April 26, 1966 A. J. HACKMAN, JR 3,247,622

PRECISION SURFACE ABRADING MACHINE

Filed July 22, 1963 4 Sheets-Sheet 1

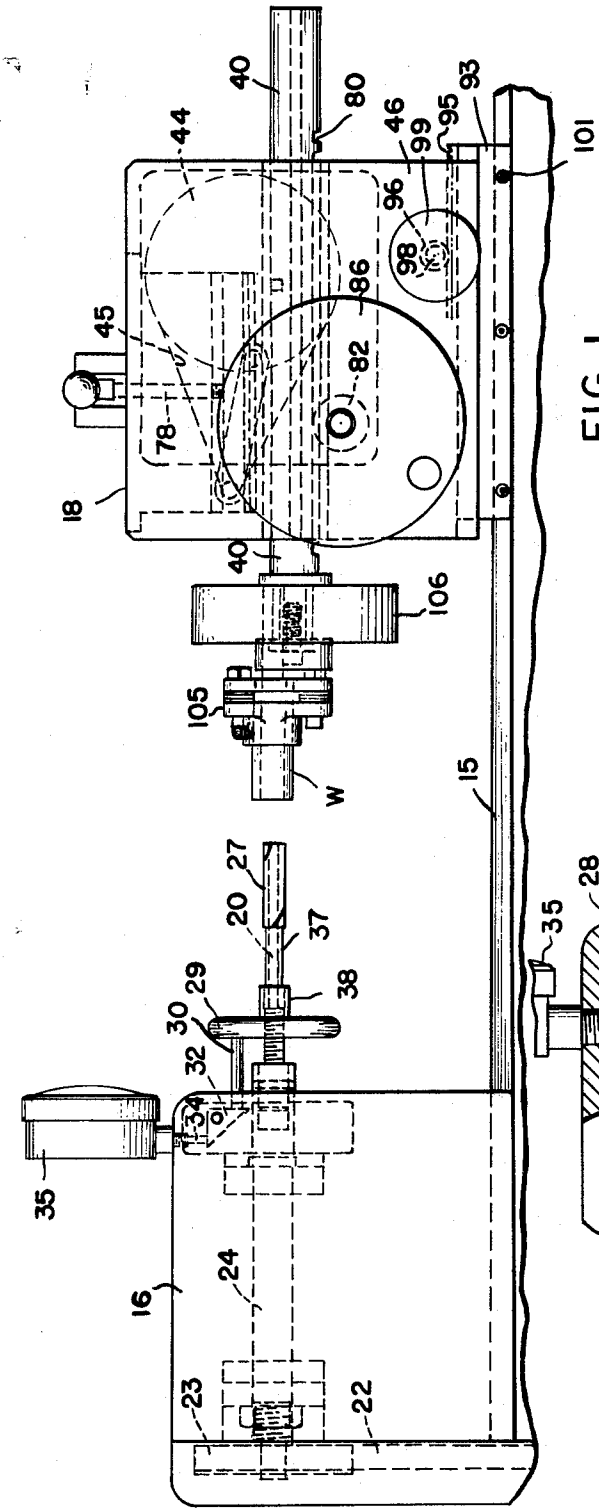



FIG. 1.

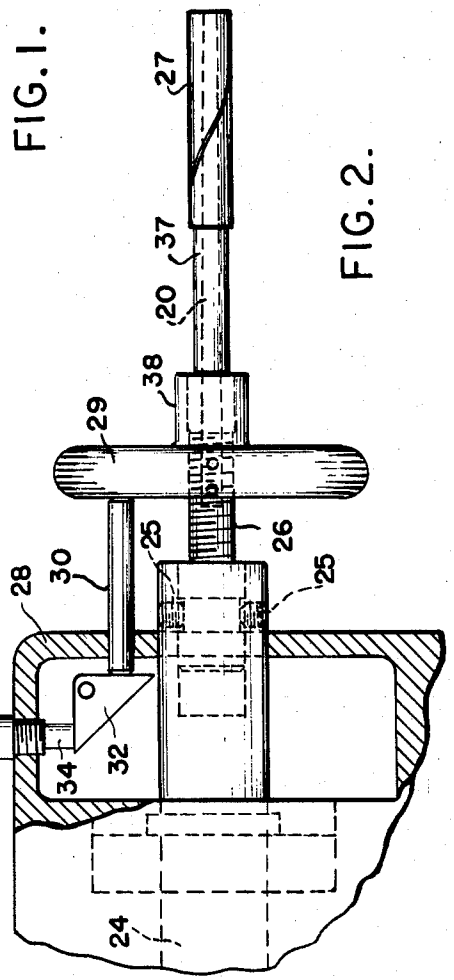



FIG. 2.

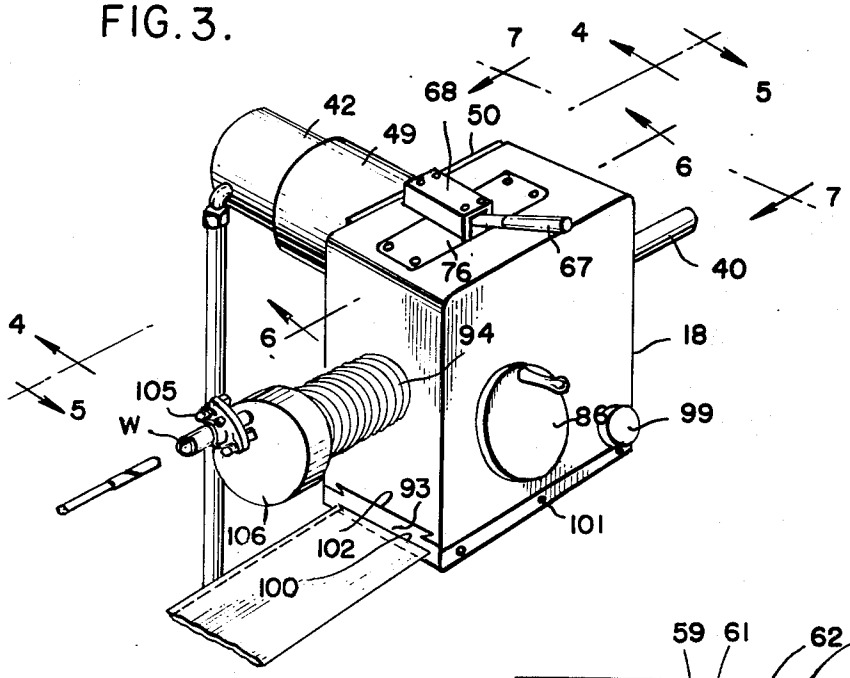
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PRECISION SURFACE ABRADING MACHINE

Filed July 22, 1963 4 Sheets-Sheet 2

FIG. 3.



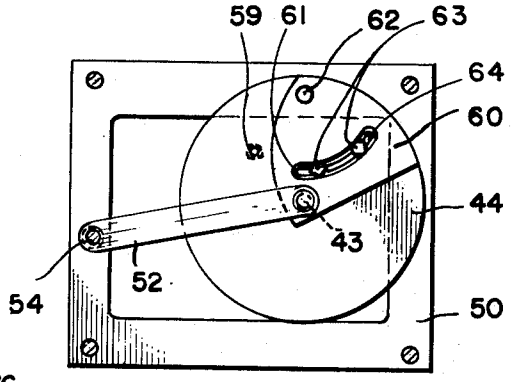




FIG. 4.

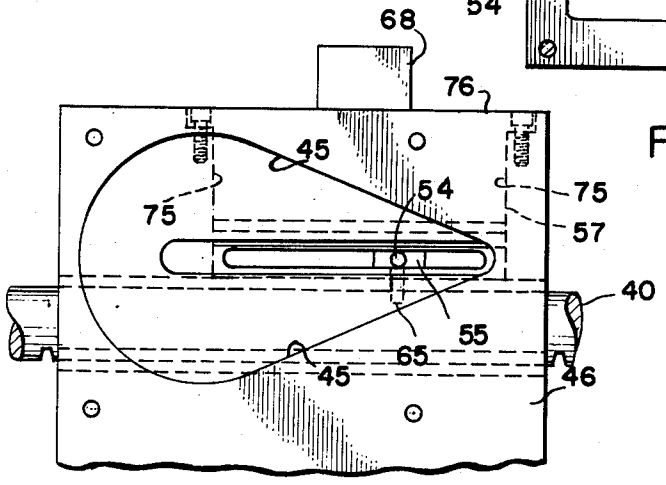



FIG. 5.

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PRECISION SURFACE ABRADING MACHINE

Filed July 22, 1963 4 Sheets-Sheet 3

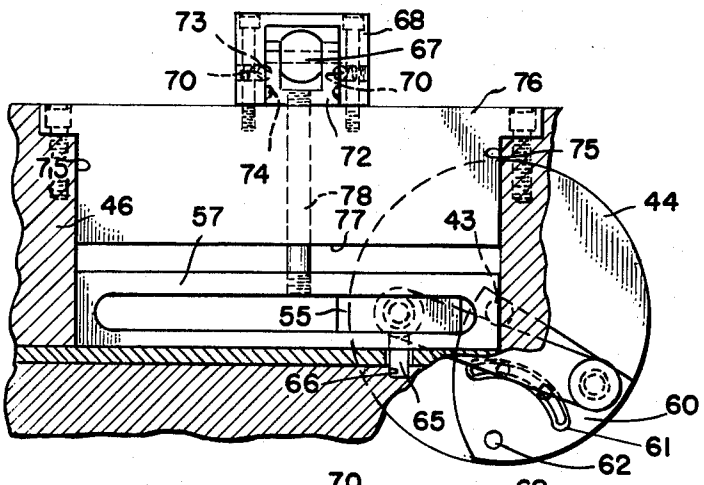



FIG. 6.

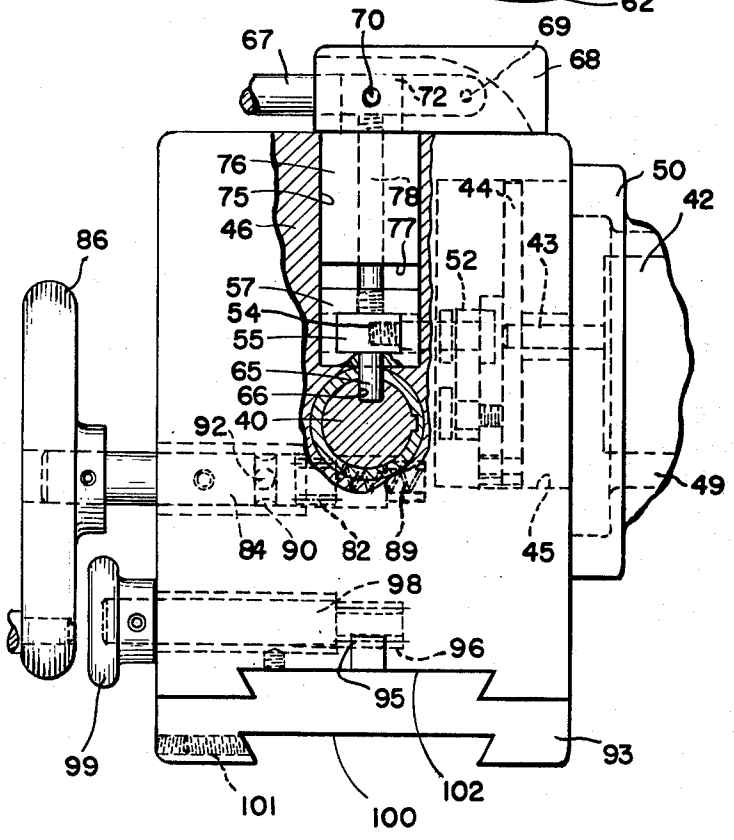



FIG. 7.

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April 26, 1966 A. J. HACKMAN, JR 3,247,622

PRECISION SURFACE ABRADING MACHINE

Filed July 22, 1963 4 Sheets-Sheet 4

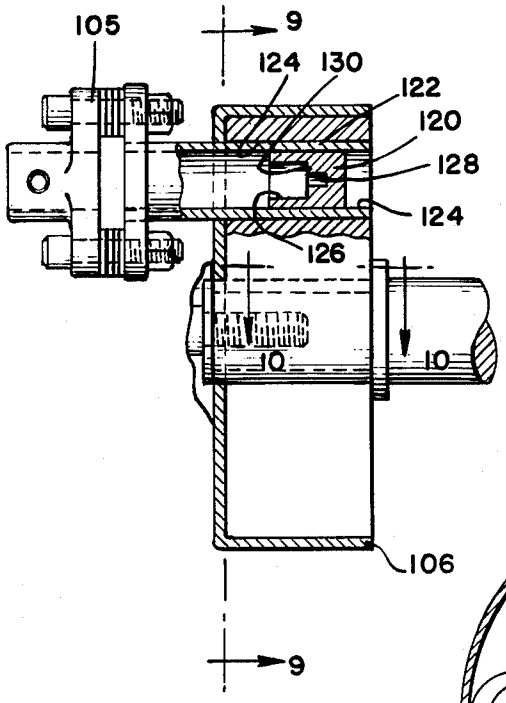



FIG. 8.

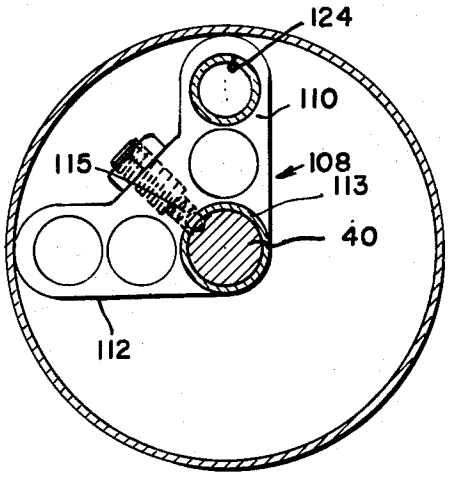



FIG. 9.

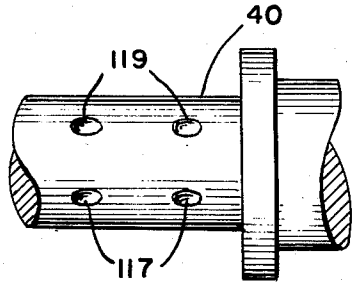



FIG. 10.

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3,247,622

# PRECISION SURFACE ABRADING MACHINE

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17 Claims. (Cl. 51—165)

This invention relates to precision surface abrading apparatus by which is meant abrading apparatus of the type capable of holding tolerances on metal surfaces to the millionths of an inch.

Its principal object is the provision of such apparatus which supplants the deficiencies existing in this art in respect to the means heretofore available for such surface finishing.

Such object and others will appear from the following description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a side elevational view of a lapping machine embodying the present invention;

FIG. 2 is a similar view but enlarged and partly in section of a part of the structure of FIG. 1;

FIG. 3 is a perspective view of the tailstock section of said machine;

FIGS. 4, 5, 6 and 7 are vertical sectional views in elevation of the structure of FIG. 3 taken, respectively, along the lines 4—4; 5—5; 6—6 and 7—7 thereof;

FIG. 8 is an elevational view of a part of the structure of FIG. 1;

FIG. 9 is a sectional view in elevation of the structure of FIG. 8 as viewed along the line 9—9 thereof; and

FIG. 10 is a fragmentary sectional view in elevation of the structure of FIG. 8 as viewed along the lines 10—10 thereof.

Referring to the drawings in greater detail 15 designates the base of the lapping machine on which is mounted a head stock 16 and a tailstock 18. The headstock rotatably drives an arbor 20 from a variable speed drive (not shown) which rotates, via a belt 22, a pulley wheel 23 mounted fast on a shaft 24 which is connected to the arbor 20 by a threaded adapter 26. The adapter 26 has one end which receives and secures the arbor 20 and the other end is secured in an end of the shaft 24 by set screws 25. The arbor 20 is tapered and carries on its free end a slotted (helical in this instance) lap 27, the internal bore of which is also tapered so that as it is moved further onto the arbor its diameter increases and as it is moved off the arbor its diameter decreases. The precise axial position of the lap 27 on the arbor is controlled by sensing and indicating mechanism which includes a handwheel 29 threadably engaged on the adapter 26 and a rod 30 slidable in the headstock body 28 which actuates a bellcrank 32 that actuates a shaft 34 of an indicating gauge 35 which may be calibrated in diameters of the lap 27 or simply have graduations without absolute values for relative indication of the axial lap position. In use of such mechanism the handwheel 29 may be pre-set for a given lap diameter or for a given axial position of the lap 27 on the arbor 20. The lap is then tapped unto the arbor by the machine in the manner which will be later described to expand it and force a spacer member 37 against a hub 38 for the handwheel which terminates further expansion of the lap. The axial position of the lap 27 on the arbor 20 can thus be duplicated precisely which is useful for production purposes and the handwheel 29 prevents over expansion of the lap. In addition to serving as a stop for the inward movement of the lap on the arbor the handwheel 29 can be used to back the lap off the arbor so that in each direction of movement of the lap the machine provides for the operator a feel of the tightness of the lap in preparation for lapping.



While the lap is rotating on its axis a workpart whose internal bore is to be finished is reciprocated over it by the tailstock 18 of the lapping machine. The tailstock reciprocates a shaft 40 by means of an electric motor 42 the shaft 43 of which carries a flywheel 44 which operates within a teardrop shaped cutout 45 in the body section 46 of the tailstock section. The motor 42 which is equipped with a variable (in infinite variations from zero to maximum) speed transmission having an instantaneous clutch snugly fits into a housing sleeve 49 which has a flange 50 in front of which the flywheel 44 is assembled fast on the motor shaft 43. The sleeve 49 by way of its flange 50 bolts unto the rear face of the body section 46 so that the flywheel projects into and operates within the cutout 45. The flywheel carries a connecting rod 52 provided with a pin 54 on its outer end that fits into a block 55 which is slidably carried in a cage 57 so that it is capable of reciprocation accordingly as the rod 52 reciprocates. The inner end of the rod 52 is capable of being set at dead center (see FIG. 4) in respect to the motor shaft 43 or at substantially (i.e. up to 90%) the radius of the flywheel 44 (see FIG. 6) by means which includes a series of threaded apertures 59 extending inwardly into the front face of the flywheel 44 and disposed in an arc thereover and an essentially triangular positioning plate 60 having an arcuately shaped slot 61 which plate is bolted to the flywheel front face by a bolt 62 which serves as a pivot axis for the plate 60 and by a pair of bolts 63 which are disposed in the slot 61 and bear against a shoulder 64 therein to secure the plate in any selected position on the flywheel.

Maximum reciprocation of the block 55 occurs with the inner end of the rod 52 in its maximum radius position and no reciprocation occurs with the rod 52 concentric with the motor shaft 43. Any pre-selected variation of reciprocation stroke between and including zero to maximum is achieved by rebolting the plate 60 in its different selected positions on the flywheel 44. Whenever the block 55 is in the engaged position a pin 65 that it carries extends into an aperture 66 which is formed inwardly into the shaft 40 from its upper surface so that the shaft 40 reciprocates accordingly as the rod 52 reciprocates provided that the shaft 40 is clutched to the rod 52 by the block 55 being in its engaged position.

The block 55 is moved between its engaged and disengaged position by means of a handle 67 which operates within a housing 68 mounted on the top of the tailstock body 46. The housing 68 carries a pivot pin 69 for the inner end of the handle 67 and a pair of spring pressed detents 70 each in a side of the housing so that the pair press against opposite sides of a yoke 72 to which the handle is affixed. Such sides of the yoke carry depressions 73 and 74 corresponding to the lowered and raised positions of the handle 67 into which depressions the detents 70 press to retain the handle in either of its two positions. The tailstock body 46 is provided with a cavity 75 which extends inwardly from its top face in front of the teardrop cutout 45 and which extends longitudinally of the body 46 as seen in FIGS. 3 and 6 particularly by the member 76 which covers the cavity 75 and extends thereinto to serve as a guide for a rod 78 which slides within it. The rod 78 is threaded at its opposite ends by which it connects the cage 57 with the handle 67 via the yoke 72 so that raising of the handle 67 into its elevated position raises the block 55 into its disengaged position. In such position the block 55 and cage 57 in which the block reciprocates are disposed near the bottom surface 77 (see FIG. 6) of the member 76 so that the pin 65 is raised out of the shaft 40 and these parts are retained in such position along with the handle 67 which is retained in its elevated position by engagement of the detents 70 in the depressions 74 and in the yoke 72. Whenever

the handle **67** is lowered from its elevated position to engage the block **55** the latter may have to travel for part of a stroke before its pin **65** finds the aperture **66** in the shaft **40**. Of course the aperture **66** must be within the range of the reciprocation stroke of the block **55** and pin **65** and for this purpose the shaft **40** must be moveable axially of the tailstock **18** by means other than that to reciprocate it.

The shaft **40** is provided with a gear rack **80** on its under surface which is engageable by a pinion **82** carried on the inner end of a slidable shaft **84** which extends transversely of the tailstock body section **46** and carries on its outer end in front of such body section a handwheel **86**. The pinion **82** is normally held out of engagement with the rack **80** by a spring **89** which urges such pinion and the shaft **84** outwardly of the tailstock body **46** (see FIG. 7) so that the handwheel **86** must be pushed in while it is rotated to move the shaft **40** axially of the tailstock body **46**. The shaft **84** has an annular notch **90** formed on it which is engageable by a spring pressed detent **92** which retains the shaft within the tailstock body **46**. Being able to change the axial position of the shaft **40** relative to the tailstock **18** quickly and easily by way of the handwheel **86** means (1) that the lap can be tapped onto the arbor and a feel for the lap tightness maintained by the operator through the handwheel **86** (the mechanism by which the lap can thus be tapped will be later described); (2) the work can be brought away from the lap for cleaning and gauging and back to it for repetition of the lapping cycle (in such case the aperture **66** in the shaft **40** is brought out of range of the reciprocation stroke of the block **55** and pin **65** and back into such range by the handwheel **86**). In FIG. 3 the bellows type cover **94** which is omitted in the other figures serves simply to accommodate the different positions of the shaft **40** while keeping out dust and other foreign bodies. The tailstock base **93** is provided with a gear rack **95** that is engaged by a pinion **96** carried on the inner end of a shaft **98** which also extends transversely of the tailstock body **46** and carries on its outer end in front of such body a handwheel **99**. The tailstock base **93** is mounted on a way **100** on the machine base **15** but is fastened by set screws **101** in any given position whereas the tailstock body **46** is mounted on a way **102** on the tailstock base without being fastened so that upon rotation of the handwheel **99** the tailstock body **46** by coaction of the rack **95** and pinion **96** is moved axially of both such bases to provide a means of varying the center of reciprocation of the workpart relative to the lap which means is operative during such reciprocation.

The workpart W is secured in a holder **105** on a turret **106** carried on the operative end of the shaft **40** which turret is provided with a mechanism by which it can be rotated from its working position in concentric alignment with the arbor **20** which carries the lap **27** to a swung-away position 90 degrees displaced from said working position where the workpart can be sprayed with solvent under pressure and gauged without handling. Formerly it was to be expected with manual lapping that certain tolerances could not be maintained (but of course can be by the means of the present invention) since these would be within the dimension changes from temperature effects brought about simply from handling the workpart.

Such mechanism includes a mounting bracket **108** for the turret which is secured to the inside face of the latter and disposed within it as shown in FIGS. 8 and 9. The bracket has arms **110** and **112** at right angles which are joined by a hub **113** that carries a pair of spring pressed ball detent assemblies **115** as shown which urge a pair of ball bearings into one of the two pairs of recesses **117** and **119** formed on the extreme end of the shaft **40** and circumferentially spaced 90 degrees apart thereof. The coaction of the recesses **117** and **119** and the assemblies **115** provide for a snap-action of the turret as it is rotated



into its extreme positions to carry the workpart W between its operative and swung-away positions. The workholder **105** is fitted with a bushing **120** in its barrel **122** which extends through the turret and into a bore **124** in the bracket arm **110**. The bushing **120** has concentric apertures **126** and **128** of different diameters which form a shoulder **130** at their junction as shown. The aperture **128** is blind and is adapted to receive the tapered end of the arbor **20** while the aperture **126** is open at its opposite ends and is adapted to receive the lap **27** on the arbor while the shoulder **130** serves as a stop for the lap preventing its movement while providing for the arbor's movement axially inwardly of the bushing **120** and of the workholder **105**. Consequently when the shaft **40** is reciprocated by the handwheel **29** the bushing **120** may be brought up to the arbor and lap and its shoulder **130** used to tap the lap to expand it further unto the arbor while its aperture **128** receives the end of the arbor and accommodates the amount it protrudes beyond the lap.

It will thus be seen that there has been provided by the present invention an improved precision surface abrading machine in which the object heretofore set forth together with many thoroughly practical advantages has been successfully achieved. While a preferred embodiment of the invention has been shown and described it is to be understood that modifications, variations and changes may be resorted to without departing from the spirit of the invention as set forth in the appended claims.

What is claimed is:

**1.** In a precision surface abrading machine, means including a reciprocative shaft for cyclicly reciprocating one of a tool part and a work part relative to the other, a cage, a block slidable in the cage, the block connected to said cyclic reciprocation means, and means for moving the cage to engage the block with the shaft to reciprocatively drive it and to disengage the block from the shaft to render it non-cyclicly reciprocative.

**2.** In a precision surface abrading machine having a base, means for supporting a work part and an abrading tool part for rotary and axial reciprocative movement relative to and in frictional surface contact with each other in the presence of an abrasive compound, a cylindrical and tapered arbor for carrying a tool part, the tool part cylindrical, internally tapered, fully expansible radially and changing its circumference according to its axial position on the arbor, and positioning means for precisely adjusting the axial position of the tool part on the arbor, the positioning means comprising screw-threaded means operating axially upon and in line with the tool part, the positioning means including a solid positive stop against which the tool part abuts in being positioned on the arbor.

**3.** Apparatus as claimed in claim **2** which includes indicating means independent of and responsive to the positioning means for indicating the precise axial position of the tool part on the arbor, the indicating means including a member which is moveable axially in response to the movement of said screw-threaded means.

**4.** Apparatus as claimed in claim **2** in which the screw-threaded means includes a screw-threaded handwheel under control of the machine operator, the axial position of which governs the axial position of the tool part on the arbor, and indicating means independent of and responsive to the positioning means for indicating the precise axial position of the tool part on the arbor, the indicating means including a rod slidably mounted in respect to the base, a gauge responsive to the position of the rod in reference to the handwheel, the rod bearing against the handwheel and following its axial position.

**5.** Apparatus as claimed in claim **2** which includes means to tap the tool part to move it on the arbor against the solid positive stop.

**6.** Apparatus as claimed in claim **5** in which the tapping means includes means by which the tool part is passed through the work part during the time the axial position

of the work part on the arbor is adjusted by such tapping means.

7. In a precision surface abrading machine having an arbor for carrying a tool part, positioning means for precisely adjusting the position of the tool part on the arbor comprising a screw-threaded handwheel under control of the machine operator, the axial position of which governs the axial position of the tool part, and indicating means responsive to said positioning means for indicating the precise position of the tool part on the arbor, said indicating means including a slidably mounted rod, a gauge responsive to the position of the rod in reference to the handwheel, the rod bearing against the handwheel and following its axial position.

8. In a precision surface abrading machine having a base, means for supporting a work part and an abrading tool part for axial movement relative to the base and to each other, means for cyclicly reciprocating one of said parts relative to and in frictional surface contact with the other in the presence of an abrasive compound, means for rotating one of said parts relative to the other during such reciprocation, said cyclic reciprocation means having a predetermined range of reciprocation, means independent of the cyclic reciprocation means and operative during operation of the machine to move said parts axially relative to each other so that they may be separated from such frictional surface contact with each other and apart a distance greater than such reciprocation range, and means to instantaneously de-clutch the cyclic reciprocation means in respect to the part it reciprocates during the times the parts are being so separated from each other and being separated apart such greater distance.

9. Apparatus as claimed in claim 8 which includes a shaft reciprocated by the cyclic reciprocation means axially of the base and carrying the part which is reciprocated, said instantaneous de-clutching means including a moveable pin and means operative during such reciprocation for instantaneously disconnecting the pin from the shaft to de-clutch the latter from said cyclic reciprocation means.

10. In a precision surface abrading machine having a base, means for supporting a work part and an abrading tool part for axial movement relative to the base and to each other, means for cyclicly reciprocating one of said parts relative to and in frictional surface contact with the other in the presence of an abrasive compound, means for rotating one of said parts relative to the other during such reciprocation, said cyclic reciprocation means having a predetermined range of reciprocation, means for varying the reciprocation stroke of the cyclic reciprocation means in continuous increments from zero to a maximum of said reciprocation range, said means including a flywheel and a crank, and a connection between them including a plate connected to an end of the crank and pivotally mounted eccentrically on the flywheel, said connection also including means for locking the plate in selected pivoted positions on the flywheel to vary the location of the connected end of the crank between dead center of the flywheel and its maximum radius, said connection being disposed wholly within the confines of the flywheel in each of said locations of the connected end of the crank.

11. In a precision surface abrading machine having a base, means for supporting a work part and an abrading tool part for axial movement relative to the base and to each other, means for cyclicly reciprocating one of said parts relative to and in frictional surface contact with the other in the presence of an abrasive compound, means for rotating one of said parts relative to the other during such reciprocation, a shaft reciprocated by the reciprocation means axially of the base and carrying the part which is reciprocated, and means operative during such reciprocation for instantaneously clutching and de-clutching the shaft to and from said cyclic reciprocation means, said clutching and de-clutching means including a moveable cage, a block slidable in the cage, the block connected to said cyclic reciprocation means, and means for moving the cage to engage the block with the shaft to reciprocatively drive it and to disengage the block from the shaft to render it non-cyclicly reciprocative.

12. In a precision surface abrading machine having a base, means for supporting a work part and an abrading tool part for axial movement relative to the base and to each other, means for cyclicly reciprocating one of said parts relative to and in frictional surface contact with the other in the presence of an abrasive compound, means for rotating one of said parts relative to the other during such reciprocation, means for varying the center of cyclic reciprocation in respect to the non-reciprocating part, said reciprocation center varying means operative during such reciprocation, means to instantaneously disable the cyclic reciprocation means in respect to the part it reciprocates, and means independent of said cyclic reciprocation means and of said reciprocation center varying means for moving the reciprocative part axially relative to the non-reciprocating part so that the two parts may be brought into and separated from such frictional surface contact with each other, said last-mentioned means operative during disablement of said cyclic reciprocation means and upon less mass than that upon which said reciprocation center varying means operates.

13. In a precision surface abrading machine having a base, means for supporting a work part and an abrading tool part for axial movement relative to the base and to each other, means for cyclicly reciprocating one of said parts relative to and in frictional surface contact with the other in the presence of an abrasive compound, means for rotating one of said parts relative to the other during such reciprocation, a shaft reciprocated by the reciprocation means axially of the base and carrying the work part, means for indexing the work part circumferentially of the shaft into a working position in which it may be worked upon by the tool part and a non-working position in which it may be cleaned and gauged.

14. Apparatus as claimed in claim 13 which includes a work holder for the work part, a turret carrying the work holder, the turret mounted on the shaft so that it can be rotated between two indexed positions circumferentially spaced in respect to the shaft, and means for releasably detaining the turret on the shaft in said indexed positions whereby to hold the work part in said working and non-working positions.

15. In a precision surface abrading machine, means for cyclicly reciprocating one of a tool part and a work part relative to and in frictional surface contact with each other in the presence of an abrasive compound, means for varying the reciprocation stroke of the cyclic reciprocation means in continuous increments from zero to a predetremined maximum reciprocation range, said means comprising a flywheel and a crank, and a connection between them including a plate connected to an end of the crank and pivotally mounted eccentrically on the flywheel, said connection also including means for locking the plate in selected pivoted positions on the flywheel to vary the location of the connected end of the crank between dead center of the flywheel and its maximum radius, said connection being disposed within the confines of the flywheel in each of said locations of the connected end of the crank.

16. In a precision surface abrading machine having a base, means for cyclicly reciprocating one of a tool part and a work part relative to and in frictional surface contact with each other in the presence of an abrasive compound, said means including a bearing supported shaft reciprocable axially of the base and carrying the part which is reciprocated, a flywheel and a crank connected at one end to the flywheel, a pin connected to the other end of the crank, a socket in the shaft, means operative during rotation of the flywheel for moving the

pin to insert it in said socket to instantly reciprocatively drive the shaft and to remove it from said socket to instantly render said shaft noncyclicly reciprocative.

17. In a precision surface abrading machine having a base, cyclic reciprocation means, a shaft reciprocable axially of the base by said cyclic reciprocation means, means for instantaneously clutching and de-clutching the shaft to and from said cyclic reciprocation means, said clutching and de-clutching means including a moveable cage, a block slidable in the cage, the block connected to said cyclic reciprocation means, and means for moving the cage to engage the block with the shaft to reciprocatively drive it and to disenage the block from the shaft to render it non-cyclicly reciprocative.



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