylindrical passage, a work support reciprocable relative to said base and rotatable relative thereto about an axis extending generally in the direction of its reciprocatory movement, said support including members for releasably holding said work against expansion from a contracted condition, means for drivingly rotating and reciprocating a portion of said work support within said cylindrical passage defined by said lapping elements and expanding said lapping element to define a larger diameter cylindrical passage when said work support portion is within said cylindrical passage, and means for automatically releasing said members of said support periodically to allow said work to expand toward said lapping elements.

12. Lapping apparatus comprising relatively movable lapping element supporting and work supporting units, said lapping element supporting unit having a lapping element and said work supporting unit including members for releasably clamping a piece of work against movement toward said lapping element, driving mechanism for producing relative lapping movement between said units, and means operable during said relative movement of said units for intermittently releasing said clamping members.

13. Lapping apparatus comprising relatively movable lapping element supporting and work supporting units, said lapping element supporting unit having a lapping element and said work supporting unit including members for releasably clamping a piece of work against movement toward said lapping element, driving mechanism for producing relative lapping movement between said units, and means operable during and in timed relation to said relative movement of said units for periodically releasing said clamping members when said units are in a predetermined relative position.

14. Apparatus for lapping an article having a tendency when deflected from a normal relaxed condition to return to said relaxed condition comprising relatively movable lapping element supporting and work supporting units, said lapping element supporting unit having a lapping element and said work supporting unit including members for releasably clamping said article against movement relative to said work supporting unit and in an unrelaxed condition such that it tends to deflect toward said lapping elements, driving mechanism for producing relative lapping movement between said units, and means operable during relative movement of said units for intermittently releasing said clamping members for accommodating deflection of said article toward said lapping element.

15. Lapping apparatus for lapping an article having a tendency when deflected from its relaxed condition to return to said condition comprising relatively movable lapping element supporting and work supporting units, said lapping element supporting unit including a movably mounted lapping element and mechanism for moving the same toward and away from said article to deflect and accommodate relaxing of said article respectively and said work supporting unit including members for releasably clamping said article relative to said work supporting unit and in an unrelaxed condition such that it tends to deflect toward said lapping element, driving mechanism for producing relative lapping movement between said units, and means operable during relative movement of said units for intermittently releasing said clamping members for accommodating deflection of said article toward said lapping element.

16. The method of lapping an article which comprises yieldably urging a surface of said article against a lapping element, releasably clamping said article against further movement toward said element while it is yieldably urged thereagainst to positively hold said surface in a predetermined relationship with respect to said article, drivingly producing relative lapping movement between said article and said lapping element, and intermittently releasing said article to accommodate movement of said lapping surface toward said lapping element during said relative lapping movement and in a predetermined timed relationship with respect thereto.

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