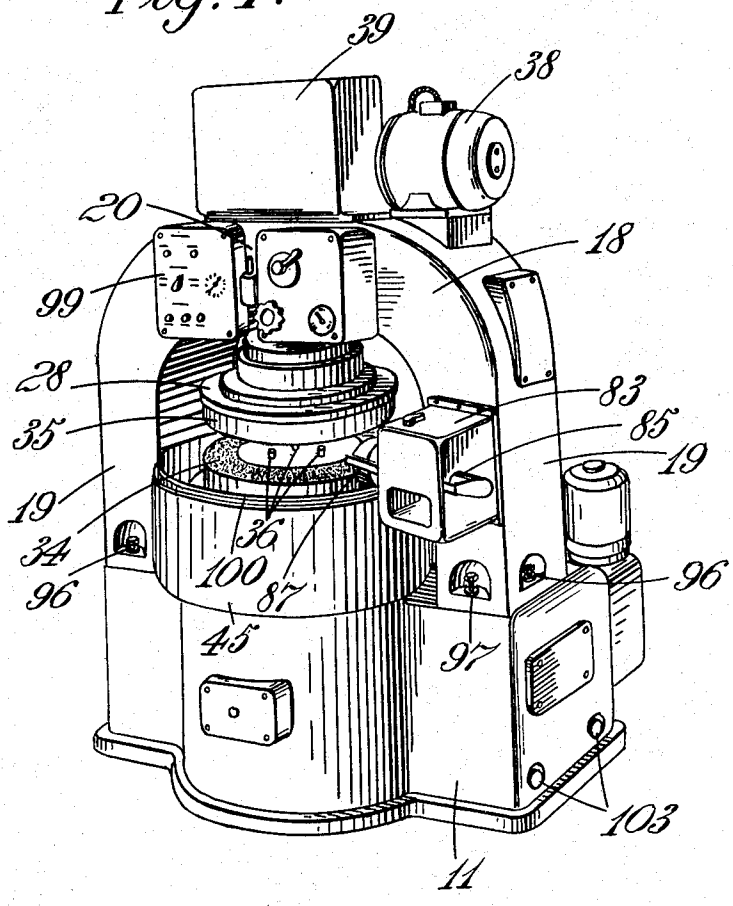
May 29, 1956 S. W. HOARE 2,747,338

MACHINES FOR LAPPING AND GRINDING

Filed Feb. 2, 1953 6 Sheets-Sheet 1

Fig. 1.



INVENTOR
Stanley W. Hoare

By: Watson, Cole, Grindle & Watson
ATTORNEYS

May 29, 1956 S. W. HOARE 2,747,338

MACHINES FOR LAPPING AND GRINDING

Filed Feb. 2, 1953 6 Sheets-Sheet 2

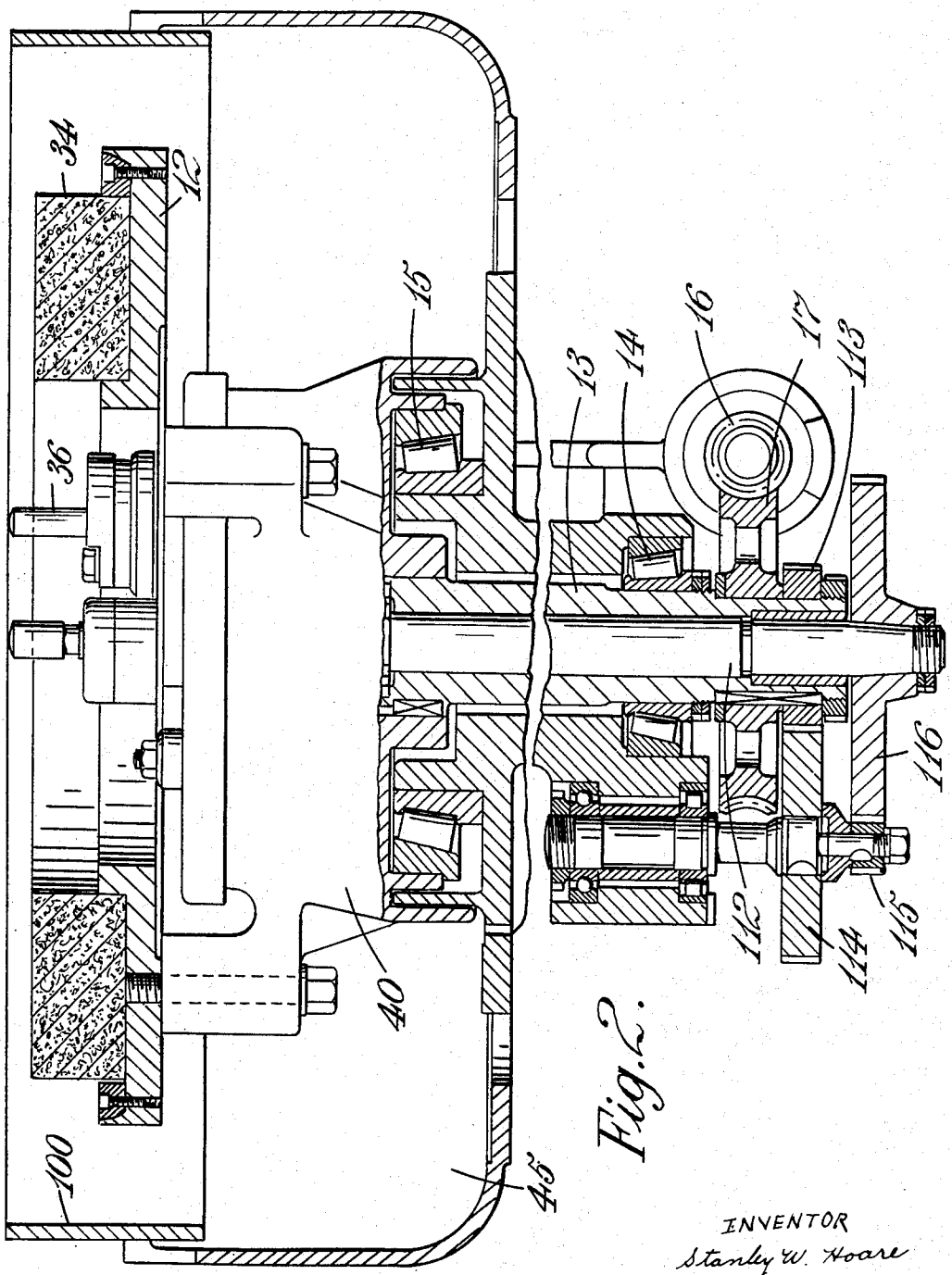


Fig. 2.

INVENTOR
Stanley W. Hoare
By Watson, Cole, Grindle & Watson
ATTORNEYS

May 29, 1956 S. W. HOARE 2,747,338

MACHINES FOR LAPPING AND GRINDING

Filed Feb. 2, 1953 6 Sheets-Sheet 3

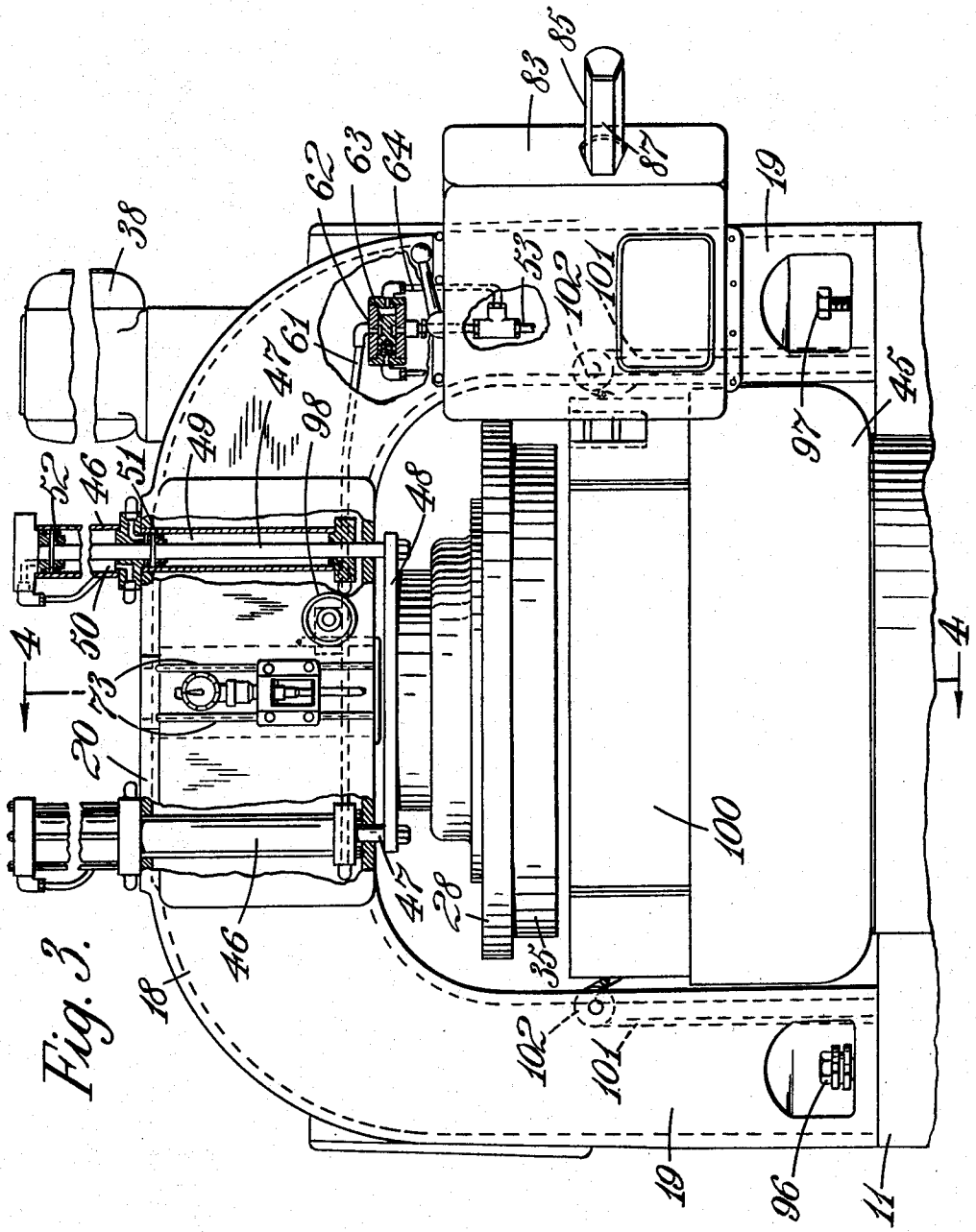


Fig. 3.

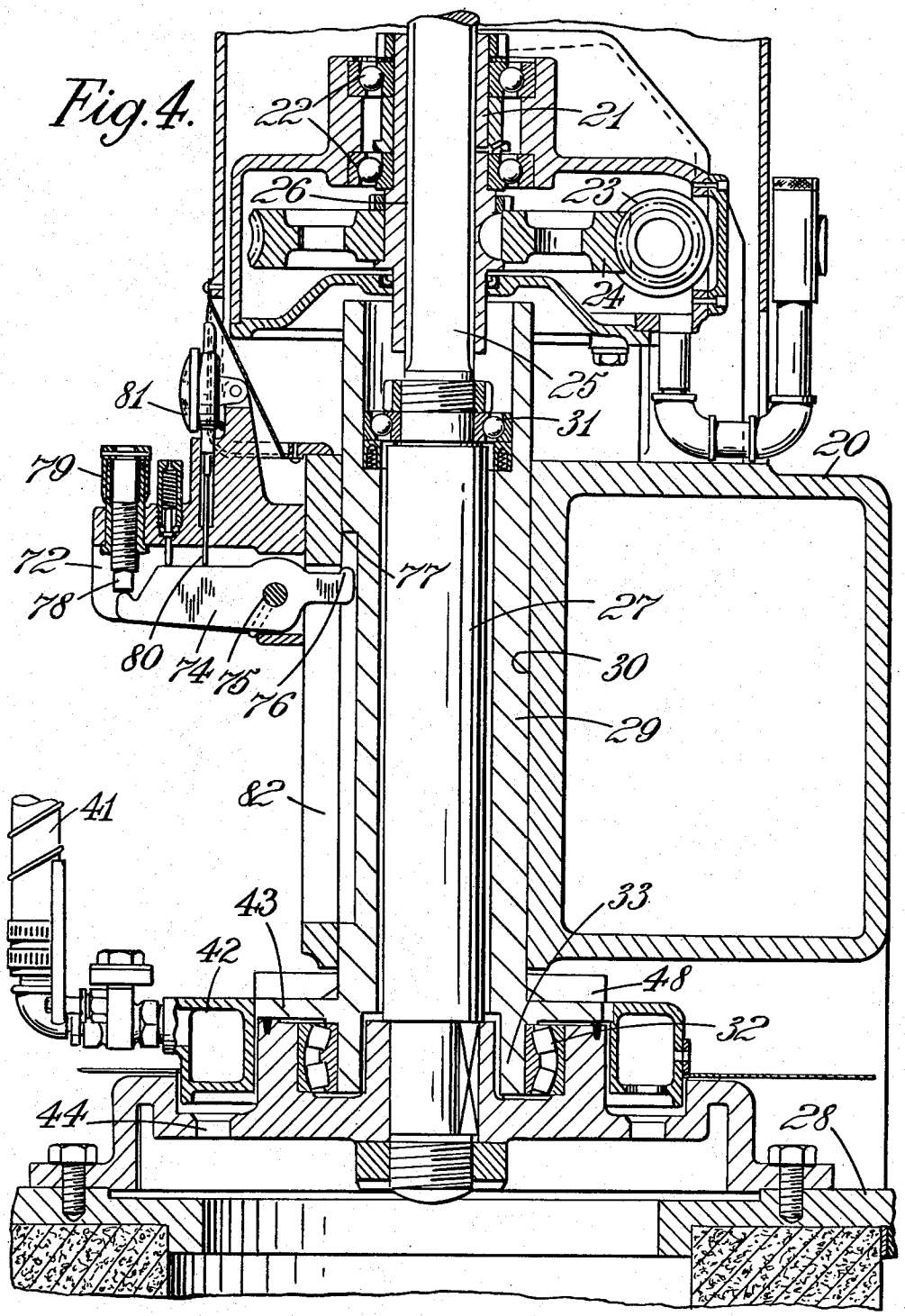
INVENTOR
Stanley W. Hoare.
By Watson, Cole, Grindle & Watson
ATTORNEYS

May 29, 1956 S. W. HOARE 2,747,338

MACHINES FOR LAPPING AND GRINDING

Filed Feb. 2, 1953 6 Sheets-Sheet 4

Fig. 4.



INVENTOR
Stanley W. Hoare
By Watson, Cole, Grindle & Watson
ATTORNEYS

May 29, 1956 S. W. HOARE 2,747,338

MACHINES FOR LAPPING AND GRINDING

Filed Feb. 2, 1953 6 Sheets-Sheet 5

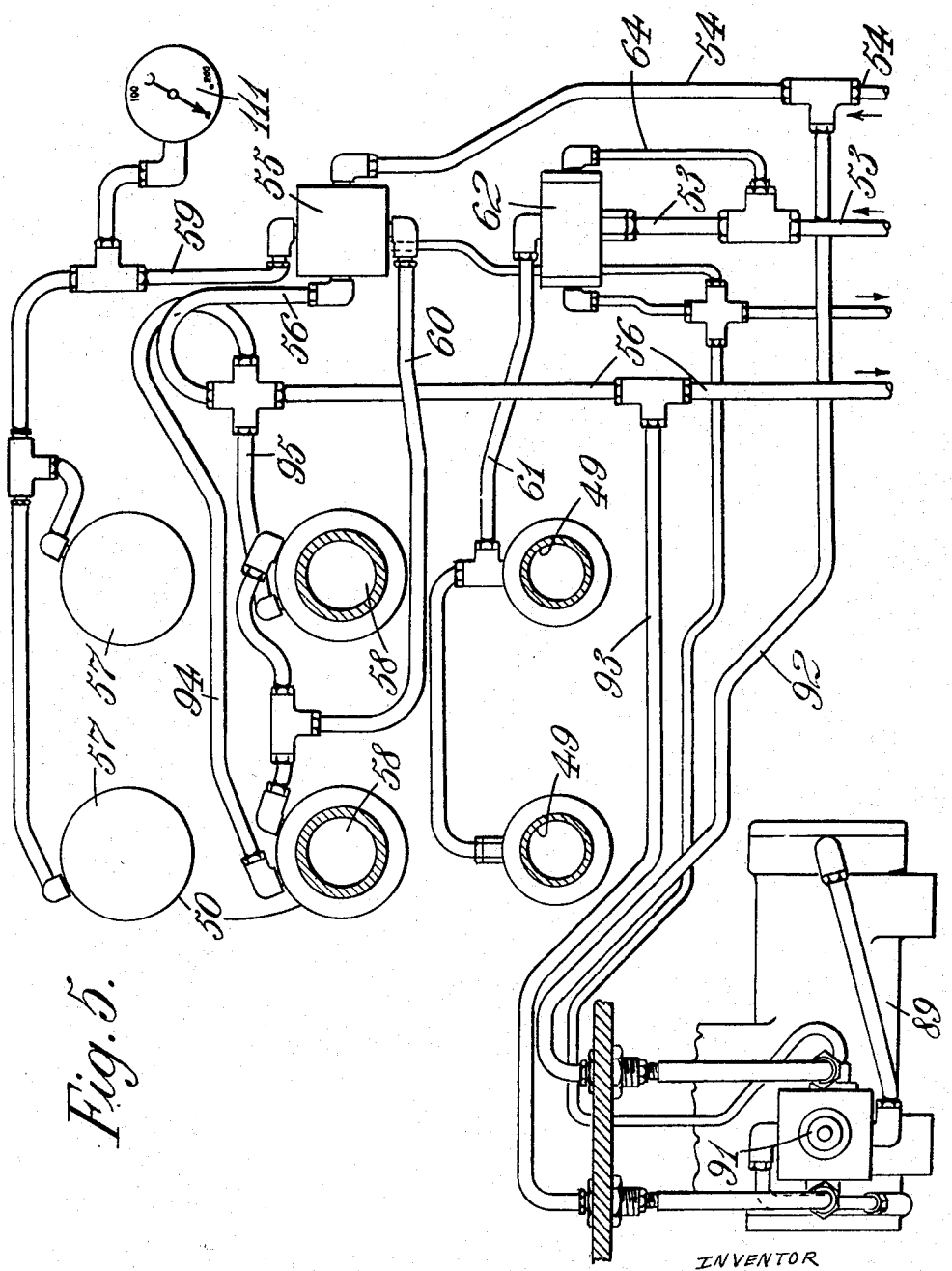


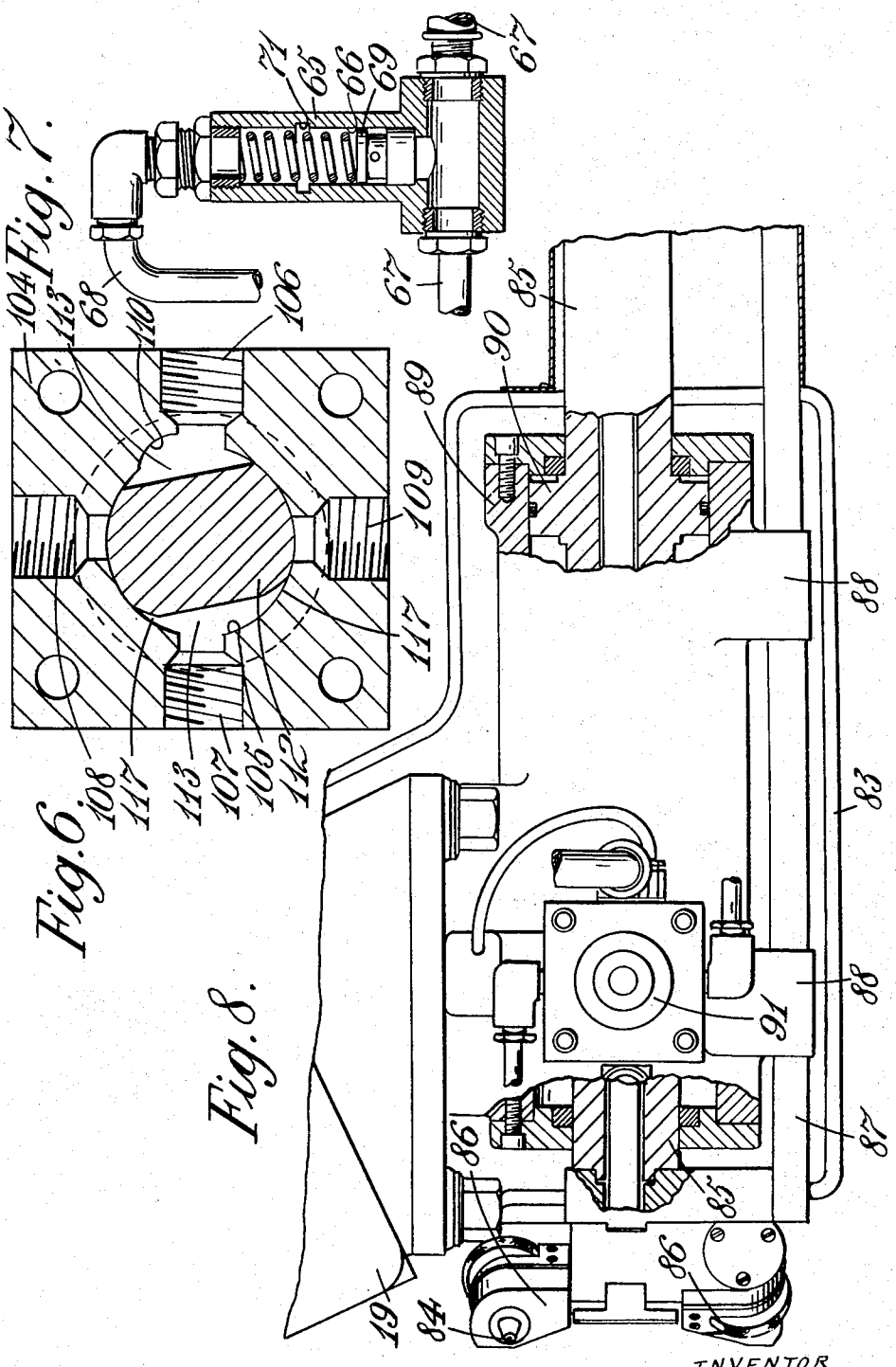
Fig. 5.

INVENTOR
Stanley W. Hoare
By Watson, Cole, Grindle & Watson ATTORNEYS

May 29, 1956 S. W. HOARE 2,747,338

MACHINES FOR LAPPING AND GRINDING

Filed Feb. 2, 1953 6 Sheets-Sheet 6



INVENTOR
Stanley W. Hoare
By Watson, Cole, Grindle & Watson ATTORNEYS

United States Patent Office 2,747,338 Patented May 29, 1956

2,747,338

MACHINES FOR LAPPING AND GRINDING

Stanley William Hoare, Peterborough, England, assignor to The Newall Engineering Company Limited, Peterborough, England, a British company

Application February 2, 1953, Serial No. 334,560

Claims priority, application Great Britain September 12, 1952

8 Claims. (Cl. 51—118)

This invention comprises improvements in or relating to machines for lapping or grinding, and is concerned with lapping or grinding machines of the type in which the work is performed by co-operation of relatively rotatable parts mounted, on the one hand, upon a machine base or bed and, on the other hand, upon a machine head supported over the base.

According to the present invention, in a machine of the type described the machine head is constituted by a bridge structure supported at both its ends upon columns which are adapted to be rigidly anchored at their lower ends to the machine base. The bridge structure and columns may be integral with one another, for example in the form of a frame work of inverted U-shape.

In one construction, a lapping machine, according to the invention may comprise a machine base, a bridge structure upon the base and two supporting columns therefor one at each end of the bridge structure, which columns are adapted to be rigidly anchored at their lower ends one to each side of the machine base, a lower lap assembly mounted on the machine base between the columns for rotation about a vertical or substantially vertical axis and carrying above the base an abrasive wheel, and an upper lap assembly mounted on the bridge structure for rotation about the same vertical axis and carrying below said structure a second abrasive wheel to co-operate with the first mentioned wheel in simultaneously lapping both upper and lower faces of work pieces held between the laps, said upper lap assembly being arranged for vertical movement upon the bridge structure towards and away from the lower lap.

Previously in vertical lapping machines the upper lap has been carried upon a head supported cantilever-fashion by a single column at the rear of the machine. It is found that with lapping machines constructed according to the present invention work can be finished to appreciably finer limits than could be achieved with prior machines, presumably owing to the fact that the bridge structure supported on two columns is more rigid and deflects less under load than a machine head carried on a single column as a cantilever. Furthermore, machines embodying the bridge construction can, in general, be designed to take up less floor space than a machine having a single column at the rear.

Further features of the invention will be apparent from the following specific description of a lapping machine in accordance with the invention, given by way of example and with reference to the accompanying drawings.

In the drawings:

Figure 1 is a general perspective view of the machine,

Figure 2 is a front sectional elevation of the lower lap assembly and the driving mechanism therefor,

Figure 3 is a front elevation, in part section, of the upper part of the machine showing the upper lap in full view,

Figure 4 is a side elevation, in section on the line 4—4 of Figure 3, showing the upper lap assembly and driving mechanism therefor,

Figure 5 is a diagrammatic layout of the hydraulic circuits of the machine,

Figure 6 is a section through a control valve of the machine,

Figure 7 is a section through a relief valve, and

Figure 8 is a plan view, in part section, of a diamond dresser unit for the laps.

Referring firstly to Figures 1 and 2, the machine has a lower frame member 11 constituting the machine base which rests upon the floor, and the lower lapping member 12 is carried for rotation above the machine base upon a robust casting 40 keyed to the upper end of a hollow vertical spindle 13 mounted in said base. The spindle and the casting 40 run on two robust large diameter tapered roller bearings 14, 15. The lower lap spindle 13 is driven by a two speed electric motor (not shown) through a worm 16 and gear wheel 17 enclosed in an oil bath. An upper frame 18 of inverted U-shape (Figures 1 and 3) has the lower ends of its two limbs or columns 19 supported upon the machine base 11 one on each side of the lower lap, and a vertical sleeve 21 (Figure 4) is mounted in ball bearings 22 in a housing 39 on top of the bridge piece 20 connecting the upper parts of the columns 19 of the U-shaped frame 18 to rotate above the lower lap and about the same vertical axis, the sleeve 21 being driven in the opposite directional sense to the lower lap through a worm 23 and gear wheel 24 by a single speed electric motor 38. A shaft 25 journalled in the sleeve 21 is slidable vertically therein but is constrained to rotate therewith by means of feather keys or splines 26, and is coupled at its lower end to the spindle 27 of the upper lap 28 which spindle rotates in a quill 29 that is axially slidable in a vertical guide-bore 30 in the bridge piece 20 of the U-shaped frame 18, a ball bearing 31 for the spindle 27 being provided in the quill 29 at the upper end of the spindle. Thus, the upper lap 28, which is mounted upon the lower end of its spindle 27 and runs upon a roller bearing 32 provided around an extension 33 of the lower end of the quill 29, is able, while being rotated, to move vertically towards and away from the lower lap 12.

The lower and upper laps are each fitted with bonded abrasive wheels 34, 35 in annular form. For flat lapping, the work is normally held in position between the two abrasive wheels by means of a work holder consisting, for example, of a disc of wood or metal with a series of cut-outs around the disc to receive a plurality of similar work pieces. The work holder rests on the abrasive wheel 34 of the lower lap 12 and the work pieces are laid in the cut-outs of the work holder so that their lower faces are in contact with the wheel. The laps are then set in rotation and the upper lap 28 is brought down until its abrasive wheel 35 presses upon the faces of the work pieces; it will be clear that the work holding disc must be chosen of a thickness less than the required finished thickness of the work pieces. During lapping the work pieces are caused to perform a to and fro or orbital motion with respect to the axis of the laps by means of three eccentric pins 36 located within the annulus of the lower abrasive wheel and fitting into corresponding holes in the work holder, which pins are driven from a vertical shaft 112, passing up through the hollow spindle 13 of the lower lap, by means of adjustable planetary gearing situated within the hollow interior of the large rotary casting 40 carrying the lower lap. The planetary gearing for driving the pins is not shown in the drawings since it is a well know mechanism, not forming part of the present invention. The shaft 112 is coupled to the lower lap spindle 13 through a train of gear wheels 113, 114, 115, 116.

It will be understood that the machine may also be employed for cylindrical lapping, the work holder being held, in this case, in the correct offset position with respect to the axis of the lap by means of a guide-bar instead of being gyrated by the eccentric pins 36. Lapping fluid, such as paraffin, is fed to the abrasive wheels 34, 35 through a flexible hose 41 connected to an annular duct 42 carried by a flange 43 upon the lower end of the quill 29 which surrounds the upper lap spindle 27, from which duct the fluid runs down to the lapping surfaces through apertures 44 in the upper lap within the annulus of the abrasive wheel 35 carried thereby and thus on to work holder. The used fluid drains to a sump 45 in the machine base and is led away to a tank not shown.

The weight of the upper lap 28 is sustained, and the lap is raised and lowered, by hydraulic power. Two piston and cylinder units 46 (Figure 3) with their axes vertical are mounted on the bridge piece 20 of the U-shaped frame member 18 within the housing 39 one on each side of the lap axis, and have piston rods 47 extending downwardly from the cylinders which rods are fastened to opposite ends of a transverse yoke 48 that is rigidly secured to, and extends laterally in both directions from, the aforementioned flange 43 upon the lower end of the quill 29. Each of the piston and cylinder units 46 comprises two cylinder chambers 49, 50 arranged end to end with a piston working in each, and the piston rod extending upwardly into the cylinders from the yoke 48 is common to both pistons and connects them to slide as one.

A hydraulic pressure is maintained beneath the piston 51 in the lower cylinder chamber 49 of each of the two piston and cylinder units 46 sufficient to sustain the dead weight of the upper lap assembly, while the upper cylinder chambers 50 and pistons 52 therein are employed as double acting units for raising and lowering the upper lap 28 and for applying the working pressure between the laps.

Referring now to the hydraulic circuit diagram of Figure 5, fluid under pressure is supplied from a reservoir to the hydraulic system by a motor driven pump; the pump delivers to two pressure lines 53, 54 one of which 53 supplies pressure fluid constantly to the spaces beneath the pistons 51 in the lower cylinder chambers 49 of the piston and cylinder units 46 for sustaining the weight of the upper lap 28, while the other 54 leads to a control valve 55 which also has a connection 56 to exhaust and can be operated at will to put the upper ends 57 of the upper cylinder chambers 50 in communication with pressure through line 59 and the lower ends 58 of said cylinder chambers with exhaust through line 60 or vice versa, according to whether the upper lap is to be lowered or raised. The upper ends of the lower cylinder chambers 49 are permanently connected to exhaust through lines 94, 95 communicating with line 56 while the pressure line 61 to the lower ends of said chambers includes a piston valve 62 which acts as a hydraulic lock to prevent the pressure fluid in said cylinders from escaping quickly and allowing the upper lap assembly to descend rapidly in the event of failure of the pressure supply. The piston 63 of said piston valve 62 (see Figure 3) is subjected to the fluid pressure in the supply line 53 through a pipe 64 which normally holds it in the open position against spring pressure, but if the supply pressure fails the piston is spring urged into the closed position and communication between the supply line 53 and the lower cylinder chambers 49 is automatically cut off.

The control valve 55 (Figure 6) for the upper cylinder chambers 50 is a rotary valve comprising a valve body 104 having a bore 105 in which a cylindrical valve member 112 works. The valve body 104 has four ports leading into the bore and spaced at 90° intervals, one pair of opposite ports 106, 107 being connected to pressure and to exhaust respectively while the other pair 108, 109 are connected to the upper ends 57 of the upper cylinder chambers 50 and to the lower ends 58 respectively. The cylindrical member 112 in the bore 105 has a pair of

channels 113 cut in opposite sides of its cylindrical surface parallel with, and symmetrical with respect to, a diameter of said member, one of the channels having its ends extended somewhat by grooves 117, and the channels 113 serve to connect one of the ports 108, 109 communicating with the upper cylinder chambers to pressure and the other to exhaust in accordance with the setting of the valve. The four ports 106, 107, 108, 109 of the control valve are produced simply by drilling circular bores in the valve body 104, but the pressure supply port 106 is extended on the side adjacent the port 108 communicating with the upper ends 57 of the upper cylinder chambers 50, by a shallow channel 110 of decreasing depth cut in the interior surface of the valve and allowing a gradual cut-off or admission of pressure fluid to the upper ends of said chambers 50 to be achieved whereby the speed on descent of the upper lap and the working pressure between the laps may be regulated at will. The control valve 55, which is illustrated in the closed position, thus serves both as a reversing valve and also as a speed and pressure control valve. A visual gauge 111 is provided to register the pressure in the line 59 leading to the upper ends 57 of the cylinders 50, which pressure is proportional to the working pressure at the laps during lapping.

The pump delivering to the hydraulic system is provided with a relief valve 65 (Figure 7) on the delivery, which valve comprises a valve bore 66 connected at one end to the pressure line 67 and at the other end to an exhaust line 68 and a piston 69 working in the bore. The piston 69 is normally held near the pressure line end of the bore 66 by a valve spring 70 but when the pressure becomes excessive the piston is forced back along the bore until it reaches an enlarged section 71 of the bore which enables pressure fluid to escape past the piston 69 to exhaust. In this construction of relief valve, the valve piston is not so susceptible to sticking in the bore as in the case where one or both line connections are made through the side wall of the bore.

A micrometer dead stop device 72 (Figures 3 and 4) is mounted on the front of the bridge piece 20 of the U-shaped frame member 18 in guides 73 which allow it to be slid vertically and clamped in any desired position. The device comprises a substantially horizontal lever 74 mounted on a horizontal pivot 75 which lever extends through a slot 82 in the wall of the bridge and carries a feeler 76 which lies in the path of a shoulder 77 on the quill 29 of the upper lap. When the feeler 76 is pushed down by the quill the opposite end of the lever 74 abuts against a stop 78 having a micrometer adjuster 79 and also pushes up an operating rod 80 for a visual dial indicator 81. The device may also, if desired, incorporate a warning lamp to light up just before dead stop is reached.

For dressing the abrasive wheels 34, 35 a diamond dresser unit 83 (Figures 1, 3 and 8) is rigidly mounted upon one limb 19 of the U-shaped frame member 18. The diamonds 84, two of which are normally used, one for the upper lap and one for the lower, are adjustably mounted on heads 86 on the end of a carrier bar 85 which is rigidly connected with a guide bar 87 parallel to itself and slidable in guides 88 to enable the diamonds to traverse the abrasive wheels in a radial direction. The guide bar 87 and guides 88 are of robust construction and finished to very fine limits in order to avoid play and ensure that the wheels will be traversed as accurately as possible, and the carrier bar 85 itself constitutes the piston rod for a piston 90 of a double acting piston and cylinder unit 89 for operating the dresser. The piston and cylinder unit 89 is supplied with pressure fluid from the pressure line 54 of the aforedescribed hydraulic system through a pipe 92 and a control valve 91 is provided for the dresser similar in construction to the valve 55 for controlling the vertical movement of the upper lap, so that the speed at which the abrasive wheels are traversed by the diamonds can be regulated and

very slow speeds obtained. The exhaust line for the dresser unit is indicated at **93**.

Since the dresser unit is fixed with respect to the axis of the upper lap **28**, the upper wheel **35** is dressed first, and is then brought parallel to the face of the lower wheel **34** by shifting the U-shaped frame member **18** upon the machine base **11**; then the lower wheel **34** is dressed. The lower ends of the limbs **19** of the U-shaped member **18** are secured to the machine base **11** by means of three adjusting bolts **96** and two fixed bolts **97**. Two of the adjusting bolts **96** are shown in Figures 1 and 3, while the remaining adjusting bolt which is not visible in the drawings is located at the back of the left-hand limb of the U-shaped member **18**, in a position corresponding to that occupied by the like bolt shown at the front of said limb in Figures 1 and 3. The two fixed bolts **97** are located one at the front of the right-hand limb, as shown in Figures 1 and 3, and the other in a corresponding position at the back of said limb. The U-shaped member **18** is shifted on the base **11** by loosening the two fixed bolts **97**, adjusting the adjustable bolts **96** as desired and then retightening the fixed bolts. It will be appreciated that provided the surfaces of the abrasive wheels **34**, **35**, and their axes of rotation, are parallel to one another it is immaterial if the lap axes are not quite vertical; consequently, there is no need for levelling of the machine base on the floor. A clamp operated by a handwheel **98** is provided for immobilising the quill **29** while the upper lap is being dressed.

All the controls for the machine are conveniently mounted upon the front of the U-shaped frame member **18**. The motors are controlled from a press button switch panel **99** and provision is made for stepwise rotation, or "inching" of the lower lap, in order to facilitate loading and unloading of the work pieces from the operator's station at the front of the machine and thereby obviate any disadvantage which might otherwise result from the fact that the limbs **19** of the U-shaped member **18** prevent access to the laps from the sides of the machine.

A vertically movable annular splash guard **100** is suspended around the laps upon chains **101** which run over pulleys **102** on the limbs **19** of the U-shaped member **18** and carry counterbalance weights within the machine base **11**. The machine is readily portable horizontal holes **103** being bored through the base to receive lifting bars around which slings may be placed.

I claim:

1. A lapping machine comprising in combination a machine base, an over-frame on the base said over-frame having two upstanding limbs with their lower ends anchored to the base and a bridge portion supported between the upper ends of the limbs, a lower lap mounted upon the base and between the limbs of the over-frame for rotation about a substantially vertical axis said lower lap bearing above the base a substantially horizontal upwardly-facing lapping surface, an upper lap mounted upon the bridge portion of the over-frame above the lower lap for both vertical movement and rotation about an axis co-linear with the axis of the lower lap, said upper lap bearing a substantially horizontal downwardly-facing lapping surface to co-operate with the lapping surface of the lower lap, driving means for relatively rotating the upper and lower laps, hydraulically-operated means for lowering and lifting the upper lap towards and away from the lower lap, a hydraulically-operated dresser unit mounted on one of the limbs of the over-frame for dressing the lapping surfaces, said dresser unit comprising guide means secured to the limb of the over-frame, a guide-member slidable in said guide means and dressing heads on the guide-member to traverse the lapping surfaces as the guide-member slides, and a piston-and-cylinder dresser-operating unit connected to the guide-member and hydraulic connections including pressure supply and exhaust lines extending to the means for lowering and lifting the upper lap and the dresser unit.

2. A lapping machine according to claim 1 wherein there is provided in the pressure supply line a relief valve comprising a valve-body with a valve-bore formed therein, a valve-piston working in the bore, a connection at one end of the valve-bore to the pressure line and a connection at the other end of the valve-bore to exhaust, said valve-bore having a portion of enlarged diameter which extends in the longitudinal direction of the bore for a distance greater than the distance between the opposite faces of the valve-piston, and a spring in the valve-bore to bear upon the valve-piston and urge it toward the pressure line connection, said spring serving normally to hold the valve piston on the pressure side of the enlargement in the valve bore but yielding when over-pressure occurs in the pressure line until the piston arrives at said enlargement whereupon pressure fluid is able to flow past the piston to exhaust.

3. A lapping machine comprising in combination a machine base, an over-frame of inverted U-shape upon the base with the lower ends of its limbs anchored to the base and the portion connecting the limbs forming a bridge above the base, a lower lap mounted upon the base and between the limbs of the over-frame for rotation about a substantially vertical axis said lower lap bearing above the base a substantially horizontal upwardly-facing lapping surface, an upper lap mounted upon the bridge portion of the over-frame above the lower lap for both vertical movement and rotation about an axis co-linear with the axis of the lower lap, said upper lap bearing a substantially horizontal downwardly-facing lapping surface to co-operate with the lapping surface of the lower lap, driving means for rotating the upper and lower laps in opposite directions, hydraulically-operated means mounted on the over-frame for lowering and lifting the upper lap towards and away from the lower lap, and a hydraulically-operated dresser unit for dressing the lapping surfaces mounted on one of the limbs of the over-frame said dresser unit comprising guide means secured to the limb of the over-frame, a guide-member slidable in said guide means and dressing heads on the guide-member to traverse the lapping surfaces as the guide-member slides, and a piston-and-cylinder dresser-operating unit connected to the guide-member.

4. A lapping machine comprising in combination a machine base, an over-frame on the base said over-frame having two upstanding limbs with their lower ends anchored to the base and a bridge portion supported between the upper ends of the limbs, a lower lap mounted upon the base and between the limbs of the over-frame for rotation about a substantially vertical axis said lower lap bearing above the base a substantially horizontal upwardly-facing lapping surface, an upper lap mounted above the lower lap for both vertical movement and rotation about a substantially vertical axis and bearing a substantially horizontal downwardly-facing lapping surface to co-operate with the lapping surface of the lower lap, a supporting member for the upper lap which member is mounted on the bridge portion of the over-frame so as to be slidable vertically with the lap but is constrained against rotation, the upper lap being constrained against axial movement with respect to the supporting member but free to rotate relatively thereto, driving means for relatively rotating the upper and lower laps, and a pair of piston-and-cylinder units mounted on the bridge portion of the over-frame and coupled to said supporting member, and wherein each piston-and-cylinder unit comprises two cylinder chambers, two pistons working one in each chamber, and a common piston rod connecting the two pistons, and one cylinder chamber has a pressure-line connection to the space below the piston therein through which pressure fluid is supplied for supporting the upper lap, while the other cylinder chamber has a first fluid line communicating with its lower end and a second fluid line communicating with its upper end and valve means are provided for connect-

ing said first fluid line to pressure and the second to exhaust, and vice versa, whereby the upper lap can be raised and lowered at will.

5. A lapping machine according to claim 4 wherein the valve means comprises a ported valve block with a valve bore therein and a rotary valve member working in the bore, the valve block having four ports for connection respectively to pressure, to exhaust and to the fluid lines communicating with the upper and lower ends of the cylinder chambers controlling lifting and lowering of the upper lap and the rotary valve member being formed with channels therein whereby appropriate pairs of the valve ports can be brought into communication by rotation of said valve member, and the pressure supply port is extended on one side by a recess of progressively decreasing cross-section formed in the wall of the valve bore whereby a gradual admission and cut-off of pressure fluid to and from the upper ends of said cylinder chambers controlling lifting and lowering of the upper lap can be achieved.

6. A lapping machine according to claim 5 wherein automatically-operating valve-means is provided in the pressure line supplying pressure fluid to the cylinder chambers for supporting the upper lap such that if the supply pressure fails said cylinder chambers are isolated by said valve means so that the pressure fluid in the cylinder chambers is trapped therein.

7. A lapping machine comprising in combination a machine base, an over-frame on the base said over-frame having two upstanding limbs with their lower ends anchored to the base and a bridge portion supported between the upper ends of the limbs, a lower lap mounted upon the base and between the limbs of the over-frame for rotation about a substantially vertical axis said lower lap bearing above the base a substantially horizontal upwardly-facing lapping surface, an upper lap mounted upon the bridge portion of the over-frame above the lower lap for both vertical movement and rotation about a substantially vertical axis, said upper lap bearing a substantially horizontal downwardly-facing lapping surface to co-operate with the lapping surface of the lower lap, driving means for relatively rotating the upper and lower laps, hydraulically-operated means for lowering and lifting the upper lap towards and away from the lower lap, and a hydraulically-operated dresser unit mounted on one of the limbs of the over-frame for dressing the lapping surfaces, said dresser unit comprising guide means secured to the limb of the over-frame, a guide bar slidable in said guide means and diamond dressing heads on the guide bar to traverse the lapping surfaces as the guide bar slides, and a double-acting piston-and-cylinder unit connected to the guide bar.

8. A lapping machine comprising in combination a machine base, an over-frame on the base said over-frame having two upstanding limbs with their lower ends anchored to the base and a bridge portion supported between the upper ends of the limbs, a lower lap mounted upon the base and between the limbs of the over-frame for rotation about a substantially vertical axis said lower lap bearing above the base a substantially horizontal upwardly-facing lapping surface, a supporting member for an upper lap which member is mounted on the bridge portion of the over-frame so as to be slidable vertically but is constrained against rotation, an upper lap carried above the lower lap by said supporting member and constrained against axial movement with respect thereto but free to rotate relatively thereto about a substantially vertical axis, said upper lap bearing a substantially horizontal downwardly-facing lapping surface to co-operate with the lapping surface of the lower lap, driving means for relatively rotating the upper and lower laps, and means connected between the bridge portion of the over-frame and the aforesaid supporting member for lowering and lifting the upper lap towards and away from the lower lap, and wherein there is provided a dead-stop device comprising a carrier mounted for vertical adjustment on the over-frame, a rocking lever pivoted on the carrier and arranged to extend at one end into the path of part of the supporting member for the upper lap so that when the upper lap nears the limit of its downward travel said supporting member engages the lever and rocks it, an adjustable stop mounted on the carrier to limit said rocking of the lever and thereby arrest the downward movement of the upper lap, and means operatively connected with the lever for visually indicating the approach of the lap to the dead-stop position.

References Cited in the file of this patent

UNITED STATES PATENTS

240,966	Chappell	May 3, 1881
1,424,764	Knowles	Aug. 8, 1922
1,598,341	Fraser	Aug. 31, 1926
1,634,745	Fraser	July 5, 1927
1,843,300	Player et al.	Feb. 2, 1932
2,085,005	Cole	June 29, 1937
2,176,481	Waldron et al.	Oct. 17, 1939
2,209,711	Young	July 30, 1940
2,374,928	Frauenthal	May 1, 1945
2,387,044	Silven	Oct. 16, 1945
2,664,711	Howlett	Jan. 5, 1954
2,690,034	Laverdisse	Sept. 28, 1954