Nov. 25, 1941. H. S. INDGE 2,264,163

LAPPING MACHINE

Filed May 3, 1941 2 Sheets-Sheet 1

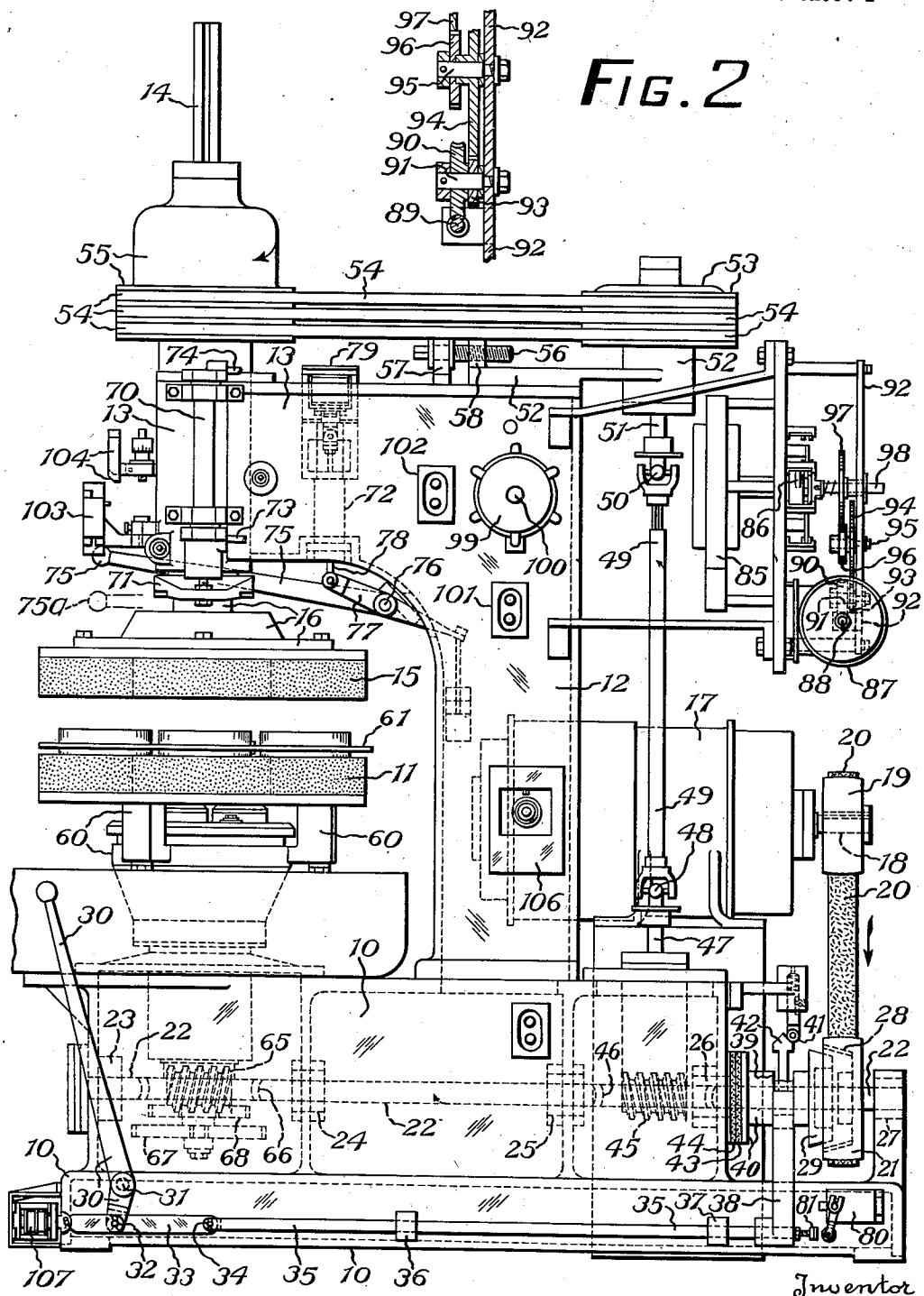


FIG. 1

FIG. 2

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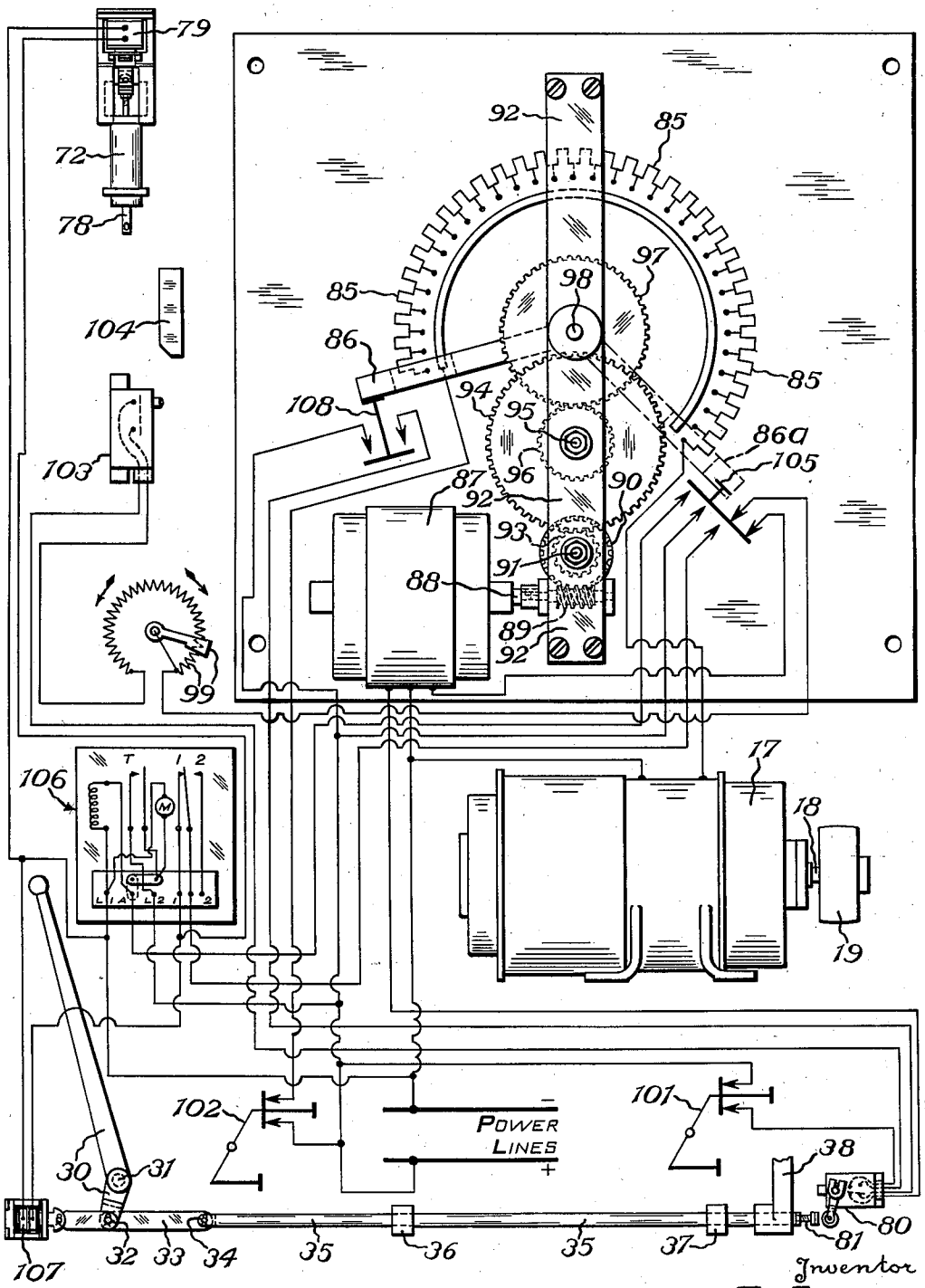


FIG. 3

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UNITED STATES PATENT OFFICE

2,264,163

LAPPING MACHINE

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Application May 3, 1941, Serial No. 391,655

11 Claims. (Cl. 51—118)

The invention relates to lapping machines, and more particularly to an electrically controlled lapping machine for lapping either opposed faces of flat work pieces or cylindrical work pieces.

One object of the invention is to provide a simple and thoroughly practical hydraulically operated lapping machine. Another object of the invention is to provide a lapping machine having two relatively rotatable opposed lapping elements, the speed of which is gradually and continuously increased from a relatively slow speed at the start of the lapping operation to a relatively fast speed at the completion thereof. Another object of the invention is to provide a lapping machine having an electrically controlled driving mechanism for the lapping elements, whereby the speed of rotation of the lapping elements together with the speed of rotation and gyration of the work cage may be progressively and continuously increased as the lapping operation proceeds. A further object of the invention is to provide a lapping machine having a progressively changing lap and work speed combined with a dwell control mechanism whereby the lapping operation continues at a finish lapping speed for a predetermined time interval.

Another object of the invention is to provide such a machine with an automatically actuated electrical control mechanism, whereby the lapping operation proceeds at a gradually and continuously changing lap and work speed followed by a predetermined lapping operation at the finish lapping speed, after which the lapping cycle is automatically terminated. Other objects will be in part obvious or in part pointed out hereinafter.

The invention accordingly consists in the features of construction, combinations of elements, and arrangements of parts, as will be exemplified in the structure to be hereinafter described, and the scope of the application of which will be indicated in the following claims.

In the accompanying drawings, in which is shown one of various possible embodiments of the mechanical features of this invention,

Fig. 1 is a side elevation of the lapping machine;

Fig. 2 is a fragmentary vertical sectional view, on an enlarged scale, through the gear mechanism for driving the motor driven rheostat; and

Fig. 3 is an electrical wiring diagram illustrating diagrammatically the electrical control of the machine.

The lapping machine may be constructed in its general aspects similar to the lapping machines illustrated in my prior U. S. Patents Nos. 1,610,527 dated December 14, 1926 and No. 2,103,984 dated December 28, 1937. This machine as illustrated in the drawings may comprise a base 10 which rotatably supports a lower lapping wheel 11. The base 10 is provided with an upwardly extending column 12 having an outwardly extending horizontal arm 13 formed integral therewith. The arm 13 serves as a support for a rotatably mounted vertically adjustable spindle 14. The spindle 14 supports a rotatable lapping wheel 15 at its lower end by means of a supporting and driving plate 16. Power may be obtained from a suitable source such as, for example, a variable speed electric motor 17 which is provided with a motor shaft 18 and a driving pulley 19. A driving belt 20 connects the pulley 19 with a pulley 21 which is rotatably supported on a rotatable shaft 22 journalled in bearings 23, 24, 25, 26 and 27 in the base 10. The pulley 21 is provided with an internal frusto-conical clutch face 28. A frusto-conical clutch member 29 is keyed to the shaft 22. When the clutch member 29 is in the full line position as indicated in Fig. 1, no power is transmitted to the shaft 22.

When it is desired to rotate the shaft 22, the cone clutch member 29 is moved toward the right (Fig. 1) into engagement with the internal cone clutch face 28 within the pulley 21 so as to cause a rotation of the shaft 22. In order that the clutch may be readily actuated from the operating station adjacent to the front of the machine, a pivotally mounted control lever 30 is supported on a stud 31 on the base 10. The lower end of the lever 30 is connected by a stud 32 with a link 33. The link 33 is connected by a stud 34 with one end of a slide rod 35. The slide rod 35 is journalled in bearings 36 and 37 which are fixedly mounted on the base of the machine. A yoked member 38 is mounted on the other end of the slide rod 35 and is arranged to engage a groove 39 formed in a hub 40 of the clutch member 29. By movement of the control lever 30 is a counterclockwise direction, the clutch member 29 may be thrown into engagement with the clutch member 28 within the pulley 21 to cause a rotation of the drive shaft 22, or when moved into the position illustrated in full lines in Fig. 1 may disconnect the clutch and stop the rotation of the shaft 22. A spring-pressed roller 41 cooperating with an arrow point 42 on the yoked member 38 serves as a load and fire mechanism which is arranged normally to hold the

clutch member 29 either in or out of engagement with the clutch member 28.

In order that the shaft 22 may be stopped quickly when the clutch is disengaged, a brake is provided comprising a brake disk 43 which is operatively connected to the clutch member 40 and is arranged to engage a clutch plate 44 mounted on the base of the machine.

The shaft 22 is provided with a worm 45 which meshes with a worm gear 46 on the lower end of a vertically arranged rotatable shaft 47. The shaft 47 is connected by a universal joint 48 with a shaft 49. The shaft 49 is preferably a telescopic shaft and is connected by a universal joint 50 with a vertically arranged rotatable shaft 51. The shaft 51 is rotatably journalled in a bracket 52 which is adjustably mounted on the upper surface of the column 12. The shaft 51 is provided with a multiple V-groove pulley 53 which is connected by V-belts 54 with a multiple V-groove pulley 55 which is slidably keyed to the spindle 14. It will be readily apparent from the foregoing disclosure that when the clutch 29 is moved to an engaged position, a rotary motion will be transmitted through the worm 45, the worm gear 46, the shaft 47, the universal joint 48, the telescopic shaft 49, the universal joint 50, the shaft 51, the pulley 53, the belt 54, and the pulley 55, to impart a rotary motion to the spindle 14 and thereby to rotate the upper lapping wheel 15. The bracket 52 is adjustably mounted on the upper surface of the column 12 and is provided with a screw adjustment comprising a rotatable screw 56 which is rotatably supported in a boss 57 and is screw threaded through an upwardly extending boss 58 formed integral with the bracket 52.

The lower lapping wheel 11 is connected by a rotatable spider 60 and is rotated by means of a vertical sleeve (not shown). A work carrying cage 61 is supported above the lower lap 11 and is provided with a plurality of work receiving apertures for supporting a plurality of work pieces for simultaneous lapping thereon. The work carrying cage 61 is carried by a plurality of driving pins or studs (not shown) and is carried through an irregular combined rotary and gyratory movement by means of a power driven gear mechanism the details of which have not been illustrated in the present drawings since this mechanism is not considered to be part of the present invention. For details of disclosure as to the means for rotating the lower lapping wheel 11 and for rotating and gyrating the cage 61, reference may be had to the prior U. S. patent to Indge No. 1,610,527 dated December 14, 1926.

The shaft 22 is provided with a worm 65 which meshes with a worm gear 66 mounted on a rotatable vertically extending sleeve (not shown) which is operatively connected to the spider 60 to rotate the lower lapping wheel 11. The gears 67 and 68 are connected in the manner illustrated in the prior Indge patents above referred to to produce a predetermined rotary and gyratory movement of the work carrying cage 61. For details of this mechanism, reference may be had to the above mentioned prior patents. The upper lapping wheel 15 is arranged so that it may be moved vertically toward or from an operative position.

In the preferred form a hydraulically operated mechanism is provided comprising a pair of diametrically arranged cylinders 70 (only one of which has been shown in the drawings) which are connected to diametrically opposite portions of a member 71 carried by the spindle 14. A fluid pressure system is provided for admitting and controlling fluid under pressure passing to and from the cylinders 70. A control valve 72 is provided whereby fluid under pressure may be admitted either through a pipe 73 or a pipe 74 to the cylinder 70 to produce either an upward or downward movement of the lap 15. The valve 72 is manually controlled by means of a lever 75 which is pivotally mounted on a stud 76. The stud 76 is fastened to the column 12. The stud 76 also carries an arm 77 which is operatively connected to a piston rod 78 to move the control valve 72 vertically. This hydraulically operated mechanism for moving the upper lapping wheel toward and from an operative position has not been illustrated in the present application since it is not considered to be a part of the present invention and since it is identical with the mechanism shown in my prior U. S. Patent No. 2,103,984 dated December 28, 1937, to which reference may be had for details of disclosure not contained herein.

A downward or a counterclockwise movement of the control lever 75 into broken line position 75*a* (Fig. 1) serves to shift the valve 72 so as to admit fluid under pressure through the pipe 74 to produce a downward movement of the lapping wheel 15. An electric solenoid 79 is operatively connected to move the valve 72 in an upward direction automatically to change the direction of flow of fluid to the cylinder 70 so as to raise the upper lapping wheel 15 to an inoperative position away from the work after a predetermined lapping operation has been completed.

A control mechanism is provided whereby the lapping operation may be started and the lapping wheels 11 and 15 may be rotated and the work carrying cage 61 rotated and gyrated at a relatively slow speed at the start of the lapping operation and the speed of the elements gradually and continuously increased as the lapping operation proceeds. By such a control a rough lapping of the work pieces is provided at the start of the lapping operation and the gradual continual increase of speed of the elements produces a gradually refined surface of high quality. A two-way limit switch 80 is provided which is arranged to be actuated by means of an adjustable screw 81 carried by the clutch shifting rod 35 and yoked member 38 which is arranged so that when the rod 35 is shifted toward the right (Fig. 1) to engage the clutch parts 29—28, the switch 80 will be closed to render an electric circuit.

In the preferred construction, the lapping wheel and cage driving motor 17 is controlled by an automatically actuated rheostat mechanism such as, for example, by a motor driven rheostat. A motor driven rheostat, such as the motor operated switch CR8490 manufactured by the General Electric Company, may be employed. The motor operated switch unit comprises a rheostat member 85 which is provided with an actuating arm 86. The arm 86 is automatically rotated by means of a variable speed electric motor 87. The electric motor 87 is connected by means of a reduction gear mechanism to actuate the control arm 86. The motor 87 is provided with a motor shaft 88 having formed integrally therewith a worm 89 which meshes with a worm gear 90. The worm gear 90 is rotatably mounted on a stud 91 which is fixedly supported by a frame 92 which in turn is supported on the column 12 of the machine. A small gear 93 is also rotatably supported on the stud 91 and is fixedly keyed to ro-

tate with the worm gear 90. The gear 93 meshes with a large gear 94 which is rotatably mounted on a stud 95. The stud 95 is fixedly mounted on the frame 92. The stud 95 also supports a gear 96 which is operatively connected to rotate with the gear 94. The gear 96 meshes with a gear 97 which is fixedly supported on a rheostat control shaft 98. The rheostat control arm 86 is also fixedly supported on the control shaft 98.

The motor operated rheostat switch 85 is connected to control the rotation of the lapping wheel and cage driving motor 17 so that at the first of the lapping cycle, the lapping wheels 11 and 15 together with the work cage 61 are rotated and the cage 61 is gyrated at a relatively slow speed, which speed is continuously and progressively increased until a maximum is reached at the end of the lapping cycle.

The speed of the motor 87 for driving the rheostat 85 may be adjusted manually so that the cycle of operation may be readily varied and controlled. A manually operable rheostat 99 is mounted on the column 12 of the machine (Fig. 1) and is manually controlled by means of a knob 100. By adjusting the rheostat 99, the speed of rotation of the motor 87 may be varied as desired, thus providing a manual control for adjusting the extent and duration of the lapping cycle.

The motor operated rheostat switch unit 85 is of an automatic reset type in which the variable speed reversible motor 87 is rotated in one direction during the lapping operation and is automatically reversed and rotated in the reverse direction after the lapping cycle has been completed to reset the rheostat 85 for the next lapping operation. The motor driven rheostat unit 85 is a standard, well known unit such as, for example, that manufactured by the General Electric Company and, therefore, it is not deemed to be necessary to illustrate further details thereof. A push button switch 101 mounted on the side of the column 12 is provided for rendering the electric circuit to the motor 87 operative or inoperative as desired. A push button switch 102 also mounted on the side of the column 12 serves to close an electric circuit to start or stop the cage and lapping wheel driving motor 17 when desired.

It is desirable that the motor driven rheostat 85 be set in motion when the lapping wheel 15 is moved into operative engagement with the work pieces at the start of the lapping operation. It is also desirable that the motor 87 be operatively connected so that it cannot be set in motion until the upper lapping wheel is first moved into operative position, after which the clutch 29 is thrown into engagement with the clutch member 28 to start the rotation of the lapping wheels 11 and 15 and also the rotation and gyration of the work cage 61. In order to accomplish this desired result, a normally open limit switch 103 is adjustably mounted on the arm 13. The limit switch 103 is connected in an electric circuit in series with the upper contact of the limit switch 80 so that when the limit switch 103 is closed the circuit will not be closed to start the rheostat motor 87 until the rod 35 is shifted toward the right (Figs. 1 and 3) to close the upper contact of the switch 80 at the same time the clutch 29 is thrown into engagement with the clutch member 28, at which time the rheostat motor 87 is set in motion.

It will thus be seen that an interlocked relationship is provided between the vertical movement of the lapping wheel 15 to and from an operative position and the engagement or disengagement of the clutch parts 29—28 which is arranged so that the motor 87 cannot be started until the upper lap is in an operative position and also the clutch 29 is thrown into engagement to set the lapping wheels 11 and 15 and the cage 61 in motion. A cam 104 is adjustably supported on a sleeve which moves vertically with the upper lapping wheel 15 to move the same to and from an operative position. The relative positions of the switch 103 and the actuating cam 104 are adjusted so that the switch 103 is closed when the upper lapping wheel 15 moves downwardly into operative engagement with the work pieces to be lapped. After the upper lapping wheel 15 has been moved into an operative position, the lever 30 is moved in a counterclockwise direction to throw the clutch member 29 into operative engagement with the clutch member 28 to start the rotation of the lapping wheels 11 and 15 and the rotation and gyration of the cage 61. This movement of the clutch shifting member serves to actuate the switch 80 to close the upper contacts thereof, thus completing the circuit to start the rheostat driving motor 87 as the lapping operation begins. As the lapping operation proceeds, the speed of rotation of the lapping wheels 11 and 15 together with the rotary and gyratory movement of the work carrying cage 61 is gradually and continuously increased.

The speed of rotation of the motor 17 gradually increases as the rheostat control arm 86 travels in a clockwise direction (Fig. 3) until it reaches a dotted line position 86a. When the rheostat control arm 86 reaches the position 86a, it actuates a switch 105 which serves to break a circuit to stop the rheostat drive motor 87 and at the same time makes a circuit to set an electrical time delay relay 106 in motion. The time relay 106 may be any standard electrical time relay such as, for example, that known as the Microflex time delay relay manufactured by the Eagle Signal Corporation of Moline, Illinois. The time relay 106 is adjustable so that a predetermined fiinsh lapping operation may be had while the wheels and the cage rotate at a fast or finish lapping speed, after which the lapping operation may be automatically terminated.

After the predetermined time interval has elapsed, the time relay 106 serves to make a circuit simultaneously to energize the solenoid 79 and a solenoid 107. The energization of the solenoid 79 serves to shift the valve 72 upwardly so as to reverse the flow of fluid to the cylinders 70, thus raising the upper lap 15 to an inoperative position. The energization of the solenoid 107 serves to shift the link 33 together with the yoked member 38 toward the left (Figs. 1 and 2) to disengage the clutch parts 29—28, thus stopping the rotation of the lapping wheels 11 and 15 and also stopping the rotation and gyration of the work carrying cage 61. By adjusting the time relay 106, the extent of the finish lapping operation may be varied as desired, that is, either a long or a short period of finish dwell with the wheel and cage moving at a relatively fast or finish lapping speed may be obtained.

When the clutch shifting rod 35 is moved toward the left to withdraw the stop screw 81 into the position illustrated in Figs. 1 and 3, the switch is shifted to make contact with the lower contact point which operates to make a circuit to reverse the flow of current to the motor 87 to rotate it in the reverse direction so as to reset

the rheostat, that is, to return the rheostat control arm from position 86a into full line position 86 (Fig. 3). When the control arm 86 reaches its full line position, it engages and actuates a switch 108 again to break a circuit to stop the rheostat drive motor 87 with the rheostat control arm 86 reset in a starting position.

The operation of this improved lapping machine will be readily apparent from the foregoing disclosure. Assuming all of the required adjustments to have been previously made, work pieces to be lapped are inserted in operative position in the work receiving apertures in the cage 61, after which the push button 101 is closed to render the circuit to the motor 87 in condition for automatic operation, and the push button switch 102 is closed to start rotation of the lapping wheel and cage driving motor 17 at a relatively slow speed. The control lever 75 is then shifted from the full line position (Fig. 1) into dotted line position 75a, which movement shifts the control valve 72 to cause a downward movement of the upper lapping wheel 15 to position its operative face in engagement with the upper surfaces of the work pieces to be lapped. The control lever 39 is then shifted in a counterclockwise direction to throw the clutch member 29 into engagement with the clutch face 28 so as to impart a relatively slow rotary movement to the lapping wheels 11 and 15 and a relatively slow rotary and gyratory movement to the work carrying cage 61. During the downward movement of the lap 15, the cam 104 actuates the limit switch 103 and during the engagement of the clutch member 29 with the clutch member 28, the switch 80 is actuated to close the upper contacts thereof, which movement serves to start the rotation of the rheostat control motor 87 gradually and continuously to increase the rotative speed of the lapping wheels 11 and 15 and the rotary and gyratory movement of the work carrying cage 61.

The lapping operation proceeds with a progressively and continuously increasing speed of the moving parts until the rheostat control arm 86 reaches the position 86a, in which position the switch 105 is actuated to stop the rheostat control motor 87 and at the same time to set in motion the electrical time delay relay 106. After a predetermined time interval has elapsed, the time relay 106 makes a circuit simultaneously to energize the solenoid 79 and 107 which in turn serves to disengage the clutch parts 29—28 to stop the rotation of the lapping wheels 11 and 15 and to stop the rotation and gyration of the cage 61 and at the same time shifts the control valve 72 upwardly to reverse the flow of fluid under pressure to raise the upper lapping wheel 15 to an inoperative position, thus terminating the lapping operation after it has proceeded to a predetermined extent.

When the clutch parts 29—28 are disengaged, the limit switch 80 shifts to close the lower contacts therein, which serves to reverse the flow of current to the reversible motor 87 to reverse the rotation of the gearing previously described so as to return the rheostat control arm from position 86a in a counterclockwise direction into position 86 (Fig. 3) to reset the motor driven rheostat ready for the next operation. When the rheostat control arm 86 reaches the full line position shown in Fig. 3, it actuates the switch 108 to again open a circuit and thus stop the rotation of the rheostat drive motor 87.

It will be readily apparent from the foregoing disclosure that by adjustment of the rheostat 99, the speed of the motor 87 may be varied so as to vary the time interval required for the rheostat control arm 86 to move from the full line position into the dotted line position 86a, thus controlling the time interval required from the initial lapping operation until the lapping elements reach their maximum or finish lapping speed. It will also be readily apparent that by manipulation of the adjustable time delay relay 106, the extent of the finish lapping operation at a relatively fast or maximum speed may be readily adjusted, after which the lapping operation is automatically terminated and the rotation of the laps together with the rotation and gyration of the cage 61 is stopped and the upper lapping wheel is moved to an inoperative position to facilitate removal of the finish lapped work pieces and the insertion of new work pieces to be lapped thereinstead.

It will thus be seen that there has been provided by this invention apparatus in which the various objects hereinabove set forth together with many thoroughly practical advantages are successfully achieved. As many possible embodiments may be made of the above invention and as many changes might be made in the embodiment above set forth, it is to be understood that all matter hereinbefore set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. In a lapping machine having a base, a pair of opposed rotatable lapping wheels, a work cage therebetween, a variable speed electric motor simultaneously to rotate said wheels and to rotate and gyrate said cage, and means including a motor driven rheostat for controlling said motor whereby the lapping operation may be started at a slow speed and gradually and continuously increased.

2. In a lapping machine having a base, a pair of opposed relatively rotatable lapping wheels, a rotatable work cage therebetween, means including a variable speed electric motor to drive said wheels and cage, means including a switch to start said motor to rotate the wheel and cage driving mechanism, means to move said lapping wheels relatively toward and from each other, a motor driven rheostat to control said electric motor, and an electrical interlock whereby the motor driven rheostat is set in motion automatically only when the lapping wheels are in an operative position and the switch is closed to rotate said wheels.

3. In a lapping machine having a base, a pair of opposed relatively rotatable lapping wheels, a rotatable work cage therebetween, a driving mechanism to drive said wheels and cage, a variable speed electric motor, means including a clutch to connect said motor with the wheel and cage driving mechanism, means to move said lapping wheels relatively toward and from each other, a motor driven rheostat to control said electric motor, and an electrical interlock whereby the motor driven rheostat is set in motion automatically only when the lapping wheels are in an operative position and the clutch is engaged to rotate said wheels.

4. In a lapping machine having a base, a pair of opposed relatively rotatable lapping wheels, a rotatable work cage therebetween, a driving mechanism to drive said wheels and cage, a variable speed electric motor, means including a clutch to connect said motor with the wheel and cage driving mechanism, means to move said

lapping wheels relatively toward and from each other, a motor driven rheostat to control said electric motor, a switch which is actuated in timed relation with said clutch to render the electric motor circuit operative, and a switch connected in series with the first switch which is actuated in timed relation with the relative approaching movement of the lapping wheels to start said motor driven rheostat so that the speed of rotation of the lapping wheels and cage is gradually and continuously increased during the duration of the lapping operation.

5. In a lapping machine having a base, a pair of relatively rotatable lapping wheels, a rotatable work cage therebetween, a driving mechanism to rotate said lapping wheels and to rotate and gyrate said cage, a variable speed electric motor, a clutch to connect said motor with the wheel and cage driving mechanism, means to move said lapping wheels relatively toward and from each other, a motor driven rheostat to control said electric motor, a switch which is actuated in timed relation with said clutch to render the electric motor circuit operative, and a switch connected in series with the first switch which is actuated in timed relation with the relative approaching movement of the lapping wheels to start said motor driven rheostat so that the speed of rotation of the lapping wheels and the speed of rotation and gyration of the work cage is gradually and continuously increased during the lapping operation.

6. In a lapping machine having a base, a pair of opposed relatively rotatable lapping wheels, a work cage therebetween, a driving mechanism to rotate said wheels and to rotate and gyrate said cage, a variable speed electric motor, a clutch to connect said motor with the wheel and cage driving mechanism, means to move said lapping wheels relatively toward and from each other, a motor driven rheostat to control said electric motor, a normally open limit switch which is actuated in timed relation with said clutch to render the electric motor circuit operative, and a normally open switch connected in series with the first switch which is actuated in timed relation with the relative approaching movement of the lapping wheels to start said motor driven rheostat so that the speed of rotation of the lapping wheels and the rotation and gyration of the cage is gradually and continuously increased during the duration of the lapping operation.

7. In a lapping machine having a base, a pair of opposed relatively rotatable lapping wheels, a work cage therebetween, a driving mechanism to rotate said wheels and to rotate and gyrate said cage, a variable speed electric motor, a clutch to connect said motor with the wheel and cage driving mechanism, means to move said lapping wheels relatively toward and from each other, a motor driven rheostat to control the speed of said electric motor, a switch which is actuated in timed relation with said clutch to render the electric motor circuit operative, a switch connected in series with the first switch which is actuated in timed relation with the relative approaching movement of said lapping wheels to start said motor driven rheostat so that the speed of rotation of the lapping wheels and the rotation and gyration of the cage is gradually and continuously increased during the lapping operation, and means to vary the speed of said motor driven rheostat whereby the duration of the lapping cycle may be readily varied as desired.

8. In a lapping machine having a base, a pair of opposed relatively rotatable lapping wheels, a work cage therebetween, a driving mechanism to rotate said wheels and to rotate and gyrate said cage, a variable speed electric motor, a clutch to connect said motor with the work and cage driving mechanism, means to move said lapping wheels relatively toward and from each other, a motor driven rheostat to control said electric motor, a switch which is actuated in timed relation with said clutch to render the motor circuit operative, a switch connected in series with the first switch which is actuated in timed relation with the relative approaching movement of the lapping wheels to start said motor driven rheostat so that the speed of rotation of the lapping wheels and the rotation and gyration of the work cage is gradually and continuously increased during the lapping operation, and means including a manually operable rheostat to vary the speed of the motor driven rheostat whereby the duration of the lapping cycle may be readily varied as desired.

9. In a lapping machine having a base, a pair of opposed relatively rotatable lapping wheels, a work cage therebetween, means including a variable speed electric motor to rotate said wheels and to rotate and gyrate said cage, a clutch to connect said motor with the wheel and cage driving mechanism, means to move said lapping wheels relatively toward and from each other, a motor driven rheostat to control said electric motor, a switch which is actuated in timed relation with said clutch to render said electric motor circuit operative, a switch connected in series with the first switch which is actuated in timed relation with the relative approaching movement of said lapping wheels to start said motor driven rheostat so that the speed of the lapping wheels and cage is gradually and continuously increased, an electrical time delay relay, said relay being connected to be set in motion by said rheostat when it reaches its high speed position, and a solenoid which is energized after a predetermined time interval as governed by said relay to disengage said clutch automatically to terminate the lapping operation.

10. In a lapping machine having a base, a pair of opposed relatively rotatable lapping wheels, a work cage therebetween, means including a variable speed electric motor to rotate said wheels and to rotate and gyrate said cage, a clutch to connect said motor with the wheel and cage driving mechanism, fluid pressure means including a manually operable valve to move said lapping wheels relatively toward and from each other, a motor driven rheostat to control said electric motor, a switch which is actuated in timed relation with said clutch to render the electric motor circuit operative, a switch connected in series with said first switch which is actuated in timed relation with the relative approaching movement of said lapping wheels to start said motor driven rheostat so that the speed of the lapping wheels and cage is gradually and continuously increased, an electrical time delay relay, said relay being connected to be set in motion by said rheostat when it reaches its high speed position, and a solenoid which is energized after a predetermined time interval as governed by said relay to shift said valve and separate said lapping wheels automatically to terminate the lapping operation.

11. In a lapping machine having a base, a pair of opposed relatively rotatable lapping wheels, a work cage therebetween, driving means to rotate

said wheels and to rotate and gyrate said cage, a variable speed electric motor, a manually operable clutch to connect said motor with the wheel and cage driving mechanism, fluid pressure means including a manually operable valve to move said lapping wheels relatively toward and from each other, a motor driven rheostat to control said electric motor, a switch actuated in timed relation with said clutch to render the electric motor circuit operative, a switch connected in series with said first switch which is actuated in timed relation with the relative approaching movement of the lapping wheels to start said motor driven rheostat so that the speed of the lapping wheels and cage is gradually and continuously increasd, an electrical time delay relay, said relay being connected to be set in motion by the rheostat when it reaches a high speed position, a solenoid operatively connected to disengage said clutch, a second solenoid operatively connected to shift said valve so as to separate said lapping wheels, and electrical connections between said time delay relay and said solenoids whereby the solenoids are simultaneously energized after a predetermined time interval to disengage said clutch to stop the lapping wheels and cage and to separate the lapping wheels after a predetermined lapping operation has been completed.

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