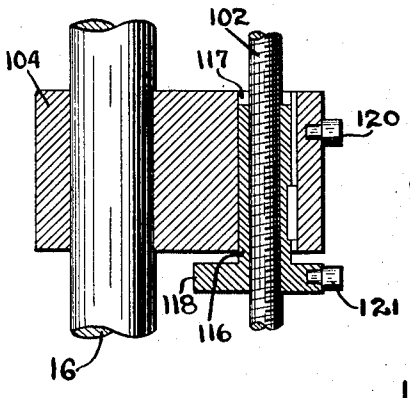
Aug. 31, 1926. 1,598,341

W. F. FRASER

LAPPING MACHINE

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Fig. 7



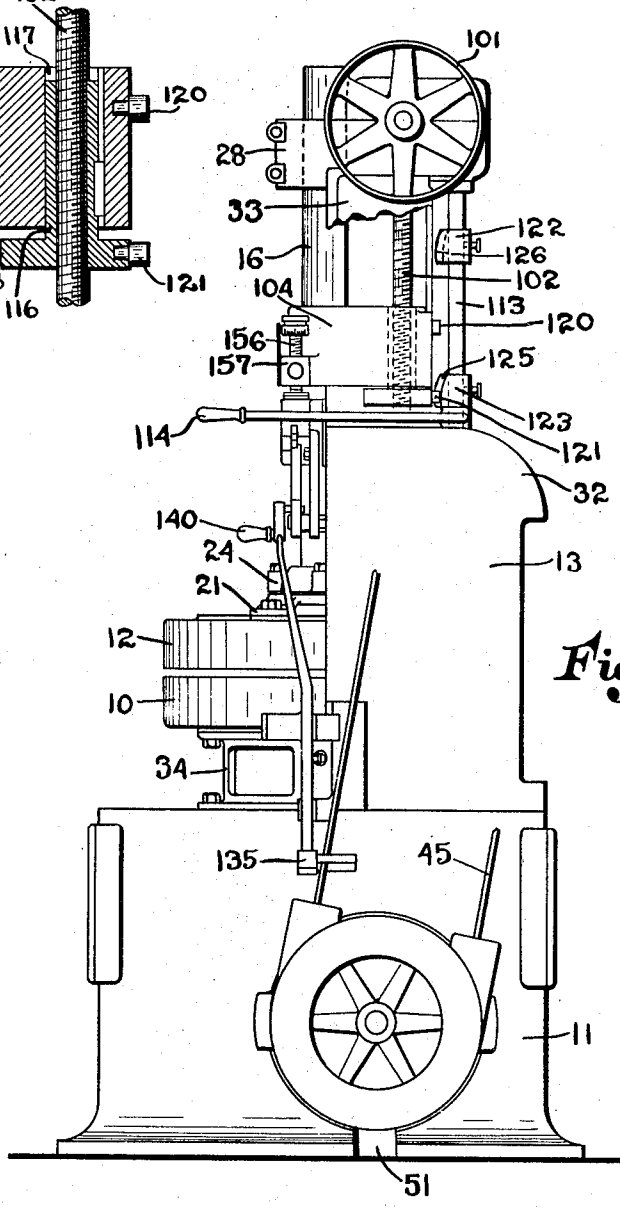


Fig. 1

Witnesses
Harold W. Eaton
Anna L. Murphy

Inventor
Warren F. Fraser
By Clayton R. Jenkins
Attorney

Aug. 31, 1926. 1,598,341

W. F. FRASER

LAPPING MACHINE

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Fig. 8

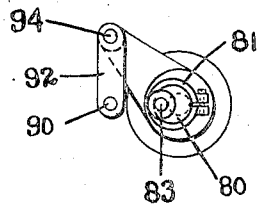


Fig. 13

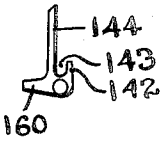


Fig. 2

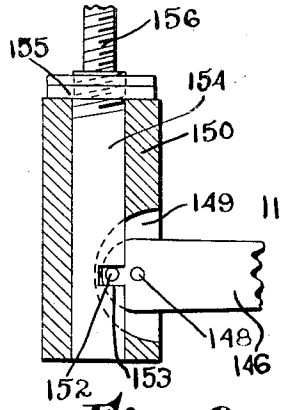


Fig. 9

Witnesses
Harold W. Eaton
Anna J. Murphy

Inventor
Warren F. Fraser
By Byron L. Jenks
Attorney

Aug. 31, 1926. 1,598,341

W. F. FRASER

LAPPING MACHINE

Filed Jan. 5, 1924 4 Sheets-Sheet 3

Fig. 10

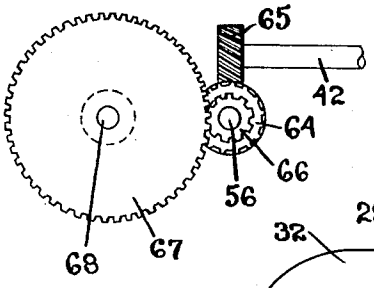


Fig. 11

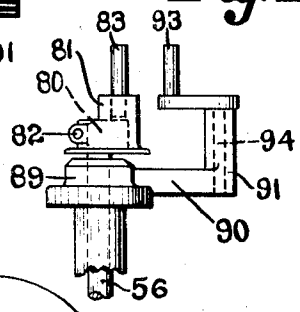


Fig. 3

Witnesses
Harold W. Eaton
Anna L. Murphy

Inventor
Warren F. Fraser
By Clayton R. Jenkes
Attorney

Aug. 31, 1926. 1,598,341

W. F. FRASER

LAPPING MACHINE

Filed Jan. 5, 1924 4 Sheets-Sheet 4

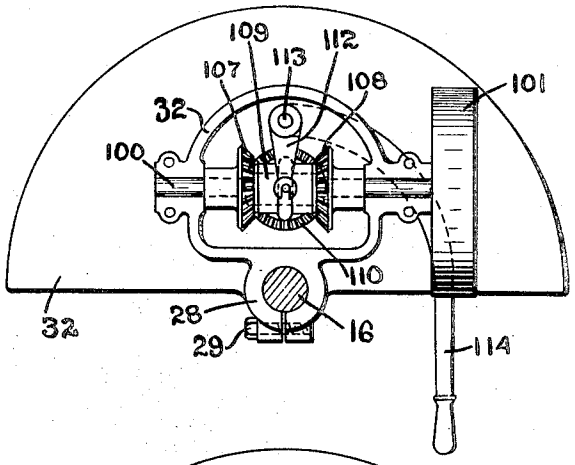


Fig. 4

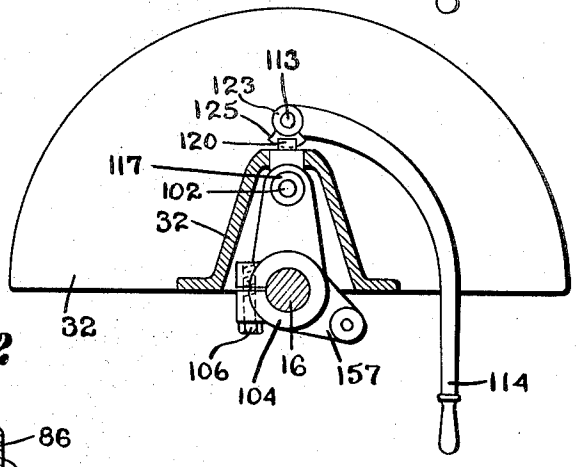
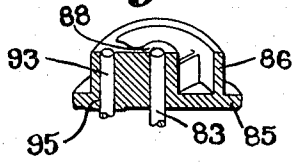


Fig. 5

Fig. 12



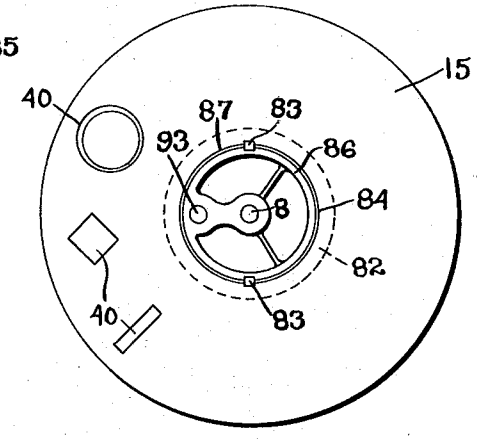


Fig. 6

Witnesses
Harold W. Eaton
Anna I. Murphy

Inventor
Warren F. Fraser
By Clayton R. Jenks
Attorney

Patented Aug. 31, 1926. 1,598,341

UNITED STATES PATENT OFFICE.

WARREN F. FRASER, OF WESTBORO, MASSACHUSETTS.

LAPPING MACHINE.

Application filed January 5, 1924. Serial No. 684,547.

My invention relates to a grinding machine and more particularly to that species known as a lapping machine.

In accordance with the usual practice in lap grinding, a number of substantially duplicate pieces of work are moved with an irregular motion between and relative to two non-abrading laps in the presence of fine abrasive grains. The laps move relatively towards each other as the work is abraded. If the work piece has a cylindrical or other regular curved surface, it may be mounted for a sliding and rolling motion between the laps. If the work has plane surfaces, it is moved only with a sliding motion.

The measurements required in the mechanical arts are often exceedingly fine and it is necessary that a machine of this type be capable of accurate duplication of results throughout successive operations. Since the work may be measurably reduced in size, and since the laps must be separable to permit introduction of the pieces of work, it has been difficult, with the machines heretofore constructed, to adjust the laps correctly and move one of them towards the other in such a manner that its operative face moves parallel with its original plane.

It is necessary that the lapping operation be stopped when the work has been abraded to a predetermined thickness. This has heretofore required that the operator frequently stop the machine and remove a piece in order to caliper it. An automatic operation of the machine would materially cut the cost of the process. Also, since the laps are massive bodies, it is difficult to move them by hand when the introduction of new work is required, and it is desirable that this be accomplished by power mechanism. Such mechanism should be under the control of the operator or capable of automatic movement which will prevent injury to the work and the machine.

It is accordingly an object of my invention to provide an improved construction of lapping machine which is largely automatic in its operation and which will give uniformly accurate and duplicatable results, both rapidly and efficiently, without requiring the services of a highly skilled workman.

It is another object of my invention to provide a lapping machine in which two opposed laps may be relatively adjusted angularly to bring their operative faces exactly into the required planes and these faces maintained in correct relationship during the entire lapping operation.

It is a further object of my invention to provide a lapping machine with power operated mechanism arranged to move the laps relatively towards and from each other and to incorporate in the mechanism a safety device which limits such movement automatically in case the operator neglects to control the mechanism properly.

It is a further object of my invention to provide a lapping mechanism which will automatically stop the lapping movement when the laps have reached a predetermined position in their relative approach towards each other so that the work may not be overground beyond a desired thickness.

It is a further object of my invention to provide a machine in which the relative motion of work holder and laps is such that a uniform wear on the operative surface of the laps may be obtained and the grinding action so broken up as to produce a fine finish on the work with a high degree of accuracy.

It is another object of my invention to so construct the machine as to provide rigid supports for the laps, and particularly the movable lap, so that no variation in the lapping operation or the thickness of the work can be caused by slight changes in the position of the lap supports.

It is a still further object of my invention to provide a lapping machine which will finish pieces of metal having parallel plane surfaces with a high degree of accuracy with reference not only to flatness of surface, but also to thickness and parallelism of surfaces.

With these and other objects in view, as will be apparent in the following disclosure, my invention resides in the combination of parts set forth in the specification and covered by the claims appended hereto.

Referring to the drawings which illustrate one embodiment of my invention and in which like reference numerals indicate like parts:—

Fig. 1, is a vertical side elevation of the lapping machine:

Fig. 2, is a vertical front elevation thereof;

Fig. 3, is an enlarged vertical cross-section partly broken away, corresponding with the view shown in Fig. 2;

Fig. 4, is a section on the line 4—4 of Fig. 3;

Fig. 5, is a section on the line 5—5 of Fig. 2;

Fig. 6, is a top plan view of the work holder in which is shown differently shaped openings for carrying various types of work;

Fig. 7, is a fragmentary detail showing a portion of the screw mechanism for raising the upper lap.

Fig. 8, is a plan view showing a detail of the lap driving mechanism;

Fig. 9, is an enlarged detail in section of the slide and tripping lever of the power controlling mechanism;

Fig. 10, is a detail showing the driving gears which rotate the work;

Fig. 11, is a detail in elevation showing the work driving linkages;

Fig. 12, is a detail in perspective, partly broken away, of the work centering and driving plate; and

Fig. 13, is a detail of the trigger mechanism.

In accordance with my invention, I provide a lapping machine comprising opposed laps and a work holder therebetween which are relatively moved to give a lapping effect, this being preferably accomplished by power driven mechanism so constructed and arranged as to give the work a compound path of travel which utilizes all of the effective portion of each lapping surface. In my preferred form, the laps remain stationary and the work holder only rotates. I also provide a power disconnecting mechanism controlled by the relative movement of the laps towards each other which insures stopping the lapping operation when the work has reached a predetermined size. A suitable mechanism for this purpose may be a trigger controlled, automatically operable belt shifter, or clutch mechanism of the usual load and fire type, which is released or operated by the movable lap.

In order that the operative surfaces on the laps may be maintained correctly positioned, I so mount one of the laps that it may be angularly adjusted relative to the other and clamped in such adjusted position. If both laps are held rigidly, relative movement towards and from each other will not affect their accuracy during the lapping operation. If the work to be ground has flat parallel faces, this adjustment may be easily accomplished by bringing the laps into contact with each other while one is loosely supported on a universal joint and then clamping the lap on its support while in contact with the other. Movement of either lap in a straight line away from the other will not destroy the parallelism of the lapping surfaces.

The movable lap is preferably arranged horizontally above the other and it may be lifted and lowered by a power driven clutch controlled mechanism. A cam device is automatically operated to throw the clutch when the lap has reached a desired limiting position.

Referring to the drawings, I have there shown one specific embodiment of my invention adapted for grinding flat work in which the lapping elements do not rotate and the work holder is mounted therebetween for a compound rotative movement. The lapping elements may be made of suitable material, like the ordinary grinding wheel of bonded abrasive grain, or of non-abrasive materials such as iron disks adapted to be used with loose abrasive material, and these laps are preferably arranged horizontally, the lower lap being mounted rigidly on the base 11 and the upper lap 12 supported on a frame 13. A holder 15 for a plurality of pieces of work is interposed between the laps, and in order that this holder may be given a lapping movement, I form the laps 10 and 12 as hollow annuli and bring the driving mechanism for the work holder up through the lower lap. Since one of the laps should be mounted for movement towards and from the companion lap, I prefer to move the upper one and to this end I suspend it from the lower end of a slidable rod 16.

The measurements required in a lapping operation are exceedingly fine and it is necessary that the operative face of the movable lap remain parallel to its original position during the abrading operation. If a piece of work mounted on one side of the holder should be slightly thicker than those on the other side, a lap which is not rigidly held in position would be tilted and so would not grind the work to uniform size. The laps become worn in time and it is substantially impossible to mount them permanently on the machine in such a manner that they will remain parallel. It is, therefore, necessary that they may be adjusted relatively to each other before the lapping operation and remain in predetermined relationship while the work is being abraded.

I accomplished this desideratum by suspending the upper lap from rod 16 through a universal joint which, after adjustments have been made, may be clamped to hold the lap rigidly in position. As illustrated, this joint may comprise a ball and socket connection. The rod 16 is formed with an enlarged portion 20, which has a partial spherical surface thereon. The lap is supported from the enlargement by means of a three-armed spider 21, which is fastened to the

lap at its outer ends by bolts 22 and is provided at its centre with a hub 23 so shaped as to fit the lower half of the spherical surface. A ring 24 similarly shaped to fit the upper portion of the ball 20 is adjustably clamped to the spider 21 by means of bolts or cap screws 25.

If the shape of the work, such as flat pieces having parallel sides, is such as to require parallel operative faces on the laps, as illustrated, these faces may be brought into exact parallelism by loosening the screws 25 when the work holder has been removed and bringing the laps into contact with each other.

The cap screws 25 are then tightened while the laps are in contact, after which either lap may be moved in a straight line away from contact with the other and their operative surfaces will remain parallel. Also three suitably shaped blocks of the same dimensions may be employed for adjusting the laps, these being spaced on the lower lap and the upper one brought into contact therewith.

As a further safe-guard to insure such parallelism, the slide rod 16 is made of a large size and its outer surface is ground to cylindrical shape and slidably mounted in two sets of adjustable bearings 27 and 28. These bearings may be of any well-known type of split bearing which may be suitably tightened on the slidable rod 16 by means of clamping screws 29 as is well known in the art.

The frame 13 carrying this slidable rod is fashioned in what may be termed a bridge shape. That is, it is supported on the base on opposite sides and has a top cross member located for suspending the upper lap vertically therefrom over the lower lap. If, as is customary, the upper lap support is in the form of a cantilever, distortional strains will easily change the position of the lap suspended therefrom. By employing a bridge which has two oppositely disposed legs, one avoids such movement. As illustrated, the frame may be made in a hollow semi-cylindrical shape, cut away at the back and front, in order to permit access to the laps. The portions not cut away form legs which are located in part substantially in a vertical plane passing through a diameter of the lower lap. The upper portion 32 of the frame constitutes the bridge proper from which the lap is suspended.

This frame is provided with an annular flange 30 which rests on the top 31 of the base 11 and is rigidly bolted thereto. The frame is provided with a superstructure 33 which is shaped, as shown in Figs. 4 and 5, to provide space for the rod 16 and its operating mechanism. The split bearings 27 and 28 are formed integral with part 33 or may be otherwise rigidly secured thereto.

In order that the lower lap may be rigidly supported on the base 11, I form the latter as an open-ended cylinder, the top 31 of which is bored to provide a central opening for passage of the work driving mechanism. The lap 10 is mounted on a casting 34, which is fitted to the top 31 of the base and bolted thereto. The top of the casting is provided with an annular plane face 35 which supports a similarly shaped face on the under side of the lap 10 and these parts are bolted together to provide rigidity of construction.

The work holder is shaped to correspond with the type of work to be lapped. If the work has parallel plane faces, the holder 15 may consist of a disk, thinner than the thickness of the work, which is provided with openings 40 corresponding with the cross-sectional shape of the work. These openings, but three types of which are shown in Fig. 6, may be arranged either radially or at a suitable angle to a radius as desired. Cylindrical or rotatable work may be mounted in a similar holder, or otherwise as found suitable.

Since a circular motion of the work holder would produce markings on the work and wear the laps unevenly, I give the work a compound motion which insures utilization of the whole surface of each lap and gives the work a slidable as well as a motion of revolution about the center of the lap. This may be effected by rotating the work holder about its center while carrying the center around a circular path and the mechanism is so arranged that the work does not fall into the same path on the laps until it has revolved a large number of times.

To this end I provide the driving mechanism illustrated, which comprises a main drive shaft 42 on the end of which is mounted a driving pulley 43 keyed to the shaft and an idler pulley 44 rotatable relative thereto. A shiftable belt 45 connects the driving shaft with a suitable source of power.

The shaft 42 and its associated mechanism is assembled and carried on two plates 48 and 49 which are attached by screws to the underside of flange 50 projecting inwardly from the base 10 and the underside of the top 31. A slot 51 cut into the base permits the shaft 42 and its bearing 52, which may be of suitable construction, to be assembled from the underside of the machine. It will be seen, by inspection of Fig. 3, that the lower portion of casting 34 and the plate 49 have flanges 53 and 54 which engage the inner periphery of the top 31, whereby both the lap 10 and the driving mechanism may be properly centered.

Centrally mounted on plates 48 and 49 is a shaft 56. A sleeve 58 surrounding this shaft and rotatable relative thereto is journaled in hub 59 integrally formed on the

plate 49. The lower end of shaft 56 carries a flanged bushing 60 which fits into a boss 61 on the plate 48 thereby forming both a radial and a thrust bearing for the shaft. A bushing 62 within the upper end of sleeve 58 forms a bearing for the upper portion of shaft 56.

The shaft 56 is rotated by means of a spiral gear 64 keyed thereto and meshing with a similar gear 65 (see Fig. 10) fixed on the end of shaft 42. The sleeve 58 is rotated at a slow rate relative to the speed of shaft 56 by means of a train of gearing comprising the small gear 66 keyed to shaft 56 which meshes with the large gear 67 mounted on the short shaft 68. This shaft is suitably journaled in a boss 69 on plate 48 and a further boss 70 which is formed on a casting 71 which rests on and is attached to plate 48. A further small gear 74 on the upper end of shaft 68 meshes with a large gear 75 keyed to the sleeve 58. The hub of the gear 75 is also supported on the casting 71.

The work holder is connected to both shaft and sleeve in order that it may be given a compound rotary movement. The upper end of the shaft 56 is formed as an enlarged head 80 which has an exterior cylindrical surface eccentric with the shaft. A split collar 81 is clamped on this cylindrical head 80 and may be suitably adjusted in position by loosening the cap screw 82 and revolving the collar 81 about its center. A driving pin 83 is mounted in a socket in the collar with its axis eccentric to the center of the head 80. The pin is also so positioned that as the collar 81 is adjusted about the head 80 the pin may be brought into axial alignment with the shaft 56, or by revolving it further around the center of the head 80, it may be given the maximum eccentricity shown in Fig. 11. By means of this adjustment I may vary the throw or the radius of movement of the pin 83.

It will therefore be seen that rotation of the shaft 56 gives the pin 83 a movement of revolution which may be transmitted to the work holder by a suitable connection. As shown, the holder 15 has a large circular opening 87 at its center and of such size that it may be dropped down onto a flanged driving plate 85. This plate, as shown in Figs. 3 and 12, has an upstanding flange 86 which is removably keyed to the holder 15 by keys 87 so that the driving plate and the work holder may be rotated together. The pin 83 loosely fits within a driving hub 88 centrally located on the plate, the axis of the pin and the center of the work holder coinciding. It will therefore be seen that when the shaft 56 is rotated the pin 83 carries the center of the work holder around rapidly with a circular motion of short radius.

In order to give the work holder a rotary motion about its center, I provide a connection between the slowly rotating sleeve 58 and the driving plate 85. To this end, I fix a flanged collar 89 tightly on the upper end of the sleeve 58, the flange overhanging the hub 59 so as to prevent access of grit or abrasive to the bearings. This flanged collar 89 has an outwardly projecting crank arm 90 which has an upturned portion 91 provided with a hole therethrough. Connection is made between this arm 90 and the driving plate 85 through a separate member comprising a horizontal plate 92 which has a pin 93 projecting upwardly therefrom at one end and another pin 94 at the opposite end projecting downwardly. The pin 94 fits rotatably within the hole in the portion 91 of the crank arm and the pin 93 is likewise adapted to be pivotally mounted in a hole 95 in the driving plate 85 which is provided for that purpose. A cover plate 96 fastened to the driving plate prevents abrasive from getting into the bearings of the two driving pins.

It will therefore be seen that when the shaft 56 and the sleeve 58 are rotated the work holder plate 15 will be rotated slowly about its center while the center is revolved at a rapid rate. These two movements cause the work to be carried around in a rapid loop like motion while it travels around the axis of shaft 56. These motions are so timed and related that the work preferably does not travel in the same path on the laps until it has been revolved many times. This insures even wear of the laps. It, however, will be understood that the gears and associated parts may be suitably constructed to give any desired movement, so far as the broader aspects of my invention are concerned. The laps are made annular in shape of such a width that all of their effective surfaces may be used, thus avoiding wearing a groove therein.

In order that the upper lap may be readily moved, I preferably provide a power mechanism which may be both manually and automatically controlled. To this end I mount a drive shaft 100 in suitable bearings in the superstructure or housing 33. This shaft is driven through the pulley 101 from a source of power and is connected through a clutch mechanism to rotate a screw 102 in opposite directions. This screw is connected at its lower end to a block 104 which is adjustably fixed on the rod 16. This block may be bored, as shown in Fig. 5, to fit slidably on the rod 16 and is split so that it may be clamped fixedly thereto by means of cap screws 106.

The clutch mechanism, which may be of any suitable construction, comprises two bevel gears 107 and 108, freely mounted on the shaft 100 and adapted to be driven by a friction cone clutch 109 slidably keyed to the shaft 100. These bevel gears mesh with a

further gear 110 fixed to the upper end of the shaft 102. A clutch lever 112, which is yoked to the member 109 to slide the same, is attached to the upper end of a rod 113 suitably mounted for turning movement on the superstructure of the machine. A hand lever 114 is connected with the lower end of this rod 113 whereby the clutch may be manually controlled.

Since the operator might, through negligence, permit the movable lap to be driven too far by the power mechanism and so injure the work or machine, I preferably provide an automatic controlling device which will limit such movement. Of the various forms of mechanism which might be utilized for this purpose, I prefer to use that illustrated. It is also desirable that the lap be mounted for yielding movement in an upward direction, but that its downward movement be definitely limited.

To these ends, I employ the construction particularly illustrated in Figs. 1 and 7, which comprises a nut 116 threaded on to the screw 102. This nut is slidably keyed within a hole 117 bored in the block 104. A flange 118 on the lower end of the nut limits the downward movement of the block relative thereto, but no upper limit is provided.

Pins 120 and 121 are suitably located on the block 104 and the flanged nut 116 respectively. Adjustably disposed on the clutch rod 113 are two collars 122 and 123 which may be fixed in any desired position by means of set screws. These collars have cam faces 125 and 126 which are shaped like fragments of screw threads and they are so arranged that they will be struck by the pins 120 and 121 when the lap is moved up and down to the limit of its motion. The cam faces are oppositely disposed and so arranged that when the pin 120 strikes the cam 126 it will turn the rod 113 in such a manner as to throw the clutch and stop the upward movement of the lap. Similarly, when the pin 121 strikes the cam face 125 it throws the clutch in the opposite direction to prevent the lap moving downwardly too far. It will be noted that the pin 121 is placed on the nut 116 so that if the work is in the machine, the lap need not be moved downwardly any further, as would be required by movement of the screw, after it has come into contact with the work. However, the nut 116 is run downwardly to a sufficient extent below the block 104 to permit a desired decrease in size of the work.

It is desirable that the lapping operation be stopped when the work has been abraded to a predetermined size, and this may be accomplished by a mechanism which will stop automatically the relative lapping movement between the work and the laps. This mechanism is preferably so constructed as to be controlled by the movable lap when it has reached a given point in its downward movement.

One simple form of mechanism for this purpose may comprise a belt shifting device which is automatically operated by a spring and is arranged to be held in a driving position by a trigger mechanism which is released by an adjustable stop which travels with the movable lap. To this end the belt shifter 135, of usual construction, is pivotally mounted on a pin 136 carried by the arm 137 projecting from the frame 13 of the machine. A spring 138 fastened to the frame and the arm tends to throw the belt shifter so as to move the belt on to the idler pulley 44. The belt shifter, is held in a driving position by means of a trigger mechanism which is releasable by means of a stop on the block 104.

The upper lever arm 139 of the belt shifter, which has a handle 140 thereon for manual movement, carries a laterally projecting pin 141 adapted to be engaged by a locking trigger to hold the belt shifter immovable. This trigger is J-shaped, the short loop 142 thereof forming a slot 143 between itself and the long arm 144. The trigger is pivotally mounted on an arm 145 projecting from the frame of the machine. The slot or recess 143 is so shaped and located that the pin 141 may travel into it when the trigger is tipped forward and be held immovable by the arms 142 and 144 when the trigger is itself held in position. This is accomplished by means of a lever 146 which has at its outer end a locking lug or catch 147. This catch and the upper end 144 of the trigger are so shaped that a slight movement of the lever 146 will release the trigger.

The lever 146 is pivotally mounted on a pin 148 fixed in recess 149 in the hub 150 which is fastened to the frame 13. (See Fig. 9.) This short end of the lever 146 carries a pin 152 which rides in a slot 153 in the slidable member 154 mounted in the boss 150. The upper end of this slidable member has two set collars 155 threaded thereon to prevent its moving downwardly too far and it is engaged by the lower end of a micrometer screw 156 threaded through a lug 157 projecting from the block 104.

The micrometer screw is of the usual construction and may be finely adjusted and set in a given position by set screw 158 so that when the block has reached a predetermined position in its downward travel, the lower end of the screw will contact with slide 154 and the latter in turn press downwardly on pin 152 until the catch 147 is released from engagement with the long arm of the trigger. The two arms of lever 146 are of such lengths that a very slight downward movement of the lap will release the trigger mechanism. A pin 159 projecting from the arm

145 is so located that it will engage a short arm 160 on the trigger when the latter has been tipped forward sufficiently to release the pin 141 from the locking groove 143. When the belt shifter arm 139 is moved back by the handle 140, the pin 141 strikes the long arm 144 of the trigger and thus moves the trigger back until the catch 147, which has a cam face for this purpose, is raised and then falls into position back of the end of the trigger arm 144 to hold the parts locked. When the trigger is released, the spring 138, being under tension, pulls the belt shifter over to an inoperative position. It is returned to a driving position by manual operation.

It will also be understood that by suitably adjusting the set collars 155 relative to the slide, the collars may be caused to strike the fixed support 150 before the lever 147 can release the trigger mechanism. This device would then form a single stop which could be easily adjusted to stop the lapping operation when the work has reached a given thickness but without stopping the relative lapping movement between the work holder and the laps. By having but a single stop as well as a single guide and support for the movable lap, I avoid inaccuracies inherent in machines having a multiplicity of these movable and adjustable parts.

In order that abrasive may be supplied to the work, if iron laps are employed, I preferably provide the upper lap 12 with a channel 165 within which a supply of material may be held. This material is permitted to feed gradually to the work through small spaced openings 166 in the bottom of the lap. Any suitable provision however, may be adopted for this purpose.

In operating this machine, the workman moves the clutch lever 114 in such a direction that the upper lap will be raised, after which the work holder may be loaded with the duplicate pieces of work. The holder may be removed by lifting it from the driving plate 85. When the upper lap has been brought down into contact with the work by reversing the clutch, the belt shifting mechanism is moved by means of handle 140 to start the lapping operation. Since the upper lap is freely slidable relative to the screw 102, as permitted by the construction illustrated in Fig. 7, it is merely necessary for the operator to lower the nut 116 sufficiently to permit the block 104 which is clamped to the lap support 16 to move freely downwardly a short distance as the work is diminished in size. This distance through which the lap may move is determined by adjustment of the micrometer screw 156. When this screw contacts with the top of the slide member 154, it pushes downwardly on pin 152 and raises lever 146 thereby releasing the trigger and permitting the spring 138 to shift the belt and stop the lapping operation. The cycle may then be repeated by raising the upper lap, removing the finished work, inserting new pieces, and so on.

The upper lap cannot run too far when moved by the automatic driving mechanism owing to the cams which are provided to control the clutch. When the block 104, which during the upward movement rests on the flange 118 of the nut 116, reaches such a position that the pin 120 contacts with the cam face 126 of cam 122, a further slight upward movement of the block serves to turn the cam rod 113 and so disconnect the clutch. The clutch control mechanism is so constructed that the clutch slide will not be thrown automatically to its extreme opposite position to start the lap in the reverse direction since it is preferable that this downward movement be started manually by the operator. When the lap has been started it travels until the pin 121 contacts with the lower cam 123 whereupon the screw 102 will be stopped. It will be noted that the pin 121 is placed on the nut 116 and not on the block 104 since it is desirable to stop the movement of the nut irrespective of the position of the block which may be determined by the thickness of the work placed in the machine.

The laps are brought into exact parallelism by running the upper lap down into contact with the lower lap or with three duplicate blocks spaced thereon, while the clamping screws 25 are loosened. Tightening these screws when the laps are correctly positioned will insure their remaining in proper position during the whole lapping operation.

It will also be apparent that by adjusting the head 80 in its collar 81, I thereby vary the extent of the loop like motion of the work relative to the laps. If the pin 83 is axially aligned with shaft 56 the work will then be given a simple movement of revolution about the center of the laps. Furthermore, it is to be understood that it will be obvious that various changes may be made in this device within the scope of my invention as covered by the appended claims.

I claim:—

1. A lapping machine comprising two opposed laps which are relatively movable towards each other, a work holder mounted between said laps and arranged to present a multiplicity of work pieces simultaneously to the action of the laps, means to cause a relative lapping movement between said holder and laps and automatically operable means to stop said lapping movement when the laps have reached a predetermined relative position in their approach towards each other.

2. A lapping machine comprising two laps having horizontal opposed grinding sur-

faces, a work holder mounted therebetween and arranged to present a multiplicity of work pieces simultaneously to the laps, means to cause a relative lapping movement between said laps and work holder, means permitting the upper lap to move freely towards the lower one during the lapping operation and means to stop the lapping movement automatically when the laps have reached a predetermined distance from each other.

3. A lapping machine comprising two opposed laps which are relatively movable towards each other, a work holder mounted therebetween to hold several pieces of work simultaneously in grinding contact with the laps, a driving mechanism to cause relative lapping movement between said holder and laps to abrade the work, a source of power therefor, and means automatically operated by movement of one of the laps to disconnect the power from the driving mechanism when the work has reached a predetermined size.

4. A lapping machine comprising two parallel, opposed, non-rotative laps, means supporting said laps which permits a relative yielding movement towards each other, a work holder therebetween which is arranged to hold several pieces of work between the laps with the faces touching the laps substantially in the same plane, a driving mechanism to impart a lapping motion to said holder and means to stop said driving mechanism when said laps have moved to a predetermined point towards each other.

5. A lapping machine comprising two laps having horizontal opposed working surfaces, means to hold the lower lap in a fixed position, means to permit the upper lap to move towards the fixed lap, means to separate the laps, a work holder between the laps, driving mechanism to impart a lapping movement to the holder, and means to stop said mechanism when the movable lap has reached a predetermined distance from the lower lap.

6. A lapping machine comprising two opposed laps one of which is freely movable towards the other during the lapping operation, a work holder therebetween, power operated mechanism to move one of said laps relatively towards and from the other, means for automatically limiting such movement of the laps, means to cause a relative lapping movement between said holder and laps, and means controlled by the movement of the movable lap towards the other to stop the lapping operation when the laps have reached a predetermined distance from each other.

7. A lapping machine comprising two horizontal opposed laps, a work holder therebetween, driving mechanism to impart a lapping motion to said holder, a support for the upper lap permitting movement thereof towards the lower lap, mechanism to raise the upper lap, and means to stop the lapping operation which is operated by downward movement of the upper lap.

8. A lapping machine comprising two opposed relatively movable laps, a work holder therebetween, means to cause a relative lapping movement between said holder and laps, and a support for one lap which permits the lapping faces to be adjusted accurately into a lapping relationship and maintained therein during the entire lapping operation.

9. A lapping machine comprising a base, a lap mounted thereon, a second lap, a support therefor mounted on the base which permits the operative surface of the lap to be adjusted into a desired plane, means to clamp the adjustable lap in such position whereby the two laps will be maintained in correct operative relationship during the lapping operation, a work holder between the laps, and means to cause a relative lapping movement between the holder and laps.

10. A lapping machine comprising two opposed laps having plane faces one of which is movable relative to the other, a work holder therebetween, means to cause a relative lapping movement between said holder and laps, means whereby said plane faces may be automatically brought into parallelism, and means for holding the lapping faces parallel during the entire lapping operation.

11. A lapping machine comprising a base, two opposed laps mounted thereon, a work holder therebetween, means to cause a relative lapping movement between said holder and laps, means permitting one lap to move towards the other, and means for angularly adjusting one lap relative to the other and fixing it in such adjusted relationship.

12. A lapping machine comprising a base, two opposed laps mounted thereon, a slidable support for one lap permitting movement towards and from the other, a work holder between the laps, means to impart a lapping movement to said holder, and means permitting angular adjustment of one lap relative to the other and for clamping the same in its adjusted position whereby the lapping faces will remain correctly positioned during the lapping operation.

13. A lapping machine comprising two opposed horizontal laps having plane faces, a work holder therebetween, means to cause a relative lapping movement between said holder and laps, a support for the lower lap arranged to hold its operative face in a given plane, a rigid support mounted over the lower lap, a vertical slide thereon, means suspending the upper lap from said slide which permits the lap to be angularly ad-

justed and fixed in a given position whereby its operative face may move parallel to itself during the lapping operation.

14. A lapping machine comprising two opposed horizontal laps, a support for the lower lap, a vertically movable support for the upper lap, a universal joint suspending the upper lap from the vertically movable support, and means to clamp the upper lap rigidly to its support.

15. A lapping machine comprising a base, two opposed horizontal laps, a work holder therebetween, means to produce a relative lapping movement between said laps and holder, a frame on said base, a vertically movable slide on said frame, a universal joint connecting the upper lap with said slide and means to clamp said upper lap to the slide so that the operative faces of the two laps may be maintained in a lapping relationship during the operation.

16. A lapping machine comprising a base, two opposed laps, a work holder therebetween, means to give said holder a lapping motion, a movable support mounted on said base, a lap angularly adjustable on said support, and means to clamp said lap on said support so that its operative face may be moved always parallel with itself during the lapping operation.

17. A lapping machine comprising a base having a lower lap mounted thereon, a bridge frame which is supported on opposite sides of the base and a second lap suspended from the frame above the lower lap.

18. A lapping machine comprising a base, a lower lap mounted thereon, a bridge frame supported on opposite sides of said base, an upper lap slidably suspended from the bridge frame over the lower lap, and means for moving the upper lap vertically.

19. A lapping machine comprising a base, a bridge frame having oppositely disposed legs supported on the base, a lower lap mounted on the base between said legs, a slide on the frame, an upper lap suspended from said slide over the lower lap, means to adjust the upper lap angularly and clamp it fixedly on said slide, a work holder between the laps and means to cause a relative lapping motion between the holder and the laps.

20. A lapping machine comprising oppositely disposed laps having annular lapping surfaces, a work holder therebetween, a driving mechanism projecting within the annulus of one lap, and means removably connecting the same with the holder, said driving mechanism comprising means to move the center of the holder rapidly about the axis of the laps while rotating the holder slowly about its own center.

21. A lapping machine comprising two horizontal opposed laps, a work holder therebetween, a vertical driving shaft, a sleeve thereon, said shaft and sleeve being mounted for relative rotation, a crank connection from said shaft to the work holder to revolve the center of the holder about the axis of the shaft, and connections from said sleeve to said holder which cause the latter to rotate about its center.

22. A lapping machine comprising two horizontal opposed laps having annular lapping surfaces, a work holder therebetween, a vertical driving shaft, a sleeve thereon and rotatable relative thereto, a crank connection from said shaft to the work holder to revolve the center of the holder about the center line of the laps, connections from said sleeve to said holder to rotate the latter about its center, and driving connections to rotate the shaft rapidly and the sleeve slowly.

23. A lapping machine comprising oppositely disposed laps arranged one above the other, a work holder therebetween, means to impart a relative lapping movement between said holder and laps, and manually controlled, mechanically operated means to raise and lower one of said laps relative to the other.

24. A lapping machine comprising two laps arranged one above the other, a work holder therebetween, means to impart a relative lapping movement between said holder and laps, mechanism to raise and lower one lap relative to the other, and means for automatically stopping the operation of said mechanism when the movable lap has reached a predetermined position.

25. A lapping machine comprising two opposed laps a work holder therebetween, means to impart a relative lapping movement between said holder and laps, power operated clutch controlled mechanism to move one lap towards and from the other, and means automatically acting to throw the clutch and prevent over-running of the movable lap.

26. A lapping machine comprising two horizontal laps, a work holder therebetween, means to give the holder a lapping motion, power operated, clutch controlled mechanism to move one lap vertically towards and away from the other and means controlled by movement of the lap to stop said mechanism when the lap has reached a predetermined point.

27. A lapping machine comprising a base, a lap immovably mounted thereon, a rigid support on the base, a single vertically movable slide thereon, a lap suspended from said slide and a single adjustable stop member capable of stopping the downward movement of the lap at a predetermined point.

28. A lapping machine comprising two opposed laps, a work holder therebetween, means to cause a relative lapping movement between the laps and holder, and mechanism

to move one lap positively away from the other but yieldingly towards the same whereby the laps cannot be forced together under pressure.

29. A lapping machine comprising two horizontal laps, a work holder therebetween, means to impart a relative lapping movement between the holder and laps, a support permitting one lap to be vertically moved towards and from the other, mechanism comprising a screw to raise and lower said lap, and a connection between said screw and lap support which is arranged to positively raise the lap but permit its downward movement under the influence of gravity to a limiting position as determined by the screw.

30. A lapping machine comprising a base, two horizontal laps, a work holder therebetween, means to cause a relative lapping movement between said holder and laps, a fixed support for the lower lap, means including a screw mechanism to move the upper lap upwardly or permit it to move downwardly under the influence of gravity, and means for adjustably limiting its vertical movement.

31. A lapping machine comprising two opposed laps, a work holder therebetween, means to give a relative lapping movement between said holder and laps, power operated, clutch controlled mechanism to move one lap towards and from the other, adjustably positioned cam members connected to throw said clutch and cam operated followers connected with said movable lap, said followers and cams being so arranged as to limit both the upward and downward movement of the lap.

32. A lapping machine comprising two horizontal laps arranged one above the other, a work holder therebetween, means to give said holder a lapping movement, a rigid support for the lower lap, a vertically slidable support for the upper lap, a screw mechanism to raise the upper lap, and means to adjustably limit the vertical movement of said lap.

33. A lapping machine comprising oppositely disposed laps, a work holder therebetween, means to cause relative rotation between the center of the holder and the laps and means to vary the radius of such rotative motion.

34. A lapping machine comprising opposed laps, a work holder therebetween. means to cause the work to rotate relative to the laps and about their center. means to give the work a secondary loop-like motion and means permitting adjustment of the extent of such loop-like motion.

Signed at Westboro, Massachusetts, this 29 day of Dec. 1923.

WARREN F. FRASER.