

June 24, 1958

S. A. BOETTCHER
LAPPING MACHINE

2,839,877

Filed March 29, 1954

4 Sheets-Sheet 1

FIG. 1

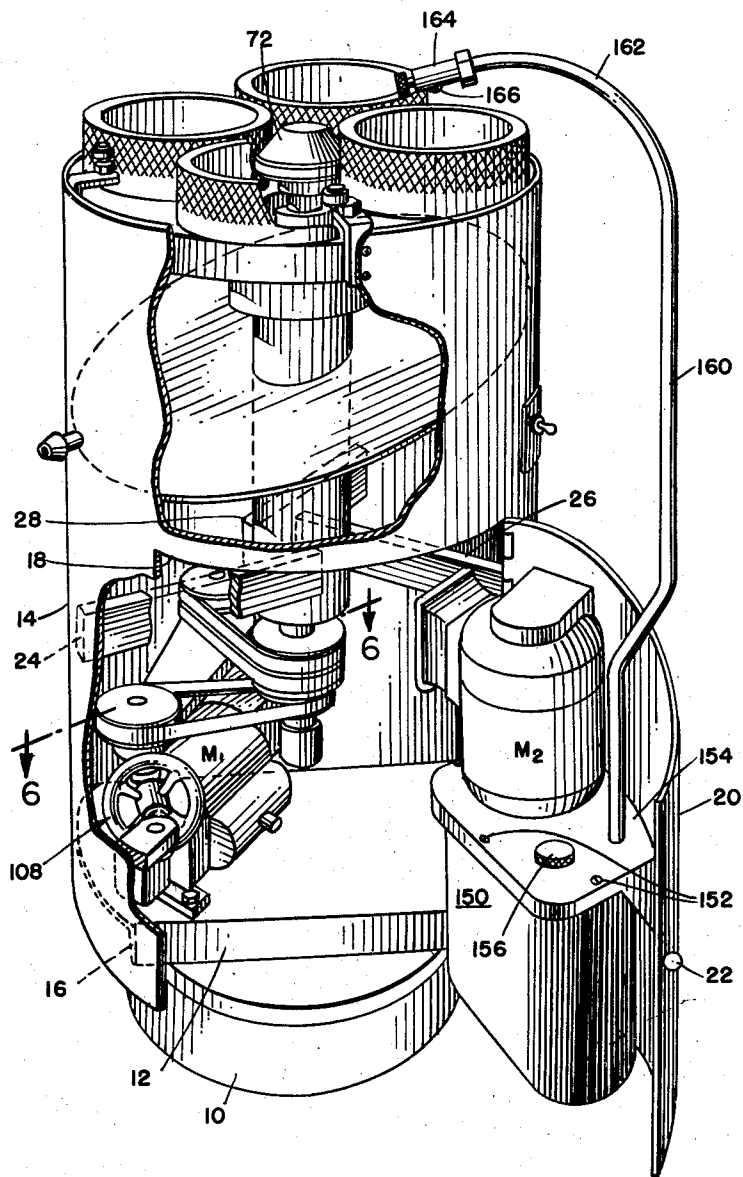
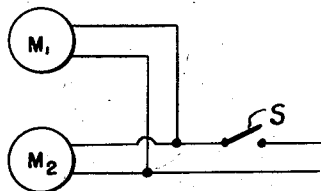


FIG. 9



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LAPPING MACHINE

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FIG. 2

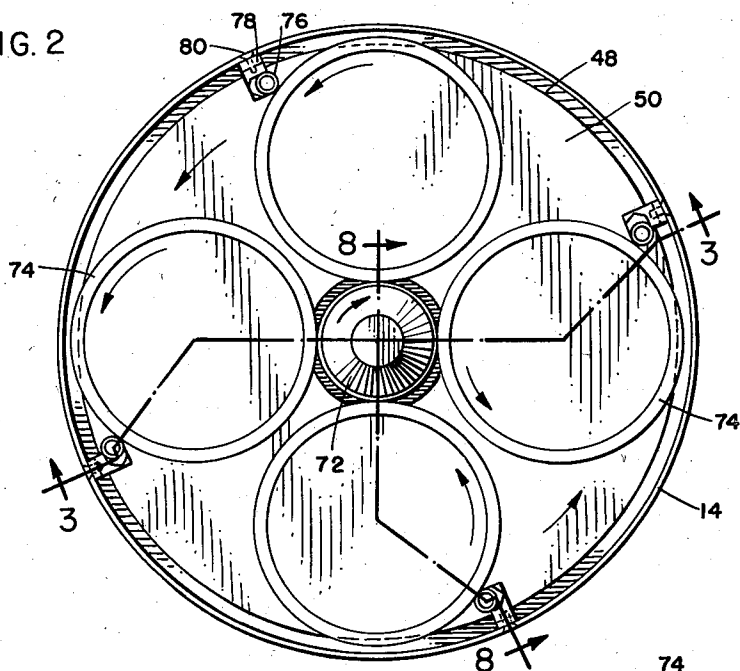
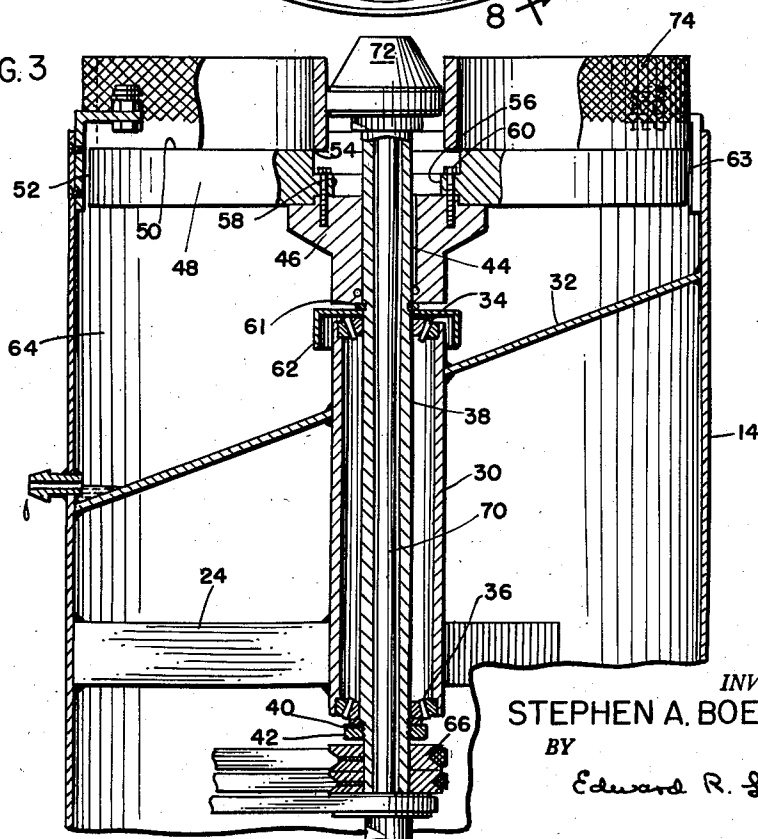


FIG. 3



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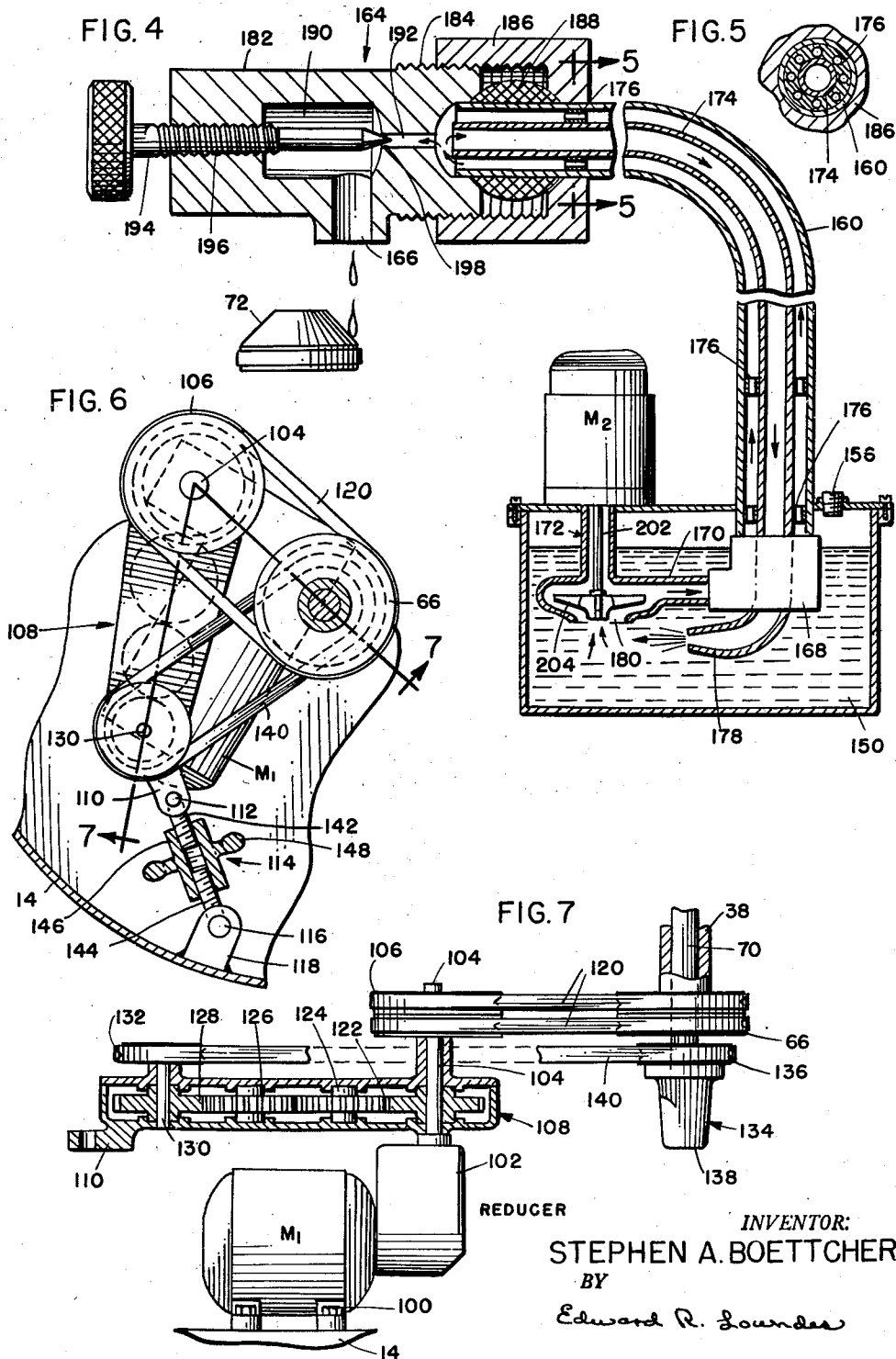
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LAPPING MACHINE

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June 24, 1958

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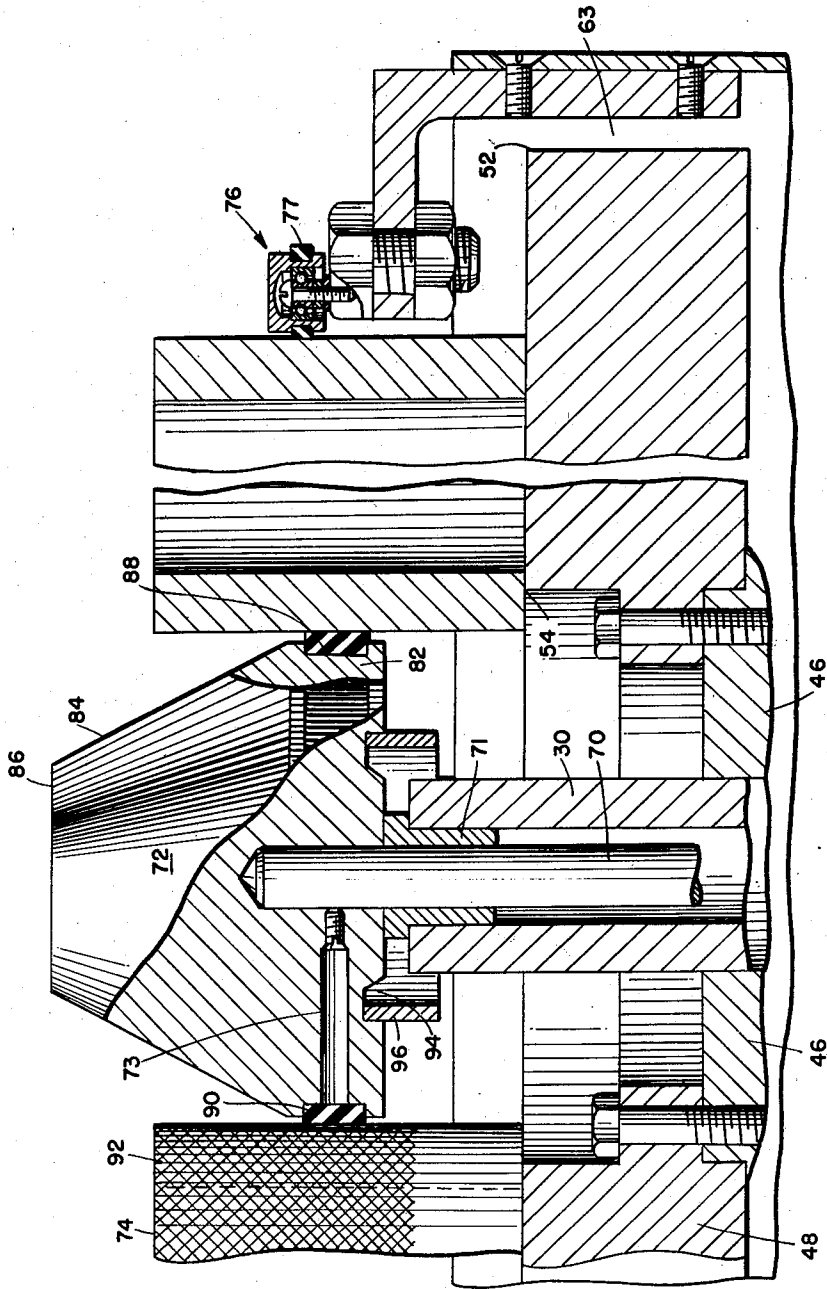
2,839,877

LAPPING MACHINE

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FIG. 8



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LAPPING MACHINE

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Application March 29, 1954, Serial No. 419,227

4 Claims. (Cl. 51—131)

The present invention relates to lapping machines for lapping and surfacing various products of manufacture as for example the annular surfaces of rotary mechanical seals, thrust washers, piston rings, flat valve faces, gage blocks, piezoelectric crystals and a large variety of other flat work too numerous to mention.

More particularly, the invention relates to lapping machines of the general type wherein there is provided a rotatable lap having a substantially flat lap surface on which there is positioned one or more wear rings each of which is adapted to overlie the lap annulus and overhang both the inside and outside peripheral edges of the annulus, together with means for preventing revolution of the wear ring or rings about the axis of the lap annulus while at the same time permitting free induced rotation of the wear ring or rings, with the further inclusion of means for adjusting the position of the wear ring or rings radially toward and away from the axis of the lap so that the lap surface will be automatically dressed during lapping operations under controlled conditions by means of which the lap annulus may assume and maintain a required convex, concave or plane surface.

It has been proposed, in connection with lapping machines of this general type, that accurate control of the contour of the lap annulus as between conditions of concavity, flatness or convexity, may be accomplished by the expedient of positively rotating or driving the conditioning rings at varying rates of speed about their own vertical axes, either in the normal direction of induced rotation or in the opposite direction, while at the same time maintaining a constant amount of overhang both at the inside and at the outside circular edges of the lap annulus. This method of controlling the contour of the lap annulus is predicated upon varying the differential between the velocity of the wear ring and the lap annulus at different radial distances from the center of the lap.

The present invention specifically relates to an improved method and apparatus for effecting a positive and variable speed drive for the wear rings of a lapping machine so as to obtain varying wear differentials between the wear ring and lap surface at radially spaced points with reference to the lap annulus.

It is among the principal objects of the present invention to provide a novel means for positively driving the wear rings associated with a lapping machine of the type briefly outlined above in which an element of the driving means also constitutes an element of the holding means by means of which the wear rings are prevented from revolving about the axis of the lap annulus.

A further object of the invention is to provide a machine of this character in which the driving and holding element above referred to is common to all of the wear rings, which is to say that it is capable of positively driving each wear ring, regardless of the number of rings employed, as well as serving to locate the wear ring in its predetermined radial position with respect to the center of the lap annulus.

In carrying out the above mentioned objects, briefly

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the invention contemplates the provision of a rotating lap annulus together with the provision of a series of wear rings adapted to rest upon the surface of the lap annulus and overhang both the inside and outside peripheries thereof. Suitably supported above the level of the lap annulus are a plurality of rollers or other antifriction members, each positioned so as to engage the outer cylindrical surface of one of the wear rings. Centrally disposed with respect to the lap annulus and slightly above the level thereof is a common driving hub or wheel which, like the previously mentioned rollers, is adapted to frictionally engage the cylindrical sides of all of the wear rings when the latter are in position on the lap annulus. The distance between each idler roller and the driving wheel or hub is less than the external diameter of the individual wear rings so that each idler roller, in combination with the driving hub, will subtend an arcuate sector of each wear ring therebetween so that the resultant vectorial force exerted upon the ring during rotation of the lap annulus due to friction with the annulus is directed between the driving hub and idler roller. In this manner each wear ring is maintained in contact with one idler roller and the common driving hub so that the ring is constrained to rotate about a fixed vertical axis. Means are also provided for positively rotating the central driving hub at varying rates of speed so that, by virtue of its frictional contact with each of the wear rings, the speed of rotation of the wear rings may be increased or decreased to cause the rings to establish different degrees of wear with the lap annulus at any given point therebetween. By such an arrangement, and in a manner that will be set forth in detail presently, the contour of the lap annulus may controllably be regulated as between concave, flat and convex.

The provision of a lapping machine of the character briefly outlined above being the principal object of the invention, a further object thereof is to provide a novel means for obtaining a high coefficient of friction between the driving hub and each of the wear rings so that slippage between these parts will be reduced to a minimum and so that small changes in the rate of rotation of the driving hub will be immediately reflected by a corresponding change in the speed of rotation of the various wear rings.

Yet another and important object is to provide such a frictional driving connection between the driving hub and the various wear rings whereby the tendency for induced rotation of each wear ring may be materially modified to either increase or decrease the speed of rotation of the wear ring or, in certain instances, to terminate such rotation altogether if so desired.

It is another object of the invention, in a machine of this general character, to provide a novel means for distributing vehicle with its suspended grit therein over the surface of the lap annulus, such means involving a more equal distribution of the vehicle and grit than has heretofore been possible.

The provision of a machine which is comprised of a minimum number of moving parts and which therefore is unlikely to get out of order; one which is extremely rugged and durable; one which is extremely compact in its design and which therefore does not have excessive space requirements; one which is relatively smooth and silent in its operation; one which is attractive in its appearance and design; one which is capable of ease of assembly and disassembly thereof, and one which is otherwise well adapted to perform the services required of it, are further desiderata that have been borne in mind in the production and development of the present invention.

In the accompanying four sheets of drawings forming a part of this specification, a preferred embodiment of the invention has been shown.

In these drawings:

Fig. 1 is a perspective view of a lapping machine constructed in accordance with the principles of the present invention. In this view the machine is shown with its access door open and with a portion of the machine casing broken away to more clearly reveal the nature of the invention.

Fig. 2 is a top plan view of the machine shown in Fig. 1.

Fig. 3 is a fragmentary sectional view taken substantially along the line 3—3 of Fig. 2.

Fig. 4 is an enlarged detailed sectional view taken substantially centrally through a vehicle and grit distributing system employed in connection with the present invention.

Fig. 5 is a sectional view taken substantially along the line 5—5 of Fig. 4.

Fig. 6 is a horizontal sectional view taken substantially along the line indicated by the line 6—6 of Fig. 1.

Fig. 7 is a sectional view taken substantially along the line 7—7 of Fig. 6.

Fig. 8 is an enlarged sectional view taken substantially along the line 8—8 of Fig. 2, and

Fig. 9 is a circuit diagram for the machine.

In all of the above described views similar characters of reference are employed to designate similar parts throughout.

Referring now to the drawings in detail, and in particular to Fig. 1, the invention is shown as being applied to a lapping machine of the general type intended for lapping flat work such as the running faces of rotary mechanical seal elements. The machine involves in its general organization a base support in the form of a heavy ring 10 adapted to rest upon the supporting surface and to the upper open end of which there is secured as by welding a base plate in the form of an inverted channel member 12 from which all of the operative machine instrumentalities are supported. The machine further includes an outer cylindrical shell or casing 14, the lower open end of which is telescopically received over the base plate 12 and is secured to the corners thereof as at 16 by welding. The front side of the machine is provided with a rectangular cutaway portion 18 adapted to be closed by a swinging door 20 of arcuate design so that when the door is closed upon the casing or shell 14 it will conform to the cylindrical confines thereof. A suitable handle 22 is provided at an appropriate location on the door 20.

Suitably secured to the casing 14 interiorly thereof and at spaced points therearound medially between the top and bottom of the shell are three supports 24, 26 and 28 respectively each in the form of a horizontally extending beam. The inner or free ends of each beam are secured as by welding to a vertically extending tubular support in the form of a sleeve or tube 30 (see also Fig. 3) which is thus centrally supported within the shell 14. Additional supporting means for the sleeve 30 consists of a flat generally elliptical disk 32 in the form of a partition member which extends across the cylindrical casing 14 interiorly thereof at an angle of approximately 30° from the horizontal. This partition member 32 is welded or otherwise secured to the tubular sleeve 30. The partition member 32 serves as a drain pan for vehicle and grit as will be described presently.

Centered within the stationary sleeve member 30 and rotatably supported in upper and lower bearing assemblies 34 and 36 respectively is a lap plate supporting and driving sleeve 38 which projects completely through the tube 30. The lower end of the sleeve 38 is threaded as at 40 and receives thereon a securing nut 42 which takes up any end play in the sleeve and the bearings therefor. Keyed to the sleeve 38 as at 44 is a supporting hub 46 on which there is centered an annular lap plate 48 preferably formed of cast iron and having an upper annular lap surface 50 provided with an outer

peripheral edge 52 and an inner peripheral edge 54 (see also Fig. 8). The lap plate 48 is provided with a central opening 56 therethrough within which there projects a securing flange 58 through which there extends a plurality of anchoring studs 60 by means of which the lap plate may be secured to the upper face of the supporting hub 46. The weight of the hub 46 and the lap plate 48 which it supports bears against a snap ring 61 which surrounds the sleeve 38 and the thrust of the snap ring is supported on a cup-shaped apron piece 62 which in turn bears against the inner race member of the bearing 34.

As shown in Figs. 3 and 8, the overall diameter of the lap plate 48 is slightly less than the internal diameter of the shell or casing 14, a slight clearance being provided as at 63 to permit free rotation of the lap plate 48 as well as to permit draining of the vehicle and grit from the upper surface of the lap plate into the compartment or space 64 existing within the shell above the inclined partition member 32.

Still referring to Fig. 3, the lower end of the rotatable sleeve 38 projects below the lower end of the stationary sleeve 30 and carries thereon a double sheave 66 by means of which the sleeve 38 is adapted to be driven in a counter clockwise direction, as viewed in Fig. 2.

Rotatably mounted within the sleeve 38 is a central shaft 70 adapted to be rotated in a direction counter to the direction of rotation of the sleeve 38. Sleeve bearings 71 and 73 are pressed into the upper and lower ends of the sleeve 30 to center the shaft 70. The shaft 70 projects upwardly above the upper end of the sleeve 38 and carries thereon a rotatable driving hub or member 72, the purpose of which is to effect a positive and variable speed drive for the various wear rings employed in connection with the present machine as well as to maintain these wear rings centered in respective sectors of the lap annulus, all in a manner that will be set forth in detail subsequently. A set screw 73 serves to maintain the hub 72 in position on the upper end of the shaft 70.

Still referring to Figs. 3 and 8, and additionally to Figs. 1 and 2, the upper surface or annulus 50 of the lap plate 48 is adapted to receive thereon a plurality of wear rings 74 of which four in number have been shown. These wear rings 74 are preferably formed of the same material as the material of the lap, i. e. cast iron, and the rings are of such diameter that they may be positioned upon the lap annulus so as to overlap slightly both the outer and inner peripheries 52 and 54 as clearly shown in Fig. 3. These wear rings 74, which sometimes are referred to as "conditioning rings," are adapted to rest frictionally on the surface of the lap annulus and means are provided for preventing them from riding with the lap, so to speak, or in other words, for holding them against revolution about the axis of the lap plate so that each ring is held permanently within its own quadrant of the lap annulus.

In order to thus support the rings against revolution about the lap axis a plurality of rollers 76, one for each wear ring 74, and each having a rubber or other resilient friction band 77 thereon, are carried on a lug or bracket 78 suitably secured by means of screws 80 to the shell 14 at the upper open rim thereof. The rollers 76 are freely rotatable and each is circumferentially spaced from the next adjacent roller at an arcuate distance of 90°. The distance between the periphery of each roller 76 and the periphery of the driving hub 72 is somewhat less than the external diameter of the wear rings 74 so that when the wear rings are positioned upon the lap annulus 50 in the manner indicated in Fig. 2, and the lap plate 48 rotates in a counter clockwise direction as shown, the various rings will be constrained to bear against their respective rollers 76 as well as against the peripheral edge of the driving hub 72.

Referring now to Fig. 8, the driving hub 72 is in the

form of a metal casting and is provided with a cylindrical portion 82 and a generally conical portion 84 which is truncated as at 86. The cylindrical portion 82 is provided with an annular groove 88 therein in which there is seated a friction drive element proper 90 which may be in the form of a band of rubber or other similar friction material. In order to increase the coefficient of driving friction between the driving element 90 and the outer face of the various wear rings 74, each wear ring is knurled as at 92. The underneath face of the hub 72 is provided with an annular groove or recess 94 in which there may be fitted a depending apron 96 in the form of a ring member and the purpose of which is to prevent the abrasive compound applied to the lap annulus from seeping into and contaminating the sleeve bearing 71.

From the above description it will be seen that when the wear rings 74 are in position on the rotating lap annulus as shown in Fig. 2, the driving hub 72 and rollers 76 will engage the various wear rings 74 at spaced points and subtend arcuate portions thereof between these rotating members. It should also be noted that the position of each roller 76 and of the driving hub 72 is such that the resultant vectorial force exerted upon the ring due to its frictional engagement with the rotating lap annulus will be directed between the two members 72 and 76 to thus hold the ring in its own lap sector and prevent revolution thereof about the axis of the lap annulus.

Referring now to Figs. 1, 3, 6 and 7, wherein the driving mechanism for the lap plate 48, as well as for the driving hub 72, is best illustrated, a driving motor M1 is suitably bolted as at 100 to the channel base member 12. The motor M1 is operatively connected through a conventional gear reduction mechanism 102 to a vertical drive shaft 104 which carries adjacent its upper end a double sheave 106. The shaft 104 projects completely through the large end of a generally flat tapered gear box designated in its entirety at 108 (Figs. 6 and 7). The small end of the gear box 108 is formed with a laterally projecting ear 110 which is pivotally connected as at 112 to one end of a turn-buckle assembly 114, the other end of the assembly being pivotally connected as at 116 to a lug 118 secured to the wall of the casing or shell 14. A pair of driving belts 120 pass over the double sheaves 106 and 66 and serve to establish a driving connection from the motor M1 to the lap plate 48 through the gear reduction device 102, shaft 104, sheaves 106, 66, sleeve 38 and supporting hub 46 directly to the lap plate 48, the direction of rotation of the lap plate being counter clockwise as viewed in Fig. 2 and as previously explained. This drive is a constant one and the various elements which cooperate to make up the power train of the drive are so designed according to engineering exigencies that a constant rate of approximately 50 R. P. M. of the lap plate is attained.

The driving mechanism for the hub 72 which effects rotational movement of the various wear rings 74 extends from the shaft 104 of the gear reduction mechanism 102 through a series of four gears 122, 124, 126 and 128 which are arranged in series meshing relationship within the gear box 108. The gear 122 is keyed to the shaft 104 and the gear 128 is keyed to a shaft 130 which projects upwardly through the gear box and which carries at its upper end a sheave 132. The lower end of the drive shaft 70 for the driving hub 72 carries a conventional Reeves drive mechanism designated in its entirety at 134 and including the usual split sheave 136 and spring housing 138. A drive belt 140 passes around the sheaves 132 and 136 and establishes a variable speed drive between the gear reduction device 102 and shaft 70.

In order to effect a variation in the speed differential between the shaft 130 and the drive shaft 70 for the hub 72, the turn-buckle assembly 114 is designed to

control limited horizontal swinging movement of the entire gear box. As shown in Fig. 6, the two oppositely threaded turn-buckle rods 142 and 144 are threadedly received within the turn-buckle cage 146 and the latter is provided with a hand wheel 148 by means of which elongation or contraction of the entire assembly 114 may be controlled.

Inasmuch as one end of the turn-buckle assembly is pivoted as at 116 to the lug 118 on the shell 14 with one end of the gear box assembly 108 being pivoted for swinging movement about the axis of the shaft 104, elongation of the turn-buckle assembly 114 will tend to decrease the angle existing between the turn-buckle axis and the gear box axis thus swinging the gear box to the left as viewed in Fig. 6 and causing the sheave 132 to be moved away from the sheave 136 thus effectively increasing the rate of rotation of the drive shaft 70. Conversely, diminution in the length of the turn-buckle assembly will move the sheaves 132 and 136 toward each other and effectively decrease the speed of rotation of the shaft 70.

It is essential to the operation of a machine of this character that the surface of the lap plate 48 be supplied with a lapping compound consisting of a gritty fluid including suitable vehicle in which particles of grit or abrasive are maintained in suspension. According to the present invention, it has been found that equal distribution of the lapping compound over the surface of the lap annulus will be accomplished by the expedient of causing the compound to drip onto the upper regions of the driving hub 72 from whence the compound will flow downwardly under the influence of gravity and be transferred by direct contact with the sides of the various wear rings 74 so that the same may flow downwardly along the rotating sides of the rings and onto the surface of the lap plate at widely distributed points.

Referring now to Fig. 1, a lapping compound container 150 is suitably suspended by means of screws 152 from a bracket or shelf 154 secured as by welding to the inside face of the shell door 20. The container 150 is provided with a filling opening 156 which projects through the shelf 154. The lapping compound is maintained within the container 150 at a fairly high level and the system depends upon a jet action for maintenance of the grit portion of the compound in suspension within the vehicle. The system is essentially a closed fluid system including a vertically extending standpipe 160 which extends upwardly from the agitation tank 150 and which is bowed inwardly over the edge of the machine as indicated at 162 and carries at its free end a drip assembly 164 having a drip opening 166 associated therewith and adapted to overlie the driving hub 72 when the door 20 is in its closed position. The standpipe 160 extends into the agitator tank 150 and has its lower end connected to an L-fitting 168 which in turn communicates with the impeller housing 170 of a submerged centrifugal type pump assembly 172 suitably suspended from the shelf or bracket 154. An internal return pipe 174 is centered within the standpipe 160 by means of apertured spacer members 176 (see also Fig. 5) and the lower end of the return pipe 174 projects completely through the bottom of the L-fitting 168 and terminates in a jet nozzle 178 which is submerged beneath the level of the lapping compound. The housing 170 is formed with an inlet opening 180 through which the agitated fluid may enter and pass upwardly through the space existing between the return pipe 174 and outer standpipe 160.

The drip fitting 164 includes a generally cylindrical body portion 182, one end of which is threaded as at 184 to receive thereon a cap member 186. The cap member is adapted to bear against a conventional seat fitting 188 provided on the end of the standpipe 160 to maintain the assembly 164 in position on the end of the standpipe. The cylindrical member 182 is provided

with a chamber 190 therein which communicates through a bore 192 with the end of the standpipe 160. A needle valve 194 threadedly received at 196 in the member 182 cooperates with a port 198 at the end of the bore 192 to admit the compound to the chamber 190 from whence it may drip from the opening 166 and fall onto the driving hub 72, preferably in the conical region 84 thereof.

As shown in Figs. 1 and 4, a pump motor M2 mounted on the shelf 154 is provided with a motor shaft 202 which extends into the pump casing 170 and carries at its lower end the pump impeller proper 204.

From the above description it will be seen that by adjusting the valve element 194, the extent of opening of the port 198 may be regulated so that the desired degree of flow or drip of the compound from the opening 166 onto the driving member 72 may be accurately attained. In actual practice it has been found that approximately sixty drops of the compound per minute issuing from the opening 166 will satisfy the requirements of the machine during full capacity lapping operations.

Since the electrical instrumentalities employed in connection with the present invention consist solely in the provision of two electric motors, namely the motor M1 for driving the lap plate 48 in one direction and for rotating the driving hub 72 in the opposite direction, and the motor M2 which controls the operation of the lapping compound agitator jet mechanism, and since these two motors are designed to be operated simultaneously, the electrical circuit diagram for the machine shown in Fig. 9 is extremely simple and needs but little description. As shown, the two motors M1 and M2 are arranged in a parallel circuit, the opening and closing of which is controlled by means of a switch S.

In the operation of the present machine, with the four wear rings in the position shown in Fig. 2 on the lap surface 50, the switch S is operated to close the parallel circuit through both motors M1 and M2 whereupon the machine will be set into operation. As the lap plate 48 rotates at a uniform rate of speed in a counter clockwise direction as seen in Fig. 2, such rotation thereof will tend to induce rotation in the various wear rings 74 due to the fact that the outer peripheral speed of the lap plate is greater than the inner peripheral speed thereof so that consequently greater frictional forces are developed between the lap plate and wear rings in the outer regions of the plate than are developed in the inner regions thereof. This tendency for induced rotation is such that each of the wear rings will be constrained to rotate in a counter clockwise direction about its own vertical axis. For theoretical considerations, let it be assumed that not only each restraining friction roller 76 but also the central hub 72 is a free rotating member. In such an instance a predetermined rate of induced rotation would ordinarily be set up in each of the wear rings. With the wear rings thus operating as freely rotating independent members, the abrading or dressing effect upon the lap will be dependent to a large extent upon the respective amounts of overhang existing between each wear ring and the lap at the inner and outer edges of the lap annulus respectively. Obviously, if a greater overhang exists at the outer periphery of the lap than at the inner periphery thereof, the tendency for the lap surface will be to gradually assume a convex contour. Conversely, if the overhang at the inner edge of the lap is greater than at the outer edge thereof, the tendency for the lap will be to gradually become concave. It follows therefore that there must be a medial radial position for each wear ring wherein the surface of the lap plate will remain substantially flat over a prolonged period of time. It is believed that this medial position is such that the amounts of overhang at the inner and outer edges of the lap are substantially equal, and the rollers 76 in the present instance are so positioned that

this condition of equal overhang obtains. The various gear ratios involved in connection with the power train leading from the motor M1 to the driving hub 72 are so designed that the peripheral speed of the driving hub in a clockwise direction as seen in Fig. 2 is substantially equal to the peripheral speed of the wear rings when these rings are allowed to rotate freely under induced frictional force developed by virtue of their contact with the lap. Under such conditions, the driving hub will neither increase the normal rate of rotation of the wear rings nor will it decrease the same. Under the conditions just outlined, and with no work being operated upon, a lap plate the working surface of which is substantially flat to begin with, will, in all probability, remain flat for a prolonged or indefinite period of time.

It so happens however that the character of work which may be placed within the wear rings and allowed to rest upon the lap surface for lapping purposes, i. e. its weight, surface area, the material of which it is composed, the number of pieces undergoing lapping, their arrangement within the wear ring, etc., may have an independent effect upon the contour of the lap over any given period of time. The localized abrasion caused by such work may tend to wear the lap out-of-flat and, in such an instance, corrective measures must be taken to bring the lap back to its condition of flatness. As stated, this correction ordinarily is performed by shifting the position of the wear rings inwardly or outwardly as the case may be. However according to the present invention, such corrective measures are obtained by either positively accelerating or positively decelerating the rate of rotation of the wear rings. If there is a tendency for the lap plate to become convex for example, an increase in the speed of rotation of the wear rings over their normal rate of rotation will tend to bring the surface of the lap plate back to its condition of flatness. This is true because, as seen in Fig. 2, the portions of a wear ring which slide over the surface of the rotating lap plate near the outer periphery thereof will have linear components of motion which are in the same general direction as the linear components of motion of portions on the lap plate with which they are in contact, whereas the contacting portions near the inner periphery of the lap will have linear components of motion which generally are in the opposite direction. An increase in rotational speed of the wear ring will therefore present a greater speed differential between the two running surfaces near the inside of the lap annulus and greater abrasive factors will come into existence at this inner region. Conversely, a decrease in the rotational speed of the wear ring will have an opposite effect and the rate of change from a normal abrasive action near the outside of the lap annulus will be greater than the rate of change from the normal abrasive action near the inside of the lap annulus.

From the above description it will be obvious that if, after the machine has been in actual operation for a given length of time, it is found that the lap plate tends to become convex, corrective measures may be taken by rotating the hand wheel 143 of the turn-buckle cage 146 in an appropriate direction to shorten the effective length of the turn-buckle assembly 114 thereby actuating the Reeves variable speed drive mechanism so as to increase the rate of rotation of the shaft 70 and consequently of the driving hub 72. Such increase in the rate of rotation will be imparted to the various wear rings through the friction member 90 and these wear rings will be accelerated until all frictional forces have been equalized after which the rings will continue to rotate at a speed slightly somewhat in excess of their normal rate of speed. If the conditions which in the first place caused the lap plate to become convex remain in effect the corrective measures which were put into effect by adjustment of the hand wheel may be allowed to operate until such time as the lap plate is again resorted to its normal flat condition. When this has been accomplished, a new setting for the hand wheel calculated to maintain the lap annulus flat

for the given set of conditions may be made. Obviously, the appropriate setting of the hand wheel 148 at any given instant or during any given interval of time will be made according to the judgment, skill and experience of the operator who will take into consideration the character of the work undergoing lapping.

What I claim and desire to secure by Letters Patent is:

1. A lapping machine comprising in combination a framework, a lap plate mounted on said framework for rotation about a vertical axis, said lap plate having an upper annular lap surface, there being a central opening extending completely through said lap plate and defining the inner periphery of the lap surface, a plurality of rotatable work-receiving wear rings open at their upper and lower ends and resting frictionally on said lap surface, said rings overhanging the inner and outer peripheries of the lap surface, said wear rings being capable of slight universal movement induced by their frictional contact with the rotating lap surface, a plurality of freely rotatable antifriction members mounted on said framework above the plane of the lap surface, each of said antifriction members being positioned for running engagement with the outer periphery of a wear ring, a rotatable support for said lap plate carried by said framework and having a vertically extending bore therein in vertical alignment with the opening provided in said lap plate, a drive shaft rotatably journaled in said bore and projecting upwardly through the bore in said support, a driving hub mounted on the upper end of said drive shaft and having an outer surface of each of said wear rings in rotational driving relationship with respect thereto, a driving motor for said support mounted on said framework, means operatively connecting said motor and said support in driving relationship to rotate the support, and consequently the lap plate, in one direction, and a variable speed driving connection between said motor and shaft for driving the latter from the former throughout an infinite range of speed increments through a predetermined speed range.

2. In a lapping machine of the character described, a rotatable lap plate having a substantially plane annular upper lapping surface, there being a central opening in said lap plate, means for rotating said lap plate about a central vertical axis, a drive shaft extending upwardly through the opening in the lap plate, a driving hub mounted on said drive shaft above the level of the lapping surface, a wear ring resting frictionally upon said lapping surface and engaging said driving hub and adapted to be frictionally and rotationally driven from the latter, said wear ring being capable of slight universal movement induced by its frictional contact with the rotating lap surface, means including said hub for preventing revolution of said wear ring about the axis of the lap plate while allowing rotation of the ring about its own vertical axis, the height of said hub above the lap plate being greater than the height of said wear ring, means for depositing a lapping compound onto a surface of said driving hub in a localized region thereof whereby said lapping compound will be transferred from said driving hub to the wear ring across the region of contact therebetween and will thereafter be distributed over the lapping surface of the lap plate by the action of gravity, and means for rotating said drive shaft.

3. Apparatus for forming a true face of predetermined

contour upon an article, said apparatus comprising a lap plate mounted for rotation about a substantially vertical axis and having an upper annular lap surface capable of producing by abrasion the desired true face, means for rotating said lap plate in one direction, a rotatable wear ring resting frictionally upon said lap surface and having an annular lap dressing surface contacting the annular surface of the lap plate and overhanging the inner and outer peripheral edges of the latter, said wear ring being capable of slight universal movement induced by its frictional contact with the rotating lap surface, a pair of rollers positioned above the plane of the lap surface and mounted for rotation about respective vertical axes, one of said rollers being freely rotatable about its own axis, said rollers being positioned to engage the outer periphery of the wear ring at spaced regions therearound and subtend an arcuate portion of the ring therebetween so that the resultant vectorial force exerted upon the ring during rotation of the lap plate due to friction between the ring and lap plate is directed between said rollers to thus prevent revolution of the wear ring about the lap axis, means for driving the other roller about its own pivotal axis in one direction to induce positive rotation of the wear ring in the opposite direction by virtue of the frictional contact existing between said latter roller and wear ring, and means for regularly varying the rate of rotation of said latter roller relative to the rate of rotation of the lap plate to thereby vary the rate of wear of the lap surface by said wear ring.

4. In combination, a lapping device having an annular lapping face, means for rotating the lapping device in one direction substantially about the center of the lapping face, a rigid tool having a cylindrical outer surface for removing irregularities in the lapping face, said tool having a flat annular surface contacting said annular lapping face and extending beyond the inner and outer peripheral edges of the latter, said tool being capable of slight universal movement induced by its frictional contact with the rotating lap surface, a freely rotatable roller positioned above the plane of the lapping face adjacent the outer periphery thereof and adapted to frictionally engage the cylindrical surface of the tool, a driving hub positioned adjacent the inner periphery of the lapping face and having a cylindrical friction surface designed for engagement with the cylindrical surface of the tool and positioned above the plane of said lapping face, means for positively rotating said driving hub in one direction whereby to induce rotation of the tool in the opposite direction, and means for varying the speed of rotation of said driving hub relative to the speed of the lapping device throughout an infinite range of speed increments through a predetermined speed range to thereby vary the rate of wear of the lapping face by the tool.

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