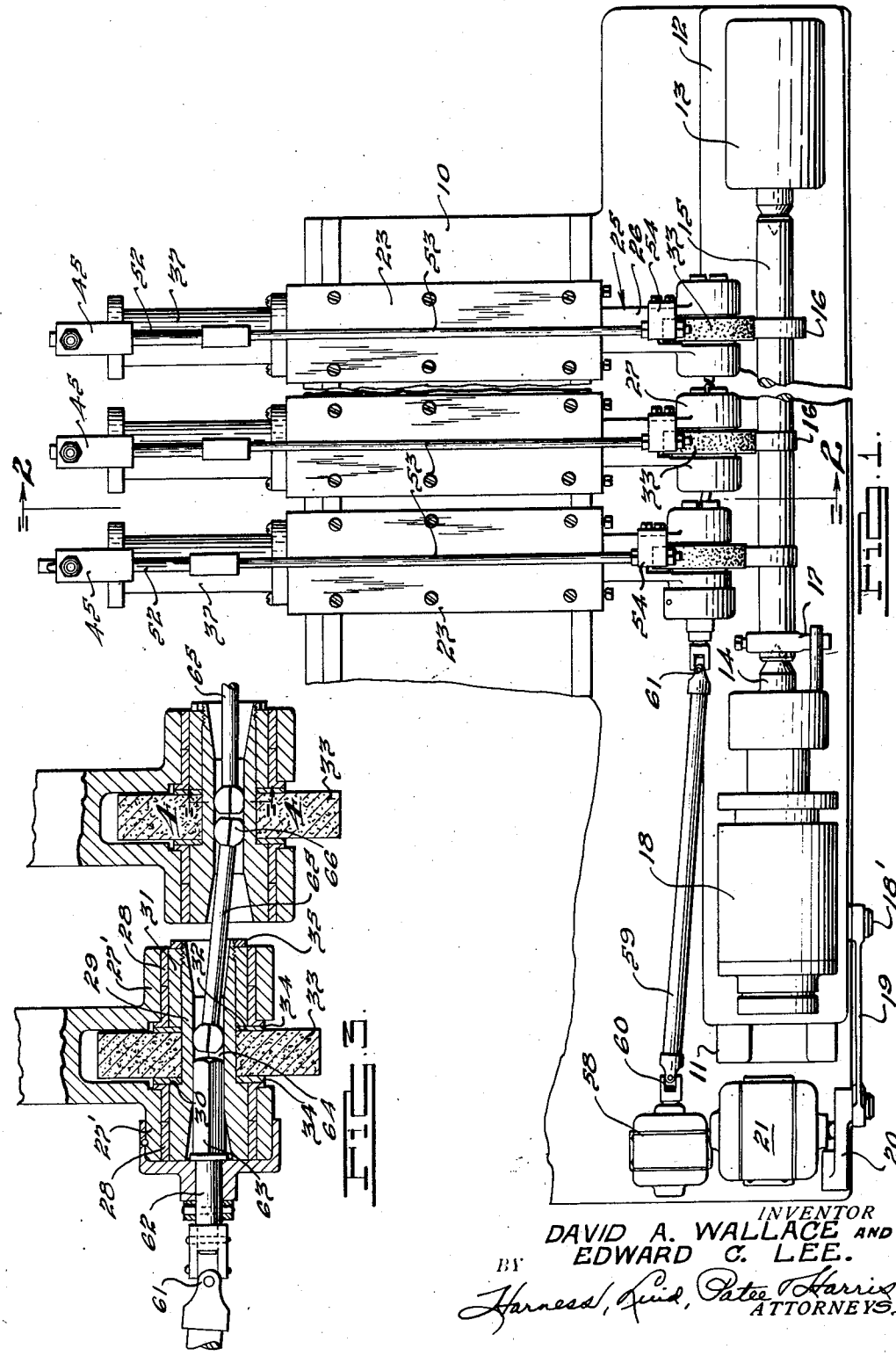
March 26, 1940. D. A. WALLACE ET AL 2,195,054

LAPPING APPARATUS

Filed Aug. 13, 1937 2 Sheets-Sheet 1



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LAPPING APPARATUS

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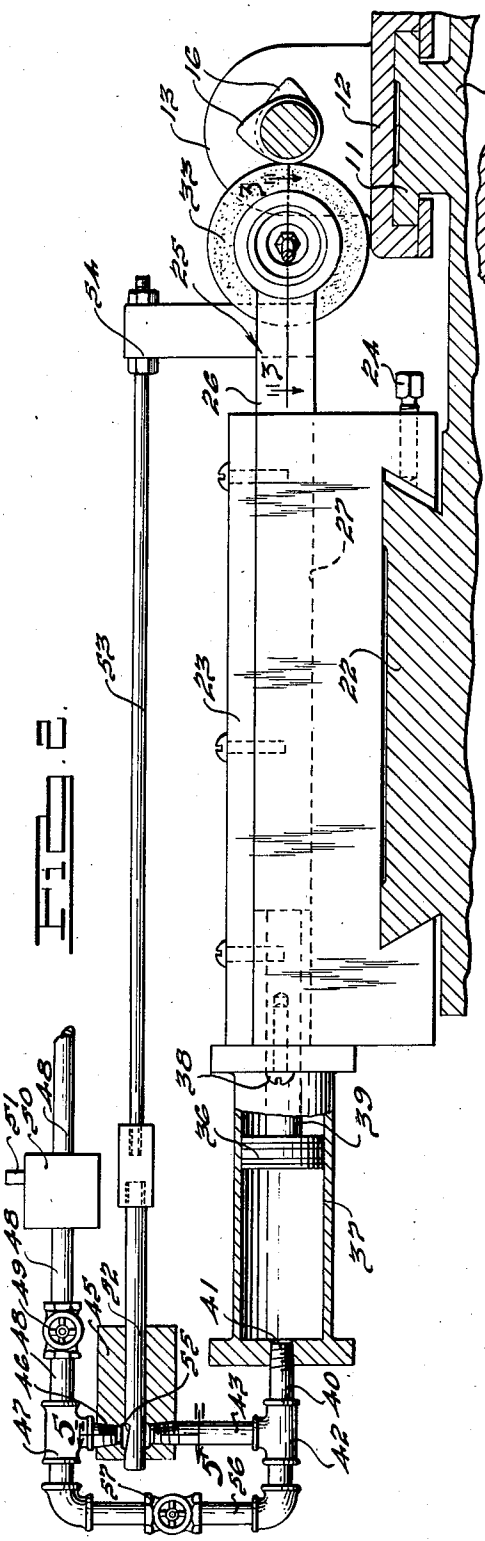


FIG. 2.

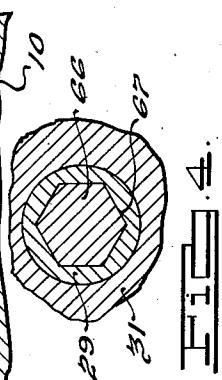


FIG. 4.

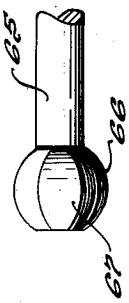


FIG. 7.

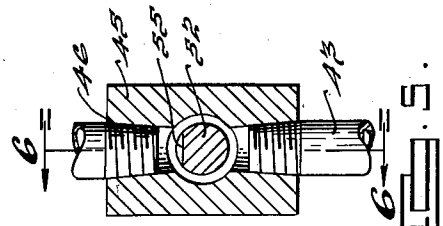


FIG. 5.

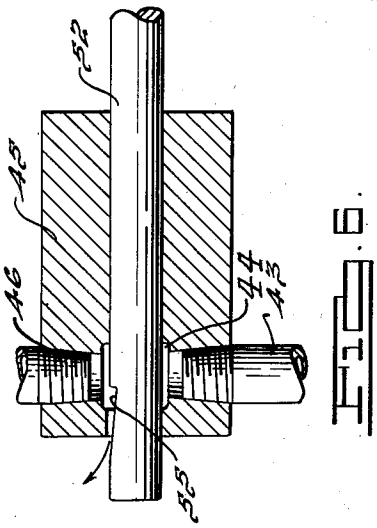


FIG. 6.

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UNITED STATES PATENT OFFICE

2,195,054

LAPPING APPARATUS

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Application August 13, 1937, Serial No. 158,828

14 Claims. (Cl. 51—45)

This invention relates to an improved lapping apparatus and lapping method.

More particularly, the invention pertains to improvements in an apparatus and method for lapping cam surfaces and other surfaces which are eccentrically located with respect to an axis of an article.

One of the main objects of the invention is the provision of an apparatus and methods of this character by which a plurality of cam surfaces of a multiple cam shaft may be simultaneously lapped.

Another object of the invention is the provision of means in apparatus of this character by which a lapping element may be yieldably urged with substantially uniform pressure against substantially all portions of a cam surface, or by which the pressure of application of the lapping element to selected portions of the cam surface may be brought to different predetermined values.

A still further object of the invention is the provision of control mechanism for varying the force of application of the lapping element to a cam surface which is responsive to movement of the element by the cam surface and which is adapted to progressively decrease the pressure of application upon increments of surface which are successively more remote from the axis of rotation of the cam.

Other objects of the invention are the provision of apparatus for controlling the application of pressure of a lapping element to a cam surface by which the pressure may be substantially relieved as the lapping element is applied to the outer end portions of the lobe part of a cam; to provide a plurality of independent and individually operable lapping element in a device of this kind which may reciprocate in cam following fashion independently of each other during simultaneous lapping of a plurality of cams of a single cam shaft; to provide fluid pressure operable lap element urging mechanism which may be relied upon to urge the lapping element toward the work with substantially uniform pressure regardless of the position of the lapping element in its path of reciprocatory movement.

Other objects of the invention are the provision of improved means for rotatively driving individually reciprocable lapping elements; to provide means for drivingly rotating the work during application thereto of drivingly rotated lapping elements; and to provide means for drivingly reciprocating the work simultaneously with the rotation thereof and the rotation of the lapping elements.

An illustrative embodiment of the invention is shown in the accompanying drawings, in which:

Fig. 1 is a fragmentary plan view of a lapping machine embodying the invention.

Fig. 2 is a transverse vertical sectional view taken on the line 2—2 of Fig. 1.

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

Fig. 4 is a fragmentary, transverse vertical sectional view taken on the line 4—4 of Fig. 3.

Fig. 5 is a fragmentary, vertical sectional view taken on the line 5—5 of Fig. 2.

Fig. 6 is a longitudinal, sectional view taken on the line 6—6 of Fig. 5.

Fig. 7 is a fragmentary view of a part of the rotative driving coupling structure shown in Fig. 3.

In the form of the invention illustrated in the drawings, the improved lapping apparatus includes a base structure or support, generally designated by the numeral 10, having an upwardly protruding table portion 11 on which is slidably mounted a carriage 12. The carriage 12 is provided with spaced dead and live spindles 13 and 14 respectively, between which a cam shaft 15 having cams 16 thereon is receivable. A clamping ring 17 carried by the live spindle 14 is provided for releasably non-rotatably securing the cam shaft 15 to the spindle 14. An electric motor 18, or other suitable driving means, carried by the carriage 12, drives the live spindle 14 and the work supported by the latter and the dead spindle 13.

The carriage 12 has an outwardly extending bearing boss 18' on which is journalled one end of a link 19, the other end of the link being journalled on a crank 20 which is adapted to be driven by a motor 21 mounted on the support 10. Operation of the motor 21 reciprocates the carriage and the live and dead spindles, as well as the work carried therebetween, in a direction substantially parallel to the rotative axis of the work.

The support 10 is provided with a dove-tail projection 22 located in spaced relation with respect to and extending parallel to the table 11 on which the work carriage 12 is slidably mounted. A plurality of lapping tool supporting blocks 23 are adjustably, shiftably mounted on the dovetail projection 22 and provided with set screws 24 by which they may be secured in a selected position of adjustment. There are as many lapping tool supporting blocks 23 mounted on the

dove-tail projection 22 as the number of cams 16 on the cam shaft 15 to be lapped. The lapping tool supporting blocks 23 and the lapping tools associated therewith are substantially identical and therefore a description of one will serve for all.

Each lapping tool, generally designated by the numeral 25 in Fig. 1, includes a shank portion 26 slidably mounted in a passage 27 in the supporting block 23 so as to reciprocate in a direction transversely of the axis of the cam shaft 15. The outer end portion of the shank 26 is bifurcated, as illustrated in Fig. 3, and provided with opposed tubular portions 27' in which suitable bearing sleeves 28 are confined. Journalled in the bearings 28 is a hollow spindle 29 having an enlarged end portion which provides a thrust shoulder 30 at the inner extremity of one of the bearing sleeves. A collar 31 mounted on the opposite end portion of the spindle 29 provides a thrust bearing shoulder 32 at the inner end of the other bearing sleeve 28. A lapping element 33, of substantially cylindrical shape, is secured to the intermediate portion of the spindle 29 and located between the thrust shoulders 30 and 32, respectively. Metal plates 34, provided on respectively opposite sides of the lapping wheel 33 have outer surfaces bearing against the thrust shoulders 30 and 32 respectively. The lapping wheel is clamped between the thrust shoulders 30 and 32 by a nut 35 threaded on the right end of the spindle 29.

Each lapping wheel 33 is yieldably urged toward the cam shaft 15 and cam 16 by fluid pressure applied on a piston 36 reciprocably mounted in the cylinder 37 which is attached by screws 38 to the left end portion of the lapping tool supporting block 23, as viewed in Fig. 2. The piston 36 has a rod piston 39 which bears against the inner end portion of the shank 26 of the lapping tool 25. Fluid, preferably compressed air, is supplied to the interior of the cylinder 37 through a pipe 40 threaded in an aperture 41 formed in the closed extremity of the cylinder. The pipe 40 is connected by a T joint 42 with a pipe 43 which leads from an annular chamber 44 formed in a valve body 45. A fitting 46 also communicates with the annular chamber 44 and with a T joint member 47 having one opening thereof connected with a fluid pressure supply pipe 48 in which is included a valve 49. The fluid pressure supply pipe 48 leads from a source of fluid pressure (not shown) and this supply pipe includes a pressure chamber 50 having a relief valve 51 for maintaining the fluid under pressure therein at a predetermined maximum pressure. The relief valve 51 is preferably of the adjustable type by which the maximum pressure limit may be variably predetermined.

The flow of fluid pressure from the supply pipe 48 to the cylinder 37 may be controlled by valve mechanism comprising a valve member 52 reciprocably mounted in the valve body 45 and extending through the annular chamber 44. The valve 52 is preferably connected with the lapping tool 25 by a valve rod 53 and upstanding lug 54. Formed in the left end portion of the valve member 52, is a notch 55, a portion of which is adapted to extend beyond the left extremity of the valve body, as viewed in Fig. 2, in order to relieve air pressure from the system. The valve mechanism is preferably so constructed and arranged as to gradually vary the pressure by which the lapping arm 33 is applied to the work as the lapping element comes into contact with selected portions of the cam which are of progressively further distances from the axis of the cam shaft. Reduction of the pressure of application of the lapping element on the cam is preferably caused to occur while the lapping element is in contact with the outermost portions of the lobe of the cam. In this manner excessive removal of metal from the lobe portion of the cam and from portions thereof in which the curvature of the cam reverses, is prevented.

Connected between the T joints 42 and 47 of the system of pipes by which fluid under pressure is supplied to the cylinder 37, is a by-pass passage 56 having a valve 57 therein by which fluid under pressure may, if desired, be supplied to the cylinder 37 independently of the valve mechanism comprising the valve body 45 and valve member 52. When the valve 57 is open, substantially uniform pressure is applied on the piston 36 irrespective of the position of the valve 52, this pressure remaining uniform throughout the entire length and stroke of the piston 36 and as a result the pressure of application of the lapping element 33 to all portions of the surface of the cam 16 is constant.

The lapping element 33 may be drivingly rotated by a motor 58 mounted on the support 10 and connected by a shaft 59 with one of the lapping wheels. The shaft 59 includes a universal joint member 60 by which one end thereof is operatively connected with the motor 58 and a universal joint 61 by which the opposite end thereof is drivingly connected with a coupling member 62 having a flat-sided end portion 63 fitted within a similarly shaped passage 64 formed in the interior of the hollow spindle 29, as viewed in Fig. 3. Each lapping wheel 33 is rotatively drivingly connected with the lapping element of the adjacent tool by a pin 65 having an enlarged head portion 66 on respectively opposite ends which, as illustrated in Fig. 7, have spaced face portions which curve sufficiently about axes extending transversely of the longitudinal axis of the pin 65, to accommodate universal movement of the end portions of the pin. The spaces 67 of the enlarged end portion 66 of the pin 65 are so constructed and arranged as to establish a driving connection between the spindles 29 in which they are disposed. In the form of the invention illustrated, the enlarged end portions 66 of the pin 65 are hexagonal in transverse cross section and the passage 64 of the spindle 29 in which they are received is of corresponding shape. The outer end portions 68 of the passage 64 are flared sufficiently to accommodate relative movement between successively adjacent lapping tools in order that each tool may reciprocate in cam following fashion during simultaneous lapping of a plurality of cams of a cam shaft.

During operation of the apparatus the work may be drivingly rotated by the motor 18 while it is simultaneously reciprocated at a relatively high speed by the motor 21. The lapping elements 33 are preferably drivingly rotated by the motor 58 during this simultaneous rotation and reciprocation of the work. The lapping tools are yieldably urged by fluid pressure against the surfaces of the cam and the tools are moved against such pressure by the cause during rotation of the crankshaft 15. When the valve 57 of the fluid pressure supply system is closed, the force of application of the lapping element 33 upon the cams is automatically variably controlled, preferably in such a manner as to re-

duce the pressure as the lapping elements operate upon the outer extremities of the lobe of the cam. When the valve 57 is open, the lapping element is applied with substantially uniform pressure to all portions of the surface of the cam with which they engage during the foregoing operation of the apparatus.

Although but one specific embodiment of this invention is herein shown and described, it will be understood that various changes in the size, shape and arrangement of parts may be made without departing from the spirit of our invention.

What we claim is:

1. Lapping apparatus including a support, means mounted on said support for rotatably supporting and drivingly rotating a piece of work, a lapping tool shiftably mounted on said support having a lapping element engageable with a surface thereof, fluid pressure operable means for urging said element against said work, and means responsive to movement of said tool for varying the effective pressure with which said fluid operable means urges said element against said work in accordance with the position of said tool in its path of shifting movement, said means being so constructed and arranged that the effective pressure with which said tool is urged against said work is increased as said tool moves towards the axis of said work in its course of shifting movement and decreased as said tool moves in an opposite direction.

2. Apparatus for lapping eccentric surfaces of a piece of work comprising a support, means on said support for rotatably supporting and drivingly rotating a piece of work having such a surface on an axis eccentric with respect thereto, a lapping tool slidably mounted on said support for shifting movement by said surface in a direction transversely of the rotative axis of said work and having a lapping element engageable with said surface, and a fluid pressure system having a fluid pressure medium against which said tool is moved under the action of said eccentric surfaces for yieldably urging said lapping element against said surface, said system having a relief valve and being so constructed and arranged as to exhaust fluid pressure medium therefrom as said tool is moved against said fluid pressure medium in order that said element will be urged against said surface with substantially uniform pressure while in engagement with all portions of said surface.

3. Apparatus for lapping eccentric surfaces of a piece of work comprising a support, means on said support for rotatably supporting and drivingly rotating a piece of work having such a surface on an axis eccentric with respect thereto, a lapping tool slidably mounted on said support for shifting movement by said surface in a direction transversely of the rotative axis of said work and having a lapping element engageable with said surface, and apparatus for yieldably urging said element against said surface including means operable during each rotation of said work responsive to movement of said tool away from the axis of said work by said surface for decreasing the pressure of application of said element to said work as portions of said surface relatively remote from said axis are operated upon by said element.

4. Cam surface lapping apparatus including a support, means on said support for rotatably supporting and drivingly rotating a cam about an axis coincident with its normal rotative axis, a lapping tool mounted on said support for reciprocatory cam following movement in a path extending transversely of said axis and including a lapping element engageable with said cam, and fluid pressure apparatus for yieldably urging said element against said cam including valve mechanism responsive to movement of said tool for varying the pressure by which said element is urged toward said cam while said element is operating upon selected portions thereof, said apparatus being so constructed and arranged that the pressure with which said tool is applied to said cam is increased as said tool moves toward said axis and decreased as said tool moves away from said axis.

5. Cam surface lapping apparatus including a support, means on said support for rotatably supporting and drivingly rotating a cam about an axis coincident with its normal rotative axis, a lapping tool mounted on said support for reciprocatory cam following movement in a path extending transversely of said axis and including a lapping element engageable with said cam, and fluid pressure apparatus for yieldably urging said element against said cam including valve mechanism responsive to movement of said tool and so constructed and arranged as to gradually increase the pressure by which said element is urged toward said cam as said element moves toward said axis into operative engagement with portions of said cam which are successively closer to said axis.

6. Lapping apparatus including a support, means on said support for rotatably and shiftably supporting and drivingly rotating a piece of work about an axis extending in the direction of its shifting movement, a lapping tool slidably mounted on said support for reciprocating movement in a direction transversely of said axis including a rotatable lapping element, fluid pressure means for yieldably urging said lapping element against said work, control mechanism for said fluid pressure means responsive to movement of said tool for varying the effective pressure with which said element is applied to said work and mechanism for drivingly reciprocating said work and rotating said lapping element during rotation of said work and while said lapping element is engaged therewith.

7. Apparatus for simultaneously lapping a plurality of cams of a cam shaft including a support, means on said support for rotatably supporting and drivingly rotating a cam shaft about its normal axis, a plurality of lapping tools each individually shiftably mounted on said support for reciprocating movement in a direction transversely of said axis and each including a rotatable lapping element, means for yieldably urging each lapping element against a cam of said shaft respectively, and mechanism for drivingly rotating said lapping elements including a driving member flexibly connected to one of said elements and members flexibly connecting each lapping element to the lapping element of the adjacent tool.

8. Apparatus for simultaneously lapping a plurality of cams of a cam shaft including a support, means on said support for rotatably supporting and drivingly rotating a cam shaft about its normal axis, a plurality of lapping tools each individually shiftably mounted on said support for reciprocating movement in a direction transversely of said axis and each including a rotatable lapping element, means for independently and individually yieldably urging each lapping element against a cam of said shaft respectively,

and a control device acting upon each lapping element urging means respectively for varying the force with which the latter urges a lapping element against a cam, each of said devices being responsive to cam produced movement of the tool with which it is associated and adapted to vary said force in timed relation to cam movement.

9. Apparatus for simultaneously lapping a plurality of cams of a cam shaft including a support, means on said support for rotatably supporting and drivingly rotating a cam shaft about its normal axis, a plurality of lapping tools each individually shiftably mounted on said support for reciprocating movement in a direction transversely of said axis and each including a rotatable lapping element, means for independently and individually yieldably urging each lapping element against a cam of said shaft respectively, a control device for each lapping element urging means respectively, each of said devices being responsive to cam produced movement of the tool with which it is associated, and mechanism for drivingly rotating said lapping elements including a driving member flexibly connected to one of said elements and members flexibly connecting each lapping element to the lapping element of the adjacent tool.

10. Apparatus for simultaneously lapping a plurality of cams of a cam shaft including a support, a carriage reciprocably mounted on said support, means on said carriage for rotatably supporting and drivingly rotating a cam shaft about its normal axis, a plurality of lapping tools each individually shiftably mounted on said support for reciprocating movement in a direction transversely of said axis and each including a rotatable lapping element, means for independently and individually yieldably urging each lapping element against a cam of said shaft respectively, a control device acting upon each lapping element urging means respectively for varying the force with which the latter urges a lapping element against a cam, each of said devices being responsive to cam produced movement of the tool with which it is associated and adapted to vary said force in timed relation to cam movement, and means for drivingly reciprocating said carriage and said shaft in the direction of its rotative axis.

11. Apparatus for simultaneously lapping a plurality of cams of a cam shaft including a support, a carriage reciprocably mounted on said support, means on said carriage for rotatably supporting and drivingly rotating a cam shaft about its normal axis, a plurality of lapping tools each individually shiftably mounted on said support for reciprocating movement in a direction transversely of said axis and each including a rotatable lapping element, means for independently and individually urging each lapping element against a cam of said shaft respectively, a control device for each lapping element urging means respectively, each of said control devices being responsive to cam produced movement of the tool with which it is associated, mechanism for drivingly rotating said lapping elements including a driving member flexibly connected with one of said elements and members flexibly connecting each lapping element to the lapping element of the adjacent tool, and apparatus for drivingly reciprocating said carriage and shaft in the direction of its rotative axis during application of said lapping elements to said cams and while said shaft and lapping elements are rotated.

12. Lapping apparatus including a support, means on said support for rotatably supporting and drivingly rotating a piece of work, a lapping tool slidably mounted on said support for reciprocatory movement in a direction transversely of the rotative axis of said work including a lapping element engageable with said work, said lapping element and work being relatively reciprocable with respect to each other in the direction of said axis, fluid pressure means for yieldably urging said lapping element against said work, control mechanism for said fluid pressure means for varying the effective pressure with which said element is applied to said work, and mechanism for drivingly producing reciprocatory movement between said work and said lapping element and for rotating work while said lapping element is engaged therewith.

13. Lapping apparatus including a support, means on said support for rotatably supporting and drivingly rotating a piece of work, a lapping tool slidably mounted on said support for reciprocatory movement toward and away from said work, variable means for yieldably urging said lapping element toward said axis and against said work, and apparatus for variably controlling said means, said apparatus being so constructed and arranged as to increase the force by which said means urges said lapping element against said work as said lapping element moves toward the rotative axis of said work.

14. Surface finishing apparatus including means for supporting for contacting relative rotation about an axis and reciprocation in the direction of said axis a piece of work having a surface to be finished and an abrading element, fluid pressure means for variably yieldably urging said abrading element against said work, control mechanism for said fluid pressure means for varying the effective pressure with which said element is urged against said work, and mechanism for drivingly producing relative reciprocatory and rotative movements between said abrading element and said work and actuating said control mechanism in timed relation while said abrading element is engaged therewith.

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